

CONTROLLING VOLUNTEER COTTON

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Introduction

The control of unwanted cotton in the farming system is an important component of rotational flexibility and management and an essential component in farm hygiene. Three types of cotton are often required to be controlled:

- seedling volunteer cotton,
- established cotton, and
- regrowth or 'ratoon' cotton.

Controlling volunteer cotton on all areas of cotton farms and roadsides is highly desirable as they are, in effect, a weed. Seedling volunteers are often scattered across furrows and plant lines within fields, and rarely yield as well as newly planted seed due to seedling disease and early emergence in cool conditions. All three types of volunteers can also be found in channels and along roadsides creating a farm hygiene problem, especially around module pads, although less so with round bales. They create problems for resistance management of Bt cotton, reduce seed purity and can act as early host plants for pests such as spider mites and aphids. In addition, susceptible varieties can interfere with disease management strategies.

The use of cotton varieties including the Roundup Ready Flex[®] trait also eliminates the use of glyphosate as a herbicide for managing the volunteers with this gene. The control of seedling volunteer cotton also provides an opportunity to rotate herbicide chemistry modes of action or to use cultivation, which are both important components of an integrated weed management program.



Volunteer cotton plants with the Roundup Ready Flex[®] trait can be highly problematic where glyphosate is used as the primary method of weed control.

Controlling Seedling Cotton

Volunteer cotton plants are plants that have germinated, emerged and established unintentionally. Volunteers normally come from seed cotton (lint + seed) but can also establish directly from fuzzy seed (ginned seed) or planting seed (delinted seed). The source of the seed cotton on cotton fields is mainly from previous cotton crops in which the seed cotton has fallen from the plant to the ground and from around module pads where seed cotton is lost during the picking process. Seed cotton is also distributed over cotton farms and surrounding roadsides at picking when large volumes of harvested cotton are transported to cotton gins and seed cotton is lost during the transport process.

Volunteers established from fuzzy seed are usually the result of seed escapes during the transportation of fuzzy seed from gins to end point use. These destinations include crushing plants and stock feeding points.

It is also common that planting seed can be spilt accidentally in transportation on-route to, or within fields, creating a ready source of volunteers.

Cultivation and herbicides are the two most common methods of controlling volunteer cotton seedlings. Both require the cotton seedlings to have germinated and emerged before control can occur. This is particularly important if the volunteer seedlings being controlled have the Roundup Ready Flex[®] gene and the following crop is cotton. Glyphosate will not control these seedlings and an alternative herbicide option must be used. Cultivation will remove the in-furrow volunteers but miss the volunteers situated in the plant line. Rainfall or pre-irrigation is required to germinate these volunteer plants prior to planting, after which effective control can be attempted.

Pre-irrigating cotton should be the option of choice on back-to-back fields where volunteers are likely to be a problem. This is especially true following a dry period, when much of the fallen seed is still likely to be viable. Pre-irrigation will germinate the bulk of the volunteer seed, allowing a herbicide to be used to control these volunteers prior to planting the crop.



Cultivation

Broadacre cultivation readily controls seedling cotton volunteers in most soil conditions, as the root systems and hypocotyls of seedlings are easily destroyed by the cultivation process. Any damage that occurs below the cotyledons kills the seedlings, as there are no growing points from which the plants can recover. Effective cultivation only occurs if the cultivation implement cultivates both the furrow and hill, avoiding leaving uncultivated strips.

Cultivation will also manage other weeds besides volunteer cotton seedlings. This non-herbicide method of weed control is an essential part of an Integrated Weed Management system (refer to the [Integrated Weed Management \(IWM\) Guidelines](#) in section B3 of [WEEDpak](#)). The disadvantage of cultivation is that it only controls established seedlings, is slow, and can cause moisture loss or soil damage if conducted at the wrong time (refer to [SOILpak](#) for more information about the potential for soil damage from cultivating wet soil).

In addition, volunteers mainly establish in periods very close to planting, which is an inappropriate time to be conducting large scale tillage operations. Nevertheless, cultivation is a valuable integrated weed management tool and should always be considered as an option for controlling difficult weeds such as volunteer cotton.



Broadacre cultivation is an effective tool for controlling volunteer cotton seedlings and larger plants.

Established Roundup Ready Flex[®] cotton volunteers on a farm road. These plants have grown from seed cotton lost during picking

Herbicides for seedling cotton

The broad spectrum herbicide glyphosate has often been used extensively to control volunteer cotton seedlings. Control has either been deliberate or inadvertent when targeting other weeds prior to cotton planting, as a fallow spray, or within crop as a shielded spray. Glyphosate rates of 1.2 L/ha (450 g/L) will control seedling cotton at the 1st and 2nd true leaf stage.

However, the widespread adoption of cotton varieties including the Roundup Ready Flex[®] trait, which are genetically modified to tolerate glyphosate, eliminates the use of this herbicide as a control tool for managing these seedlings.

As a result, alternative herbicides that control the volunteers but do not have residual affects to subsequent crops, including cotton, need to be utilised. Table 1. provides a list of herbicides registered for controlling cotton seedlings.



Cotton seedlings with the Roundup Ready Flex[®] trait readily establish anywhere glyphosate is used as the primary method of weed control.

Table 1. A guide to the herbicides registered for controlling volunteer cotton plants, including Roundup Ready Flex[®] volunteers. Some products may be available under other product names.

Product	Active ingredient	Mode of action group	Applied rate per ha	Plant growth stage	Situation	Plant back to cotton
Alliance [®]	amitrole 250 g/L + paraquat 125 g/L	L + Q	2-4 L	≤ 6 – 8 leaf	Fallow	Nil
Amitrole T	amitrole 250 g/L + ammonium thiocyanate 220 g/L	Q	4.3-5.6 L	Cotyledon - 8 leaf	Fallow	Nil
Broadstrike [®]	flumetsulam 800 g/kg	B	50 g	Pre-emergence	Pigeon peas	9 months
bromoxynil [#]	bromoxynil 200 g/L	C	1-1.5 L	Cotyledon - 6 leaf	Fallow & non-crop	Nil
Hammer [®]	carfentrazone 240 g/L	G	50-75* ml 75-100* ml	2 – 6 leaf	Fallow	Nil
Liberty [®] /Basta [®]	glufosinate-ammonium	N	3.75 L	2 – 6 leaf [^]	Fallow	14 days
metribuzin [#]	metribuzin 750 g/kg	C	470 g	Seedling stage	Pigeon peas [¤]	12 months
paraquat + diquat [#]	paraquat 135 g/L+ diquat 115 g/L	L	1.6-2.4 L 2.4-3.2 L	1 – 4 leaf 5 – 9 leaf	Fallow	Nil
Sharpen [®]	safinylfenacil 700 g/kg	G	9g 17g 26g	< 2 leaf < 4 leaf < 26 leaf	Fallow	42 days
fluroxypyr [#]	fluroxypyr 333 g/L	I	450 ml 600 ml	2 – 6 leaf 5 – 7 leaf	Fallow	14 days 28 days
Valor [®]	flumioxazin 500 g/kg	G	45 g	≤ 4 leaf	Fallow	Nil

[#] Sold under various trade names.

^{*}Rate for varieties not including the Roundup Ready Flex trait when added to the recommended rate of glyphosate.

^{*} Rate for varieties including the Roundup Ready Flex trait.

[^] Will not control cotton volunteers with the Liberty Link[®] trait.

[¤] Only on some metribuzin labels, so check the product label for details.

Other herbicides with activity on seedling cotton

While a pre-planting spray may be applied to control emerging cotton seedlings, it is also common to apply a fallow spray to control a wide range of weeds that may include cotton seedlings. Consequently, a range of herbicides were screened for efficacy against seedling volunteers at 4 and 8 nodes of growth (Table 2). These herbicides were selected on their likely efficacy of controlling seedling cotton with minimal residual carryover to either cotton or rotation crops. Glyphosate and mixtures that utilised glyphosate as the main active ingredient were excluded from testing so that results could be inferred for Roundup Ready Flex[®] volunteers, as well as conventional and Liberty Link[®] volunteers (with the exception of Basta[®], which is ineffective on Liberty Link volunteers).

The results indicate that Spray.Seed[®], Hammer[®] and bromoxynil would be most effective in controlling seedling cotton (including Roundup Ready Flex[®] volunteers) at both 4 and 8 leaf growth stages.

Surpass[™], Basta[®], Starane[®] and MCPA amine are also good options but are likely to be less reliable, giving good to very good control at Narrabri but poorer control at St George. In addition (excluding Basta), there are spray management considerations with these herbicides, including drift and plant-back times to cotton (refer to [Managing Weeds in Cotton](#), section B2 of [WEEDpak](#)).

Both Spray.Seed and Hammer are contact herbicides, with no residual carryover and their use patterns have been designed as pre-emergent knockdowns. The active components of Spray.Seed (paraquat and diquat) are from the bipyridyl group of herbicides (Group L), which inhibit photosynthesis at photosystem I. Hammer (carfentrazone) is a member of the aryl triazolinone group (Group G), which inhibits protoporphyrinogen oxidase. Both herbicides differ in modes of action to glyphosate, which inhibits EPSP synthase (group M) and these differences are important, as it allows these herbicides to control glyphosate tolerant cotton and also control weeds using a different herbicide mode of action.

Rotating herbicide chemistry (modes of action) is an important component of preventing herbicide resistance. Hammer can also be mixed with glyphosate or Spray.Seed, improving the weed spectrum it controls. In theory, a mixture of Hammer (at an adequate rate) and glyphosate would control Roundup Ready Flex seedling volunteers, as well as the usual weeds glyphosate is effective on.

Excellent spray coverage is essential for adequate control with all contact herbicides. This generally means high water volumes are required to get the best out of the herbicides (e.g. 100L/ha).

Table 2. Effect of herbicides on seedling cotton at St George (4 true leaves) and Narrabri (8 true leaves) in 2001-02.

Herbicide	Rate/ha (kg or L)	Percentage Control#	
		St George 4 true leaves	Narrabri 8 true leaves
Unsprayed	-	0	0
Buctril 200 (200 g/L)	4	100	100
Hammer 240 EC (240 g/L)	0.15	100	100
Spray.Seed 250 (135 + 115 g/L)	2	100	100
Basta (200 g/l)	3	92	96
Surpass (300 g/L)	2	0	95
Starane 200 (200 g/L)	1	25	95
MCPA 500 (500 g/L)	2	30	88
Gesagard 500 SC (500 g/L)	3	19	10
Goal CT (240 g/L)	0.25	15	0
Banvel 200 (200 g/L)	1.4	2	0
Lontrel (300 g/L)	0.15	0	0
Diuron DF (800 g/kg)	1.9	0	0
Nu-Tron 900 DF (900 g/kg)	1.9	0	0
Garlon (600 g/L)	0.15	0	0

Plants were still considered alive if they had green foliage or stems and if they regrew at any stage.

Using the double-knock strategy to control cotton seedlings

The double-knock strategy, of applying a herbicide at full rate and then a 2nd herbicide again at full rate around 7 to 14 days after the first herbicide has become a well accepted way to control some of the more difficult weeds. The value of this approach for controlling larger cotton seedlings was tested with 9 day and 28 day respray intervals, as shown in Table 3.

The results for all herbicides were disappointing, with the double-knock approach making little difference. Allowing the plants to regrow some green leaf after the first application did not improve the control (the double knock at 28 days).

These poor results emphasise the need to control cotton seedlings while they are small, ideally at 2 - 4 nodes. These small seedlings can be readily controlled with a range of herbicides, but larger seedlings are difficult to control, even with a double-knock strategy.



A double-knock of Spray.Seed, applied 9 days apart, gave good control of most cotton seedlings, but there was some subsequent regrowth.

Table 3. Exploring the value of the double-knock strategy for controlling volunteer cotton seedlings.

Herbicide	Applied at	Percentage Kill#				
		7 DAS	23 DAS	37 DAS	59 DAS	133 DAS
Unsprayed	-	0	0	0	0	0
Basta (200 g/l) 3.75 L/ha	Day 0	61	8	10	0	10
	Days 0 & 9	80	60	50	27	43
	Days 0 & 28	75	8	0	0	0
Bromicide 200 (200 g/L) 1.5 L/ha	Day 0	25	1	11	0	15
	Days 0 & 9	30	3	10	0	0
	Days 0 & 28	30	0	0	0	23
Hammer 240 EC (240 g/L) 60 ml/ha	Day 0	35	0	9	0	25
	Days 0 & 9	40	0	18	0	0
	Days 0 & 28	40	0	24	0	0
Spray.Seed 250 (135 + 115 g/L) 3.2 L/ha	Day 0	68	46	64	61	74
	Days 0 & 9	100	84	86	67	81
	Days 0 & 28	100	76	90	52	72

Plants were still considered alive if they had green foliage or stems and if they regrew at any stage. Some plants that initially appeared to be dead later regrew.

Controlling established cotton

Occasionally, cotton plants become well established before there is opportunity to control them due to unforeseen circumstances such as:

- Adverse weather,
- Hail,
- Poor plant establishment,
- Major insect problems,
- Unmanageable weeds,
- Disease problems, or
- Changing economics.

When these situations occur, the cotton grower may wish to abandon the field and replant with an alternative summer crop or a winter crop. Conventional mechanical methods of destroying the cotton would involve mulching, root cutting and cultivation. These methods are very effective at controlling established cotton, but, in some circumstances the use of cultivation is undesirable. Examples of this could include dryland crops that need to be controlled without cultivation due to the increased risk of soil erosion and the need to conserve moisture. Herbicide control may be an option provided the *Helicoverpa* pupae have not started diapausing under the crop.

Herbicides for controlling established cotton

Established cotton is very difficult to control with herbicides alone, although the large leaf area does provide an opportunity to attain good coverage of the herbicide. Table 4 provides a list of herbicides that were screened for the control of established cotton. These herbicides were initially applied as a 100% over-the-top band. This initial application did not appear to work due to poor spray coverage and penetration, with only the tops of the plants being affected. A second application was made using side directed spray nozzles on droppers and one nozzle over the top.

The results suggest that Starane® and a glyphosate + 2,4-D amine mixture (Surpass™) can provide some control of established cotton. The glyphosate + 2, 4-D amine mix is also very effective at controlling a large range of broadleaf and grass weeds at the same time.

However, none of these options is registered for this use. It is important to remember with 2,4-D amine that up to 28 days is required before replanting some crops and 15mm of rain is required in dry soils before the commencement of this plant back period. Starane® has a plant back period of 7-28 days depending on the crop. Alos, as with all Group I herbicides, the risk of spray drift onto susceptible crops is a major hazard to be avoided and thorough decontamination of all spray equipment is critical.

Table 4. Percentage of dead cotton plants after applying two applications of herbicide. Note that the Roundup treatments would have been ineffective on cotton varieties with the Roundup Ready Flex trait.

Herbicide treatments	% Dead cotton plants
Starane® (4L/ha)	100
Roundup CT Xtra (2L/ha) + Surpass™ (4 L/ha)	94
Roundup CT Xtra (2L/ha) + Surpass™ (2 L/ha)	80
Roundup CT Xtra (2L/ha) + Glean (25g/ha) + BS1000# (200ml/ha)	22

A non-ionic surfactant.

Using the double-knock strategy to control cotton plants

The herbicides used in Table 3 were also used in double-knock treatments to cotton at 16 and 24 nodes (Tables 5 & 6), with some extra treatments added for Spray.Seed at 24 nodes.

Basta, Bromicide 200 and Hammer gave poor control of these much larger cotton plants, as might be expected, as the plants were far larger than the size specified on the product labels.

A single application of Spray.Seed was also ineffective for controlling cotton plants, and the double-knock was equally ineffective when the applications were less than 7 days apart.

However, Spray.Seed gave surprisingly good control with the double-knock at 30 days apart for 16 node cotton, and 7 days apart for 24 node cotton. Part of the reason for the good results was the very large leaf area of the plants at this age, allowing a large quantity of herbicide to affect the plants. Interestingly, applying Spray.Seed twice on the same day gave as good a result as the best double-knock.

Defoliating cotton plants

In some situations, using a double-knock application of a paraquat/diquat mix, such as Spray.Seed, to defoliate volunteer cotton plants may be a useful strategy, killing some plants, but also buying time. Applying Spray.Seed to cotton plants will defoliate the plants, burning off most or all the leaves, setting plant growth back by many weeks. This will greatly reduce the growth rate of the plants, greatly reduce the moisture use of the plants, and greatly reduce their fruit production, reducing the potential for new seeds and problems further down the track. If plants already have green bolls, it is likely that the herbicides will sterilize the seed in the bolls.

These plants can then be removed by cultivation at a later date before they resume normal growth.



A double-knock of Spray.Seed, applied 7 days apart gave excellent control of large, 24 node, cotton plants.



Many plants regrow 34 days after a double-knock of Spray.Seed 21 days apart, but the herbicide effectively set the plants back by at least 6 weeks, allowing time for an alternative option to be used at a later date.

Table 5. Exploring the value of the double-knock strategy for controlling established cotton plants at 16 nodes of growth.

Herbicide	Applied at	Percentage Kill [#]		
		7 DAS	23 DAS	37 DAS
Unsprayed	-	1	0	9
Basta (200 g/l) 3.75 L/ha	Day 0	0	0	4
	Days 0 & 9	0	3	6
	Days 0 & 30	5	3	18
Bromicide 200 (200 g/L) 1.5 L/ha	Day 0	0	0	9
	Days 0 & 9	0	0	8
	Days 0 & 30	0	0	23
Hammer 240 EC (240 g/L) 60 ml/ha	Day 0	0	0	6
	Days 0 & 9	0	0	5
	Days 0 & 30	0	0	6
Spray.Seed 250 (135 + 115 g/L) 3.2 L/ha	Day 0	45	0	14
	Days 0 & 9	45	57	36
	Days 0 & 30	48	94	92

Plants were still considered alive if they had green foliage or stems and if they regrew at any stage.

Table 6. Exploring the value of the double-knock strategy for controlling established cotton plants at 24 nodes of growth.

Herbicide	Applied at	Percentage Kill [#]
		76 DAS
Unsprayed	-	9
Basta (200 g/l) 3.75 L/ha	Day 0	8
	Days 0 & 7	15
	Days 0 & 21	16
Bromicide 200 (200 g/L) 1.5 L/ha	Day 0	11
	Days 0 & 7	3
	Days 0 & 21	8
Hammer 240 EC (240 g/L) 60 ml/ha	Day 0	14
	Days 0 & 7	6
	Days 0 & 21	9
Spray.Seed 250 (135 + 115 g/L) 3.2 L/ha	Day 0	31
	Days 0 & 2	21
	Days 0 & 4	23
	Days 0 & 7	95
	Days 0 & 21	70
	Days 0, 2 & 4	90
Day 0 & 0	96	

Plants were still considered alive if they had green foliage or stems and if they regrew at any stage.

Controlling regrowth or 'ratoon' cotton

'Ratoon' cotton is cotton that has regrown from the root stock from a previous season. The control of ratoon cotton is important for the management of insects and diseases, as both can be harboured over winter by the ratoon cotton, allowing an easy method of infection for future crops. The pathogens that cause the diseases black root rot, verticillium wilt, alternaria leaf spot, fusarium wilt and bunchy top are all capable of transferring easily from one season to the next via ratoon cotton. In addition ratoon plants can act as hosts for aphids, spider mites, whitefly and early food for *Helicoverpa*.

In theory, ratoon cotton should not occur due to the requirement of harvested cotton to be controlled with adequate cultivation and soil disturbance as soon as practical after picking. This usually involves some sort of mulching and/or root cutting, followed by cultivation to destroy the cotton root system. In conducting this cultivation, an additional aim is to destroy over-wintering *helicoverpa* pupae. This pupae control is a frontline strategy in managing insecticide resistance for the cotton industry and is mandatory if growing cotton varieties with the Bollgard® technology (refer to **ENTOpak** and **MACHINEpak** for information on pupae busting).

However, in some seasons, fields may become flooded soon after picking or adverse weather may make cultivation undesirable. In these scenarios, the use of a herbicide would seem appropriate to manage cotton immediately after picking. Unfortunately, due to the large root system on ratoon cotton and relatively small leaf areas, no herbicides are likely to give effective control and no herbicides registered for this purpose.

A limited range of herbicides were evaluated for the control of ratoon cotton (Table 7), but none were effective. A double-knock application may have been more successful, but it is clear that ratoon cotton is extremely difficult to control with herbicides alone due to the small leaf area available for herbicide absorption compared to the large root system available for carbon and nutrient supply that enables the plant to continue growing.



Mulching harvested cotton.



Root cutting prior to cultivation to stop cotton ratooning.



Ratoon cotton is a problem wherever it occurs. This ratoon will need to be controlled with cultivation and hand hoeing.

Table 7. The effect of selected herbicides on ratoon cotton. Herbicides were applied 25 days before the first irrigation. The first assessment occurred 10 days before irrigation and second assessment 20 days after.

Herbicide	1 st assessment % regrowth	2 nd assessment % regrowth
Unsprayed	80%	95%
Roundup CT Xtra 4.6 L/ha	47%	93%
Basta 5 L/ha	53%	92%
Starane 2 L/ha	7%	91%
Starane 4 L/ha	5%	92%
Bromoxynil 3 L/ha	37%	93%
Prometryn 6 L/ha + DC trate 2 L/ha	47%	94%

Summary

Volunteer cotton is problematic wherever it occurs, causing a variety of problems including harbouring pests and diseases.

Cultivation is an effective and efficient method of controlling all types of volunteer cotton, seedling, established and ratoon but is not always a practical solution.

A range of herbicides is registered for controlling seedling cotton and these herbicides are generally most effective on small seedlings.

Larger plants are very difficult to control with herbicides and no herbicides are registered for controlling plants larger than 9 nodes in size.

Ratoon cotton needs to be controlled with mechanical methods, as no herbicides are effective for these plants.