

Using the critical period for weed control to manage weeds in Roundup Ready Flex[®] cotton in the 2007/8 season

Graham Charles¹ and Ian Taylor²
NSW DPI, Cotton Catchment Communities CRC¹, and CRDC², Narrabri

SUMMARY

Data from last season was used to test the critical period for weed control approach for irrigated and dryland Roundup Ready Flex[®] cotton crops.

The critical period for weed control was applied to dirty, average and clean fields, where weeds emerged after each rainfall and irrigation event.

Applying the critical period approach required that the start of weed control began soon after crop emergence, while weeds were still small. A lighter herbicide rate might be appropriate for small weeds. The duration of the critical period depended on the density of weeds that emerged after the first treatment.

All weed flushes in the 2007/8 season were controlled using Roundup during the critical period, with an inter-row cultivation or an early application of a residual layby herbicide available as an additional weed management tool if required.

The results show that ensuring weeds are controlled soon after emergence is a practical approach to weed control which will help optimize crop yields. The approach can be equally applied to irrigated and dryland crops using Roundup Ready Flex, Liberty Link[®] or conventional cotton varieties.

THE CRITICAL PERIOD FOR WEED CONTROL

The critical period for weed control is a concept that relates the yield reduction caused by weed competition to an economic threshold. It establishes an initial period when the weeds are small and do not need to be controlled as they cause no economic loss, and a period at the end of the season when late emerging weeds again cause no economic loss as the cotton plants are relatively large and competitive. These periods define the middle, critical period for weed control, in which weeds must be controlled while still small to avoid significant yield losses. Weeds can be tolerated in the last stage, after the critical period, as they will not reduce crop yields, but may still need to be controlled to avoid harvesting difficulties and lint contamination and should not be allowed to set seed, as this will lead to increased weed problems in later seasons. These weeds can also harbour pests and diseases.

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 critical period for weed control is defined in Table 1 for large and medium sized broadleaf and grass weeds using 1% and 3% thresholds. These thresholds approximate likely control thresholds for applying glyphosate to fully irrigated cotton (1% threshold) and lower yielding or rain-fed crops (3% threshold). The thresholds approximate the point where the yield loss caused by the weeds equals the cost of control with glyphosate. The point of the threshold is determined by the cost of the control input and the value of the crop.

Critical Period for Weed Control (day degrees since planting)													
Weed density (no./m²)	Large broad-leaf weeds				Medium broad-leaf weeds				Grass weeds				
	1%		3%		1%		3%		1%		3%		
	Yield loss threshold				Yield loss threshold				Yield loss threshold				
	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	
0.1	111	210	-	-	111	172	-	-	-	-	-	-	
0.2	111	310	178	222	111	249	-	-	-	-	-	-	
0.5	110	507	177	365	110	416	-	-	-	-	-	-	
1	110	678	175	508	110	583	175	227	-	-	-	-	
2	109	827	170	653	109	748	170	331	-	-	-	-	
3	108	895	166	725	108	831	166	409	123	141	-	-	
5	105	959	158	798	105	913	158	517	122	178	137	148	
10	101	1014	142	864	101	987	142	661	121	259	136	206	
20	94	1044	119	901	94	1029	119	774	120	383	132	299	
50	84	1063	89	926	84	1057	89	866	115	600	124	477	
Minimum density	0.03		0.14		0.04		0.62		2.1		4.2		

Table 1. The predicted start and end of the critical period for weed control for a range of weed types and densities, using 1% and 3% control thresholds. Examples of weeds in each category are: thornapples and noogoora burrs (large broad-leaf weeds); bladder ketmia and Chinese lantern (medium broad-leaf weeds); and barnyard grass (grass weed). The minimum weed densities needed to trigger the critical period are also shown.

To show how these thresholds would be used in the field, we applied them to 3 weed densities in irrigated and dryland cotton crops, using climatic data from Narrabri for the 2007/8 season. We used dirty, average and clean fields, with mixed populations of large and medium broadleaf and grass weeds. Weed germinations were related to rainfall and irrigation events. The models assumed most weeds emerged 50 to 100 day degrees after rain (or irrigation), and all weeds were controlled with glyphosate.

It is essential that glyphosate is not the only herbicide used in fields with very heavy weed densities, or where glyphosate tolerant weeds are present. Residual herbicides, such as prometryn, fluometuron and diuron, or alternative contact herbicides, such as Staple[®] or Envoke[®], should be used in fields where significant numbers of glyphosate tolerant weeds, such as burr medic, rhyngo and emu foot are present. The choice of herbicide(s) is determined by the weed species present. Very dirty fields are normally best managed by applying residual herbicides before or at planting, reducing the pressure on glyphosate later in the season. This is generally more satisfactory than

applying these herbicides later in the season after problems have already occurred, when it is difficult to achieve good incorporation of the herbicides, especially in the plant line.

The discussion in this article focuses on the management of Roundup Ready Flex cotton crops because the critical period approach is readily adapted to the Roundup system and this is currently the most common cropping option used. The concept can be equally applied to conventional and Liberty Link cotton crops, but the thresholds will need to be modified to take into account the costs of alternative inputs with these crops.

THE CRITICAL PERIOD IN IRRIGATED COTTON

The crops were watered-up on 8th Oct. No residual herbicides were applied before or at planting.

The start of the critical period was relatively insensitive to weed density, provided there were enough weeds to trigger the critical period. This minimum number of weeds was very low for large broadleaf weeds, at 3/100 m row (1% threshold), but much higher for grass weeds at 2.1/m row.

Given that the threshold weed density was reached, the first Roundup application was required soon after crop emergence (105 – 110 day degrees after planting), as shown in Figure 1. The end of the critical period for weed control was strongly influenced by weed type and density, rising from 583 day degrees post-planting in the clean field, to 1029 day degrees in the dirty field.

Reasonable rain fell over late spring and summer, in a relatively long, cool season. This resulted in multiple weed germinations, with later germinations triggered by irrigations. A 2nd Roundup application was required on all fields in early-November to control a flush of weeds after rain in late-October. A fall of 40 mm on 6th November delayed this application till mid-November.

Lower than maximum label rates would have been suitable for Roundup applications to young weeds, as weeds are more easily controlled while they are small, provided they have sufficient leaf area to catch the spray. Rates of 0.8 to 1 kg/ha should be sufficient to control susceptible weed seedlings, reducing cost and maintaining late-season options (the product label precludes the use of maximum label rates for all applications if the maximum number of in-crop Roundup applications is used).

An alternative input, such as a cultivation and light chip, may have been required to remove surviving weeds after this application, as required by the Roundup Ready Flex Crop Management Plan. The need for this input is determined by the in-crop survey of weed survivors. Controlling surviving weeds with an alternative management input is essential to avoid species shift and herbicide resistance.

No further weed control in the critical period was required on the clean field, but all fields were inter-row cultivated in early- to mid-December prior to the first irrigation. This cultivation was undertaken to facilitate water movement and would also have controlled most weeds present. A residual herbicide could have been applied and incorporated at this time if required. No further treatment was required in the critical period on the average field, but an additional Roundup was required at the start of January on the weedy field.

A large number of weeds emerged following good rain in December and January, necessitating treatment by Roundup or the use of an incorporated residual herbicide in late January. Roundup could not have been used on the weedy field as only 3 post-emergence applications are permitted up to the 16 node stage of crop growth (this is a requirement of the product label). An additional

directed Roundup application could have been made in late February, and a pre-harvest application could also have been used to prevent late-season weeds setting seed if sufficient weeds were present to justify these inputs.

Applying an incorporated, residual herbicide at canopy closure is a sound strategy for most fields. A residual “layby” herbicide should control any weeds that have survived the Roundup applications (reducing the risk of glyphosate resistance developing), and reduce the risk of weeds emerging later in the season when they will be difficult and expensive to control.

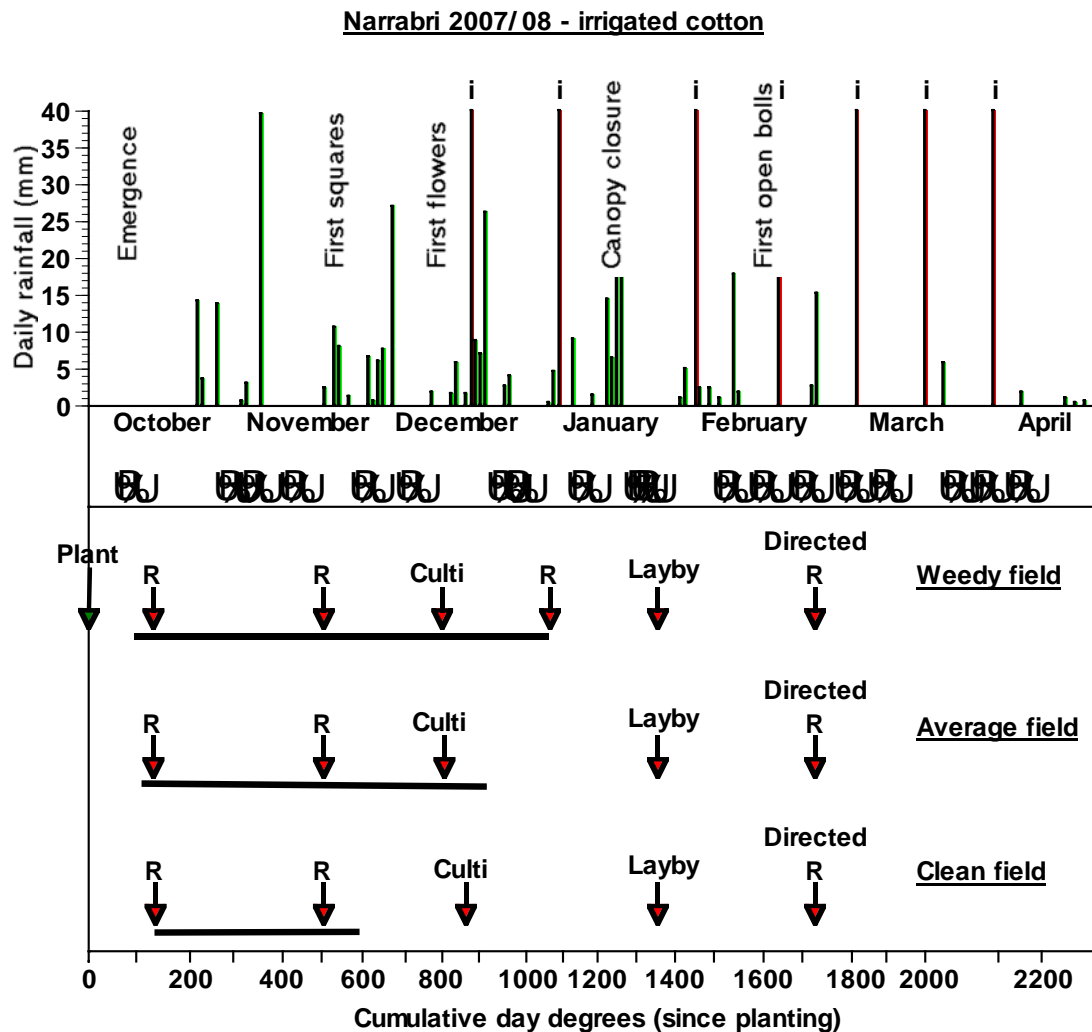


Figure 1. How the critical period for weed control could have been used in the 2007-8 season at Narrabri for weedy, average and clean fields. Symbols are: (top section) rainfall (**vertical bars**) and irrigations (**vertical bars topped by i**); (middle section) periods of peak weed emergence, **E**; and (bottom section) the critical period for weed control, **horizontal lines**; and planting and weed control inputs, **arrows**. Symbols used on arrows are: planting, **Plant**; Roundup Ready Herbicide sprays, **R**; inter-row cultivation passes, **Culti**; and application and incorporation of a residual herbicide, **Layby**.

THE CRITICAL PERIOD IN DRYLAND COTTON

The crops were planted on 28th Oct, following rain on the 25th. No residual herbicides were applied before or at planting.

The start of the critical period was again relatively insensitive to weed density, provided there were enough weeds to trigger the critical period. This minimum number of weeds was low for large broadleaf weeds, at 1 in 10 m row (3% threshold), but much higher for grass weeds at 4.2/m row.

Given that the threshold weed density was reached, the first Roundup application was required soon after crop emergence (158 – 177 day degrees after planting) (Figure 2). The end of the critical period for weed control was strongly influenced by weed type and density, rising from 365 day degrees post-planting in the clean field, to 798 day degrees in the dirty field.

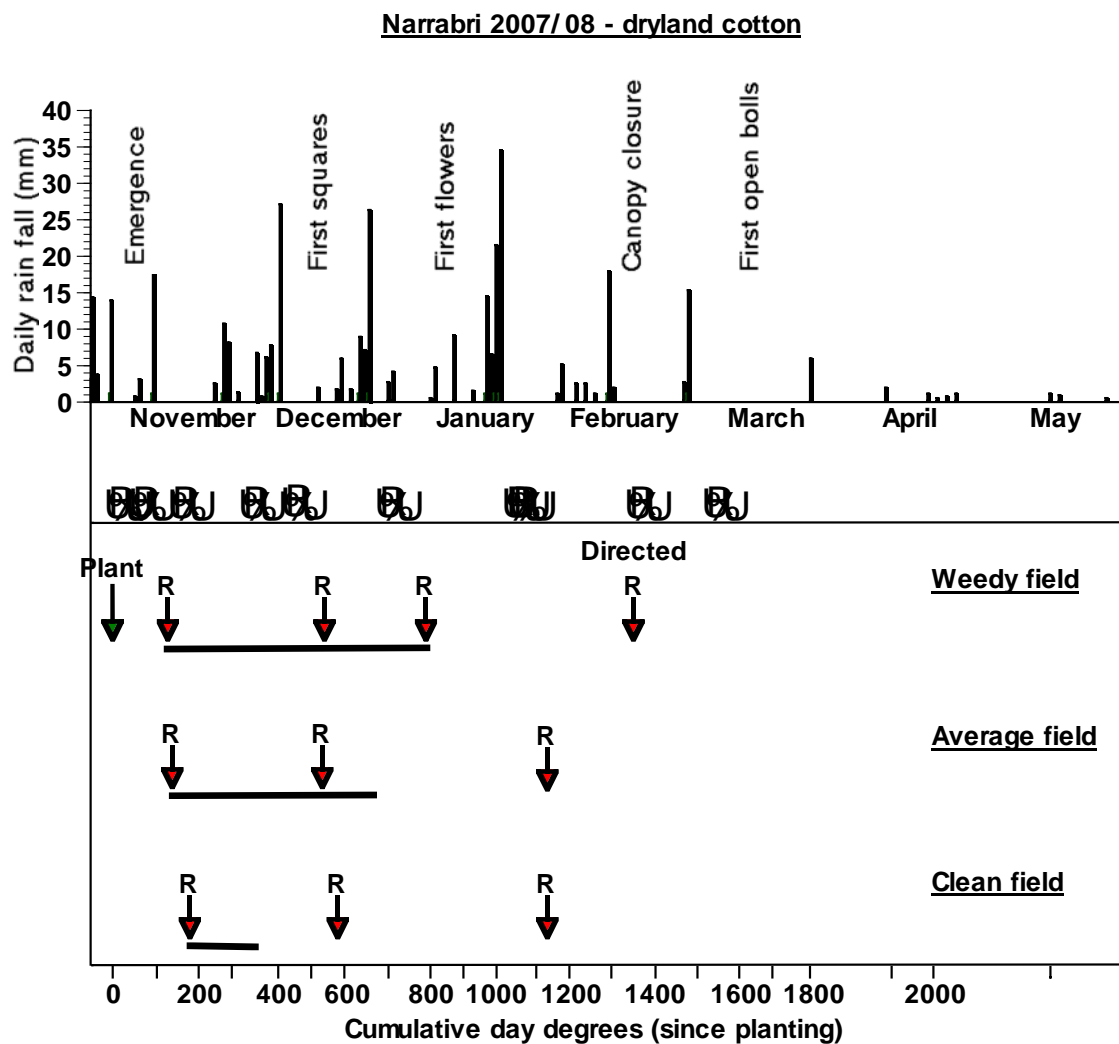


Figure 2. Using the critical period for weed control in dryland cotton in the 2007-8 season at Narrabri for weedy, average and clean fields. Symbols are: (middle section) periods of peak weed emergence, **Culti**; and (bottom section) the critical period for weed control, **horizontal lines**; and planting and weed control inputs, **arrows**. Symbols used on arrows are: planting, **Plant**; Roundup sprays, **R**; inter-row cultivation passes, **Culti**; and application and incorporation of a residual herbicide, **Layby**.

A 2nd Roundup application was required on the average and weedy fields in early-December to control a flush of weeds after rain in late-November. An application may have also been used on the clean field to manage weeds before they set seed.

Lower than maximum label rates would have been suitable for those Roundup applications applied to young weeds, as these weeds are more easily controlled. Rates of 0.8 to 1 kg/ha would give excellent control of susceptible weed seedlings, reducing cost and maintaining late-season options.

No further weed control in the critical period was required on the clean and average fields, but a Roundup may have been used in late-January, again to control weeds before they set seed. A Roundup was required at the start of January on the weedy field.

An alternative treatment, such as a cultivation and light chipping, may have been used to remove surviving weeds after the Roundup applications in mid-December, as required by the Roundup Ready Flex Crop Management Plan. The need for this input is determined by the in-crop survey of weed survivors.

OBSERVATIONS FROM THE 2007/8 SEASON

Using the critical period for weed control approach in this season didn't encounter any difficulties for either irrigated or dryland cotton production and would have closely mirrored the inputs made by good managers. Weeds could have been controlled using Roundup Ready Herbicide within the restrictions of the label.

The main difference for crop management with this approach is that weed control is focussed on the critical period, soon after crop emergence, with all inputs during this period occurring on very small weeds. This contrasts with a more common philosophy, that glyphosate applications to Roundup Ready Flex crops can be delayed to maximise the efficiency of each spray, minimising the number of sprays and ensuring that the maximum number of weeds are controlled with each input. Many cotton growers have concluded that since they are no longer constrained to the 4-node over-the-top glyphosate application window, glyphosate applications can be delayed to about 6 nodes, with a 2nd application at 10 to 12 nodes giving good weed control. While this approach appears to be valid, the science of the critical period has shown that the first glyphosate application may need to occur soon after crop emergence, with further applications following closely after successive weed germination events. This strategy of controlling very small weeds may require more Roundup applications, but can utilize lower herbicide rates and maintains the potential for higher crop yields.

The critical period for weed control approach was successfully applied in both irrigated and dryland cotton in the 2007/9 season. Applying Roundup Ready Herbicide to small weeds soon after emergence maximized herbicide efficacy and crop yields but didn't result in the maximum number of Roundup applications being used too early in the season.

In seasons where the early season weed pressure is excessive (possibly requiring more Roundup applications than are permitted by the product label), an alternative herbicide or early layby application of residual herbicide could 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 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 be applied later in the season as a standard layby application if necessary.

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. The core principle of this plan is to ensure crops are checked after a Roundup application and any surviving weeds are controlled using an alternative weed management tool before they 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.

More information on herbicide resistance and strategies for managing resistance are covered in papers by Charles, and Werth & Thornby in these proceedings.

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.
- Including alternative weed management tools in the system, such as inter-row cultivation, can reduce the pressure on Roundup applications.
- Including a directed layby residual herbicide, incorporated with inter-row cultivation, in the system can assist with the management of later emerging weeds and reduce the risk of species shift and herbicide resistance.
- If seasonal conditions lead to excessive early season weed pressure, an early layby herbicide application may be a valuable investment for reducing the pressure on glyphosate.
- Fields with significant populations of glyphosate tolerant or hard-to-control weeds should always be treated with residual herbicides before or at planting.
- 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.