

USING THE CRITICAL PERIOD FOR WEED CONTROL IN ROUNDUP READY FLEX[®] COTTON

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Introduction

The Critical Period for Weed Control (CPWC) is a concept that relates the yield reduction caused by weed competition to an economic threshold. It establishes a period at the start of the season when weeds do not need to be controlled as they cause no economic loss, and a period towards the end of the season when weeds again cause no economic loss. These periods define the middle, CPWC, in which weeds must be controlled to reduce yield losses.

Work by NSW DPI staff at the Australian Cotton Research Institute (ACRI) at Narrabri has for the first time defined the CPWC in irrigated Australian cotton. Articles describing the work were published in the August-September 2007 edition of the Australian CottonGrower.

Still, the question remains, how can a cotton grower best use this information in a cotton crop?

The main aim of this article is to explore how applying the critical period concept might have worked out in grower's fields over the last three seasons.

The critical period for weed control

In practice, the critical period is defined by the type of weed present, the density of weeds, the potential crop yield, the cost of weed control and the economic threshold the cotton grower chooses.

The CPWC is defined in Table 1 using 1% and 3% weed control thresholds for fully irrigated cotton (1% threshold) and lower yielding or rain-fed crops (3% threshold). These control thresholds were determined from the point where the yield loss caused by the weeds exceeds the cost of control with Roundup Ready Herbicide. As well as reducing lint yield, uncontrolled weeds set seed



A cotton crop with a heavy infestation of grass weeds in the plant line. This was part of the experiments used to establish the CPWC in cotton.

leading to increasing weed problems over time, impede water flow and pesticide penetration, harbor pests and diseases, and cause harvesting difficulties and lint contamination.

To show how these thresholds might be used in the field, we applied them to Narrabri data for each of the last three seasons.

The simulations and discussion focus on management of a Roundup Ready Flex cotton crop because the critical period approach is most readily adapted to this system. However, the concept can be equally applied to conventional and Liberty Link[®] cotton crops.

Table 1. The predicted start and the end of the CPWC for a range of weed species and densities using 1% and 3% thresholds. The critical period is measured in day degrees from planting.

Weed density (weeds/m ² row)	Critical period			
	1%	3% threshold	1%	3% threshold
Large broad-leaf weeds				
0.1	111	-	210	-
0.2	111	178	310	222
0.5	110	177	507	365
1	110	175	678	508
2	109	170	827	653
5	105	158	959	798
Medium broad-leaf weeds				
0.1	111	-	172	-
0.2	111	-	249	-
0.5	110	-	416	-
1	110	175	583	227
2	109	170	748	331
5	105	158	913	517
10	101	142	987	661
Grass weeds				
2	-	-	-	-
3	123	-	141	-
5	122	137	178	148
10	121	136	259	206
20	120	132	383	299
50	115	124	600	477

Model inputs

We tested the CPWC on a relatively dirty field with a mixed weed population of 1 large broadleaf weed/m² (eg. thornapple or noogoora burr), 5 medium sized broadleaf weeds/m² (eg. bladder ketmia) and 10 grass weeds/m² (eg. barnyard grass). Simulations were made for both fully irrigated and rain-fed crops in each season.

Weed germinations were related to rainfall and irrigation events. The simulations assumed most of the weeds emerged between 50 and 100 day degrees after rain (or irrigation), and all weeds were susceptible to Roundup Ready Herbicide.

The irrigated crop was pre-watered and planted on 5th Oct. each season. No residual herbicides were applied prior to or at planting. Roundup was applied before crop emergence to ensure a clean start to the season. Applying a 1% yield loss threshold, the CPWC extended from cotyledon to mid-flowering growth stages (105 to 913 day degrees) for the simulated weed population, as shown by the red lines in the figures.

The “rain-fed” simulations used similar assumptions, with no pre- or at-planting residual herbicides. Planting occurred on the first opportunity following rain after the 5th Oct., and Roundup was again applied before crop emergence to ensure a clean start to the season. Applying a 3% yield loss threshold, the CPWC extended from the 2 node stage to early squaring (136 to 517 day degrees).



A cotton crop showing the effect on crop height and biomass of a heavy weed infestation following a Roundup Ready application (foreground). Weeds have been uncontrolled since planting in the plot behind this. These plots are part of an experiment to test the CPWC in Roundup Ready Flex cotton.

The CPWC in 2004-5

Reasonable rainfall fell in the first half of the 2004-5 season at Narrabri, with a daily maximum of 138 mm recorded in Dec. Multiple weed germination events were triggered by early season rainfall and irrigation later in the season (Figure 1).

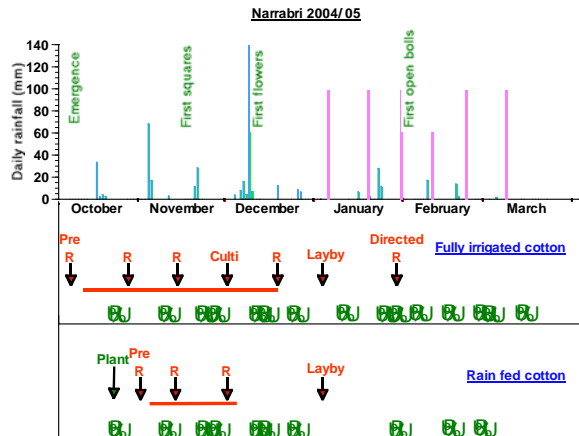



Figure 1. A simulation of how the CPWC might have been applied in the 2004-5 season at Narrabri (ACRI). Simulations are for both fully irrigated and rain fed crops. Symbols are: blue bars, daily rainfall (mm); pink bars, irrigations; red lines, the CPWC; red arrows, weed control inputs (R = Roundup Ready® Herbicide, Pre R = a pre-crop emergence Roundup, Culti = inter-row cultivation, Layby = a residual layby herbicide); and green arrow, planting. Periods of peak weed emergence are indicated by .

With no pre-planting or at-planting residual herbicides used, post-emergence weed control was required following weed emergence on four occasions during the critical period, at 6 nodes, first squares, first flowers and mid-flowering (310, 511, 719 and 946 day degrees). Ideally, weeds need to be controlled within 105 day degrees of their germination, which will be only a few days after seedling emergence. Roundup Ready Herbicide could be used on three of these occasions, with inter-row cultivation and chipping used on one occasion. This combination of inputs conforms with the Roundup Ready Flex Crop Management Plan which requires that: (1) no more than three Roundup Ready Herbicide applications are made during this crop growth period; and (2) that weeds that survive a Roundup Ready Herbicide application are controlled by an alternate method before they set seed (the combination of inter-row cultivation and chipping conforms with this requirement). Only a very light chipping should have been required as few weeds would have survived two Roundup applications and a cultivation pass.

Weeds that emerged later in the season would still need to be controlled to prevent problems such as harvesting difficulties, lint contamination and the build up of the weed seedbank (leading to increasing weed problems over time). These weeds could be controlled with a lay-by application

of residual herbicide before canopy closure and a directed application of Roundup Ready Herbicide during the 16 to 22 node stage if required. A pre-harvest application of Roundup Ready Herbicide could also be used to prevent late-season weeds setting seed if sufficient late-season weeds were present to justify this input.

This herbicide program would potentially have used the maximum number of early-season Roundup Ready Herbicide inputs allowed by the label, but probably not all these inputs would have been required in practice, with at least one inter-row cultivation pass replacing a Roundup application. It is also likely that lower than maximum label rates would have been used for the first two Roundup applications as these were applied to young weeds which are easily controlled with lower rates. Rates of 0.5 to 1 kg/ha would give excellent control of most susceptible weed seedlings. An early lay-by application of residual herbicide could have been applied in late-Dec. if an additional weed control input had been required during the critical period.

Rainfall in mid-Oct. allowed a rain-fed crop to be planted on 24th Oct. Post-emergence weed control was required on two occasions, at 5-6 nodes and first squares (282 and 490 day degrees). Weeds which emerged later in the season could have been controlled with a lay-by application of residual herbicide in early Jan. It is unlikely that further weed control inputs would have been required in this season.

The CPWC in 2005-6

Reasonable rainfall again fell in the 2005-6 season at Narrabri, and multiple weed germination events were triggered by rainfall and irrigation (Figure 2).

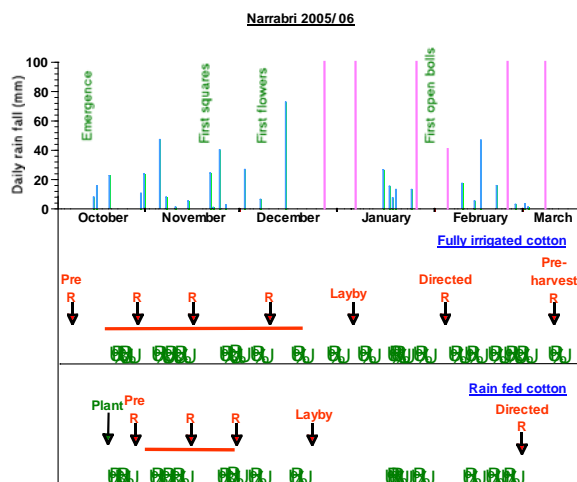


Figure 2. Using the CPWC in the 2005-6 season. Simulations for fully irrigated and rain-fed crops are shown. Weed control operations during the CPWC protect cotton yield. Weed control operations after the CPWC prevent weeds from adding seed to the soil seed bank, leading to problems in later seasons.

Using a 1% yield loss threshold, post-emergence weed control was required at 5 nodes, first squares and first flowers (259, 460, and 803 day degrees). Roundup Ready Herbicide could have been used on all occasions, although an inter-row cultivation and light chipping may have been used on one occasion to remove any weeds that survived the Roundup application, as required by the Crop Management Plan. Weeds which emerged later in the season could have been controlled with a lay-by application of residual herbicide in early Jan. and a directed application of Roundup Ready Herbicide during the 16 to 22 node stage if required. A pre-harvest application of Roundup Ready Herbicide could also be used to prevent late-season weeds setting seed.

This herbicide program may have again used the maximum number of Roundup Ready Herbicide inputs allowed by the label. Lower than maximum label rates would have been required for the first two applications to young weeds, enabling the total in-crop use to remain within label requirements even if both the directed application and the pre-harvest application were required.

Rainfall in mid-Oct allowed a rain-fed crop to be planted on 20th Oct. With a 3% yield loss threshold, post-emergence weed control was required at 7-8 nodes and mid-squaring (245 and 586 day degrees). Later emerging weeds could have been controlled with a lay-by application of residual herbicide in early Jan. A pre-harvest application of Roundup Ready Herbicide may also have been

required to prevent late-season weeds setting seed following good rain in Feb.

The CPWC in 2006-7

Very little rain fell in the 2006-7 season at Narrabri, with most weed germination events triggered by irrigation (Figure 3).

Using a 1% yield loss threshold, post-emergence weed control was only required at first squares (460 day degrees). Weeds which emerged later in the season could have been controlled with inter-row cultivation or a lay-by application of residual herbicide. No other weed control may have been necessary.

Rainfall in early Nov. may have allowed a rain-fed crop to be planted on 8th Nov. With a 3% yield loss threshold, no rainfall occurred during the CPWC and it is likely that few if any weeds emerged during this period. Weeds which emerged later in the season could have been controlled with a lay-by application of residual herbicide.

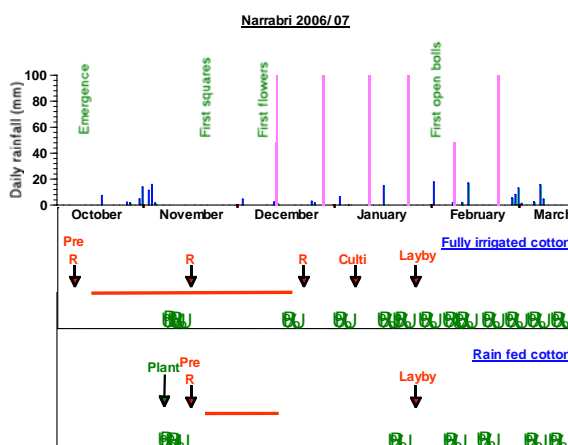


Figure 3. Applying the CPWC in the 2006-7 season. Simulations are for fully irrigated and rain-fed crops.

Observations from these simulations

The CPWC approach can be successfully applied in both irrigated and rain-fed cotton. Applying Roundup Ready Herbicide inputs to small weeds soon after emergence will maximize herbicide efficacy and yields but will not necessarily result in the maximum number of applications being used too early in the season, especially where inter-row cultivation or other herbicides are used on some occasions instead of Roundup.

In seasons where the early season weed pressure is too high (requiring too many early Roundup applications), an early layby application of residual herbicide can be used to replace a Roundup application and reduce weed pressure. Prometryn (Gesagard) or fluometuron (Cotoran), for example, can be applied as an early layby to cotton as small as 15 cm high and will control a wide range of emerged weeds provided they are applied to small weeds, as well as giving residual control, reducing weed pressure. An alternative residual, such as diuron, could then be applied later in the season as a standard layby application.

Resistance to Roundup

Some cotton growers are concerned that relying too heavily on Roundup is likely to lead to future problems with weeds that are resistant to Roundup (glyphosate). The potential for resistance is very real, as shown by the increasing resistance problems with Roundup Ready crops in the US.

However, resistance can be avoided by following two simple rules.

1. Always follow the Roundup Ready Flex Crop Management Plan. Central to this plan is the requirement that crops are checked after a Roundup application and any surviving weeds controlled using an alternative weed management tool before the weeds set seed.
2. Ensure at least one effective alternative weed management tool is used each season. An inter-row cultivation combined with a light chipping is a sound strategy for avoiding resistance. Alternatively, using a directed layby residual herbicide, incorporated with inter-row cultivation can be equally effective, although a light chipping may still be required to control larger weeds in the plant line.

Conclusions

- Using Roundup Ready Flex cotton without pre- or at-planting residual herbicides can be a sound weed management strategy in low weed pressure fields in most seasons.
- Applying the CPWC and controlling weeds within a few days of germination will minimize

yield losses from weeds, while not leading to excessive herbicide use.

- Weeds that emerge after the CPWC still have to be controlled, but timing is not critical provided they are controlled before they set seed.
- Fields that have significant populations of troublesome weeds should always be treated with residual herbicides before or at planting.
- Alternative weed management tools such as inter-row cultivation and chipping can reduce the pressure on Roundup applications.
- Include a directed layby residual herbicide, incorporated with inter-row cultivation in the system.
- Consider an early layby herbicide application if seasonal conditions lead to excessive early season weed pressure.
- These strategies can be applied equally with an alternative technology, such as Liberty Link cotton, although an at-planting residual grass herbicide will be required on most fields with Liberty Link cotton.

Acknowledgements

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Summary

Application of the Critical Period for Weed Control (CPWC) concept was tested for irrigated and rain-fed Roundup Ready Flex[®] cotton crops using data from the last three seasons.

The CPWC was applied to a relatively dirty field situation, where large numbers of weeds emerged after each rainfall and irrigation event.

The CPWC required that weeds were controlled while still small, potentially using up the in-crop Roundup Ready[®] applications early in the season.

The seasons varied from relatively wet (first half of 2004-5) to extremely dry (2006-7).

All weed flushes were able to be controlled in each season using the CPWC approach, with an early application of a residual layby herbicide available as a backup additional weed management tool.

The results show that ensuring weeds are controlled soon after emergence is a practical approach to weed control which will minimise yield losses from weeds.