



**Industry &
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<http://www.dpi.nsw.gov.au/agriculture/field/field-crops/fibres/cotton/cotton-pest-management-guide>

Integrated Weed Management (IWM) for Australian cotton

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WHAT IS IWM?

Integrated Weed Management (IWM) is the development and implementation of a plan that is made up of a range of weed management tactics. IWM aims to manage today's weed problems in a manner that reduces the potential for weed problems in the future. The main principle underlying IWM is preventing weeds from setting seed by:

- knowing the weed spectrum and considering the interaction between weeds and the farming system (plan).
- regularly examining the weed problem and the success or failure of recent practices (monitor).
- assessing the weed management system and developing economic and sustainable solutions (evaluation).
- implementing alternative management strategies to deal with any problems (response).

An IWM program uses a range of methods of weed control in combination (Figure 7), so that ALL weeds are controlled by at least one tactic in the

weed management system. In short, IWM is about NOT relying on only one or two methods of weed control alone, and in particular it does not involve relying only on herbicides.

When developing an IWM program, think strategically about how you can best utilise all available weed control methods in cotton, in rotation crops and in fallows to give the best overall result. A short term approach to weed management may reduce costs for the immediate crop or fallow, but may not be cost effective over a five or ten year cropping plan. Over this duration, problems with species shift and the development of herbicide resistant weed populations are likely to occur where weed control has not been part of an integrated plan. Herbicide resistant weed populations are increasingly common in NSW and Queensland.

WHY USE IWM IN COTTON SYSTEMS?

Effectively managing weeds using an integrated program for the entirety of the cropping rotation will reduce:

- the rate of shift in the weed spectrum towards more herbicide tolerant weeds.
- the risk of selecting herbicide resistant weeds and so prolong the useful life of each herbicide.

Figure 7. An integrated weed management system relies on a large number of interrelated, complementary components. All inputs into the system are important.



- the risk of herbicides accumulating in the soil and riverine systems.
- future weed control costs by reducing the number of weed seeds in the soil seed bank.
- the competitiveness of weeds and improve crop productivity each year.

Although all of these outcomes are important, reducing the risk of selecting herbicide resistant weeds is critical. This threat to cotton production has already had a major deleterious impact on many other cropping systems in Australia and elsewhere.

Throughout the world 185 weed species have developed resistance to different herbicides. Thirty-six weeds have developed resistance to herbicides in Australia. In northern NSW populations of 3 common grass weeds – awnless barnyard grass, liverseed grass and annual ryegrass – have resistance to glyphosate. Weeds with resistance to multiple herbicides is also occurring more frequently. The following tactics should be used to develop an integrated weed management strategy for your farm to help prevent the development of herbicide resistance.

IWM TACTICS IN COTTON

Know your weeds

Correct weed identification

Ensure that weeds are correctly identified before deciding upon a response. Similar species may respond differently to control measures. For example the strong seed dormancy mechanisms of cowvine (*Ipomoea lonchophylla*) make it less responsive to a tactic like the spring tickle than bellvine (*Ipomoea plebeia*) which has very little seed dormancy. Herbicide susceptibility can also differ between similar species. Yellow vine (*Tribulus micrococcus*) can be controlled by Staple® while caltrop (*Tribulus terrestris*) is naturally tolerant.

The *Weed Identification and Information Guide* on the Cotton CRC website is a powerful tool to assist weed identification. Unknown weeds can be identified by scrolling through the collections of pictures and the supporting text. The picture collections include seedling, flowering and mature growth stages as well as close up images of seeds for over 80 of the weeds that commonly occur in cotton. Additional weeds and more detailed biology and ecology information are added to the collections as material becomes available.

Scouting

Scouting fields before weed control is implemented enables the weed control option to be matched to the species present. Soon after a control is implemented scouting should be repeated to assess efficacy. Weed

audits are a requirement of growing Liberty Link®, Roundup Ready Flex® and Roundup Ready® cottons. See pages 103 and 106 for details. These auditing techniques can also be used to scout weeds in conventional cotton and rotation crops.

Timely scouting allows questions that affect the next weed control decision to be answered;

- Were the weeds damaged but have recovered?
- Has control been better in some parts of the field than others?
- Has there been good control but a subsequent germination?

For IWM strategies to be effective in preventing resistance, weeds that survive a herbicide must be controlled by another method before they are able to set seed. Weeds may need to be closely examined, as some are capable of setting seed while very small.

Identify and closely monitor areas where machinery such as pickers and headers breakdown. Weeds seeds are often inadvertently released when panels are removed from machines for repairs.

Weed scouting in non-crop areas of the farm is a valuable source of information for planning future weed management strategies. Non-cropping areas, such as roadways, channels, irrigation storages and degraded remnant vegetation can be a source of reinfestation and can provide opportunities for newly introduced weeds to build up significant seed banks. These can be moved into fields via water, wind and animals. Weed managers should always be on the lookout for new weeds.

Field records

For all fields, maintain records of weed control methods and their effectiveness after every operation. Consider the records from past years in this year's decisions, particularly in relation to rotating herbicide modes of action. Avoid relying too heavily on herbicides with the same mode of action. Repetitive use of the same mode of action group over time is closely associated with the evolution of herbicide resistance within weed populations.

The spring tickle

The spring tickle uses shallow cultivation in combination with a non-selective, knockdown herbicide. The aim of the spring tickle is to promote early and uniform germination of weeds prior to sowing to ease weed pressure in-crop. Some weed species are more responsive to the spring tickle than others. Highly responsive weeds include bellvine and annual grasses – liverseed grass and the barnyard grasses. Weeds that are less responsive include; cowvine, thornapple, noogoora burr and bathurst burr.

The shallow cultivation (1–3 cm) can be performed using implements such as, lillistons or go-devils. Best results are achieved when the cultivation follows a rainfall event of ≥ 20 mm. Adequate soil moisture is needed to ensure that weed germination immediately follows the cultivation. Where moisture is marginal, staggered germination may result in greater weed competition during crop establishment.

A number of non-selective, knockdown herbicides can be used to control the germinating weeds while they are young and actively growing. Glyphosate (Group M), Spray.Seed® and Gramoxone® (Group L), Pledge® and Hammer® (Group G), as well as some combinations of these herbicides can be used. Where cotton with Roundup Ready® technology is to be planted this is an excellent opportunity to rotate herbicide mode of action by using the Group L or Group G products at this time. These alternate mode of action products can also be used to control herbicide tolerant cotton volunteers. Depending on the weed spectrum, more selective products from other modes of action may be used. Refer to Table 24 page 110. For additional information regarding the plant back restrictions of these products for cotton, refer to Tables 19, 20 and 22 on pages 97 and 98.

The double-knock

The double-knock technique is a fallow weed control tactic that is being used widely in the southern states to manage hard to control weeds such as herbicide resistant annual ryegrass. When executed well (right rates, right timing, right application) the double-knock tactic will provide 100% control. In cotton systems there are several ways the technique can be applied to improve control of weeds such as flaxleaf fleabane and simultaneously reduce the risk of resistance developing in other key weed species such as liverseed grass and awnless barnyard grass.

Originally the technique was developed to maximise weed control at planting by using Spray.Seed® or Roundup CT® followed by the sowing operation. This has application at cotton planting time for effective management of volunteers.

More recently the double-knock has come to be the use of two herbicides. When using two herbicides, the basis of the double-knock is to apply a systemic herbicide, allow sufficient time for it to be fully translocated through the weeds, then return and apply a contact herbicide, **from a different mode of action group**, that will rapidly desiccate all of the above ground material, leaving the systemic product to completely kill the root system. Most commonly glyphosate is followed with a Group L product. The optimum time between the treatments is dependent on the weed targets. Small, rapidly growing grasses

Performance of double-knock strategies on flaxleaf fleabane, 6–10 leaf (7–8 cm wide)

Initial Treatment	Days	Follow-up Treatment	% Control*
Roundup CT® 2 L/ha		nil	55
Roundup CT® 2 L/ha	7	Spray.Seed® 1.6 L/ha	96
Roundup CT® 2 L/ha	14	Spray.Seed® 1.6 L/ha	96
Roundup CT® 2 L/ha	21	Spray.Seed® 1.6 L/ha	88
Roundup CT® 2 L/ha Surpass® 1.5 L/ha	7	Spray.Seed® 1.6 L/ha	100
Roundup CT® 2 L/ha Surpass® 1.5 L/ha	14	Spray.Seed® 1.6 L/ha	100
Roundup CT® 2 L/ha Surpass® 1.5 L/ha	21	Spray.Seed® 1.6 L/ha	96
Roundup CT® 2 L/ha Surpass® 1.5 L/ha	7	Spray.Seed® 2.4 L/ha	100
Roundup CT® 2 L/ha Surpass® 1.5 L/ha	14	Spray.Seed® 2.4 L/ha	100
Roundup CT® 2 L/ha Surpass® 1.5 L/ha	21	Spray.Seed® 2.4 L/ha	100

Source: Jeff Werth, DEEDI. These results are from a single trial conducted on the Darling Downs in October 2006.

* Control measured 28 days after the initial treatment was applied.

respond best when the second application occurs 3–5 days after the first. When slightly larger fleabane is the target, separate the applications by 7–10 days. Examples of double-knock treatments and their efficacy on flaxleaf fleabane compared to a standard fallow application of glyphosate are shown above.

Encourage insect predation

Insect predation can contribute significantly to natural mortality in the weed seed bank. Seed theft by ants commonly causes failure of pasture establishment, so it is feasible that weed seed banks can be decreased by encouraging ants. A study in the WA wheatbelt showed ant predation reduced annual ryegrass seed by 81% and wild radish seed by 46% over a 3 month period. Reductions were greatest in situations close to refuge areas such as fencelines and remnant vegetation. For further information, refer to the Weed CRC publication, *Integrated Weed Management in Australian Cropping Systems*. In central Queensland ant abundance in remnant vegetation has been shown to be favoured by vegetation diversity and the presence of leaf litter and fallen logs. Remnant areas need not be large to support rich diversity and abundance of ants.

Ants are affected by many of the insecticides registered for use in cotton. When possible, avoid using products with a high or very high impact on ants. Refer to Table 3 *Impact of insecticides and miticides on predators, parasitoids and bees in cotton*, page 40–41, for insecticide ratings.

In Bollgard II® cotton and unsprayed refuges feeding by the *Datura* leaf beetle, *Lema trivittata*, can prevent thornapples from setting seed.

Herbicide tolerant GM cotton varieties

Herbicide tolerant cottons allow the use of non-selective herbicides for summer weed control in-crop. Incorporating this tactic into the IWM strategy allows for more responsive, flexible weed management. Weeds need only be controlled if and when germinations occur meaning herbicide application can be timed to have maximum impact on weed populations. In relatively clean fields the reliance on residual herbicides for in-crop management is reduced. In fields known to have heavy weed burdens, using the non-selective together with residual herbicides can achieve very high levels of control. Avoid using the same herbicide to control successive generations of weeds.

Prevent weed establishment

Where cotton is grown in rotation with crops such as winter cereals or maize, retain stubble cover from these rotation crops for as long as possible. Stubble cover reduces weed establishment and encourages more rapid breakdown of weed seed on the soil surface.

Use field history records to match residual herbicides to the likely weed problems in the field. Applying residual herbicides in combination with other in-crop measures reduces the selection pressure for resistance on post emergent herbicides.

Protect yield potential

After planting, time weed control measures based on the critical periods for weed control to prevent yield loss. Young cotton is not a strong competitor with weeds. The critical times when weed competition can cause yield loss are provided in the Guide on this page for a range of weed densities and weed types. Irrespective of the type of weeds, early season control is critical to prevent yield loss. The higher the weed population, the longer into the season weed control is required. Preventing yield loss as well as preventing weed seed set ensures there is an economic return from weed control both today and in the future.

Control survivors and late germinations

Use a range of selective controls – inter-row cultivation, lay-by herbicide, chipping and spot spraying – to prevent seed set in weeds that survived early season tactics or have germinated late.

For a range of reasons, situations will occur when some weeds escape control by herbicides.

Guide to the critical period for weed control to prevent 2% yield loss.

Weed Type	Weed Density /10 m row	Cotton Growth Stage (day degrees) To prevent yield loss, control weeds			
		From		To	
Large broadleaf weeds such as; noogoora burr, thornapple, volunteer sunflower, sesbania	1	1–2 leaf	(145)	3 leaf	(189)
	2	1–2 leaf	(144)	5–6 leaf	(275)
	5	1–2 leaf	(143)	first square	(447)
	10	1–2 leaf	(141)	squaring	(600)
	20	1–2 leaf	(139)	squaring	(738)
Medium broadleaf weeds such as; bladder ketmia, mintweed, Boggabri weed	40	1–2 leaf	(131)	early flowering	(862)
	1	1–2 leaf	(145)	2–3 leaf	(172)
	2	1–2 leaf	(144)	4–5 leaf	(245)
	5	1–2 leaf	(143)	pre-squaring	(387)
	10	1–2 leaf	(141)	early squaring	(514)
Grass weeds such as; awnless barnyard grass, liverseed grass, Johnson's grass	20	–	–	–	–
	20	1–2 leaf	(139)	squaring	(627)
	40	1–2 leaf	(131)	squaring	(880)
	30	1 leaf	(122)	1–2 leaf	(139)
	40	1 leaf	(122)	2–3 leaf	(174)
80	1 leaf	(122)	4–5 leaf	(248)	
160	1 leaf	(122)	7–8 leaf	(357)	
320	1 leaf	(122)	early squaring	(531)	

Missed strips due to poor operation of equipment, insufficient coverage due to high weed numbers, applying the incorrect rate and interruptions by rainfall are just a few reasons why weeds escape control. If herbicide resistant individuals are present, they will be amongst the survivors. It is critical to the longer term success of the IWM strategy that survivors not be let to set seed.

Inter-row cultivation

Inter-row cultivation can be used mid-summer to prevent successive generation of weeds from being targeted by post-emergent herbicides. Cultivating when the soil is drying out is the most successful strategy for killing weeds and will reduce the soil damage caused by tractor compaction and soil smearing from tillage implements.

Manual chipping

Manual chipping is ideally suited to dealing with low densities of weeds, especially those that occur within the crop row. It is normally used to supplement inter-row cultivation or spraying.

Spot spraying

Spot sprayers may be used as a cheaper alternative to manual chipping for controlling low densities of weeds in crop. Ideally, weeds should be sprayed with a relatively high rate of a herbicide from a different

herbicide group to the herbicides previously used to ensure that all weeds are controlled.

Crop rotations

Rotation crops enhance IWM by;

- introducing herbicide options not available in cotton,
- producing stubble loads that reduce subsequent weed germinations,
- varying the time of year non-selective measures can be used and the time of year that crop competition suppresses weed growth.

Rotation between summer and winter cropping provides opportunities to use cultivation and knockdown herbicides in-fallow at all times of the year. When summer crops such as maize are planted earlier than cotton, there is an opportunity to use crop competition and inter-row cultivation for cotton volunteer control rather than relying on herbicides, as is required when cotton follows cotton.

Bury seed of surface-germinating species

Use strategic cultivation to bury weed seeds and prevent their germination. Some weed species, such as common sowthistle (milk thistle) and flaxleaf fleabane, are only able to germinate from on or near the soil surface (top 20 mm). Time operations such as pupae busting, where full disturbance of the soil is required, to assist in situations where these species have set seed. Burying the seed more than 20 mm below the surface will prevent its germination. This tactic is most successful when used infrequently as seed longevity of common sowthistle and flaxleaf fleabane will be extended from ~12 months to ~30 months.

Practice good farm hygiene

To minimise the entry of new weeds into fields, clean down boots, vehicles, and equipment between fields and between properties. Pickers and headers require special attention. Eradicate any new weeds that appear while they are still in small patches. Monitor patches frequently for new emergences.

Irrigation water can be a source of weed infestation with weed seeds being carried in the water. While it is not practical to filter seeds from the water, growers should be on the look out for weeds that gain entry to fields via irrigation. Give special consideration to water pumped during floods, as this has the greatest potential to carry new seeds. If possible flood water should be first pumped into a storage to allow weed seeds to settle out before being applied to fields. Control weeds that establish on irrigation storages, supply channels and head ditches.

CRITICAL SUCCESS FACTORS IN IWM

Timely implementation of tactics

Often the timeliness of a weed control operation has the largest single impact on its effectiveness. Herbicides are far more effective on rapidly growing small weeds, and may be quite ineffective in controlling large or stressed weeds. Cultivation may be a more cost-effective option to control large or stressed weeds, but additional costs can be avoided through being prepared and implementing controls at the optimum time.

Rotate herbicide groups

All herbicides are classified into groups based on their mode of action in killing weeds. Rotate herbicide groups whenever possible to avoid using the same group on consecutive generations of weeds. When this is unavoidable, use other methods of weed control in combination with the herbicide and ensure no weeds survive to set seed. The cotton industry is very fortunate to have registered herbicides in the majority of the mode of action groups.

Closely follow herbicide label recommendations

Herbicides are a principal component of most IWM strategies so it is important that they are used in the most effective manner possible. When reading the herbicide label check;

- that the rate you are about to use is right for the growth stage of the target weeds.
- whether a wetter or crop oil is required to maximise herbicide performance.
- that the application set up you are about to use is consistent with the label – water volume, droplet spectrums, operating pressure.
- for additional, specific information regarding appropriate weather conditions for spraying.

Herbicide efficacy is highly dependant of the use of correct application techniques. Always consider the suitability of weather conditions. Using higher water volumes and coarse to very coarse droplet spectrums reduce the likelihood of product being lost off target.

Consider other aspects of crop agronomy

Most agronomic decisions for cotton have some impact on weed management. Decisions such as cotton planting time, pre-irrigation versus watering-up, methods of fertiliser application, stubble retention and in-crop irrigation management all have an impact on weed emergence and growth. The influence of these decisions should be considered as part of the IWM program. For example, modify the timing and method of applying pre-plant N to achieve a 'spring tickle' in the same operation.

Table 19. Herbicide plant backs from rotation crops to cotton

Trade name	Herbicide active ingredient	Registered for use in;	Plant back to cotton	Notes
Hotshot	aminopyralid + fluroxypyr	Cereal Crops: wheat, baley, oats, triticale Fallows	9 months	When rates up to 750 ml/ha are used. If is less than 100 mm in over a 4 month period, the plant back period may be significantly longer.
atrazine	atrazine	Cereal Crops: broom millet, maize, sorghum	6 months	Where the maximum use of atrazine + smazine is 4 L/ha (500 g/L) on soils with pH ≤6.5.
		Legume Crops: lupins	6 months	Where the maximum use of atrazine + simazine is 2 L/ha (500 g/L) on soils with pH ≥6.5.
		Other Field Crops: forage sorghum, potatoes, TT canola, sugarcane Pastures: lucerne, grass pastures	18 months	Where higher rates up to 6 L/ha are used.
Primextra Gold	atrazine + s-metolachlor	Cereal Crops: sorghum, maize	6 months	When rates up to 3.2 L/ha are used.
		Other Field Crops: sugarcane	18 months	When rates above 3.2 L/ha are used.
Glean®	chlorsulfuron	Cereal Crops: wheat, barley, triticale, oats, cereal rye	18 months	Where soil pH is 6.6–7.5 and 700 mm of rain has fallen. For soil pH >7.5 only grow cotton after growing a test strip.
Lontrel®	clopyralid	Cereal Crops: wheat, barley, oats, triticale	3 months	When rates up to 75 ml/ha are used.
		Other Field Crops: canola	6 months	When rates of 75–300 ml/ha are used.
		Pastures and Fallows	24 months	When rates above 300 ml/ha are used. At least 100 mm rainfall during plant back period, including irrigation.
diuron	diuron	Cereal Crops: wheat, barley, oats, triticale, cereal rye Legumes: lupins Pastures: perennial grass seed crops, lucerne	12 months	Plant back also applies from use in cotton.
Broadstrike®	flumetsulam	Cereal Crops: winter cereals, maize Legume Crops: chickpeas, field peas, lentils, soybeans Other Field Crops: peanuts, fenugreek, lathyrus Pastures: lucerne, serredella, clover, medic, Popany vetch	3 months	On deep, well drained soils.
Flame®	imazapic	Other Field Crops: sugarcane, peanuts	24 months	Also registered for use in fallows.
Balance®	isoxaflutole	Legume Crops: chickpeas Other Field Crops: sugarcane	7 months	350 mm rainfall between application and planting the subsequent crop. Do not include flood or furrow irrigation.
Tordon 75D®	picloram + 2,4-D	Cereal Crops: wheat, barley, oats, triticale, sorghum, maize	12 months	When rates up to 1 L/ha are used. Longer periods for higher rates.
Tordon 242®	picloram + MCPA	Other Field Crops: sugarcane Pastures: Pastures		
simazine	simazine	Legume Crops: chickpeas, faba beans, lupins Other Field Crops: TT canola Pastures: lucerne, sub clover, perennial grasses	9 months	When up to 4.5 L/ha of 500 g/L formulations. Where higher rates are used, longer plant backs apply.
Logran®	triasulfuron	Cereal Crops: wheat, barley, oats	15 months	Soil pH ≤6.5
			15 months	Soil pH 6.6–7.5
			18 months	Soil pH 7.6–8.5
Grazon* Extra	triclopyr + picloram + aminopyralid	Fallow	18 months	During drought conditions (<100 mm rainfall in a 4 month period) the plant back is significantly longer.

Table 20. Plant backs to cotton for herbicides used in seedbed preparation

Herbicide active ingredient	2,4-D amine 625 g/L			2,4-D amine 300 g/L			dicamba 700 g/kg			fluroxypyr 200 g/L			triclopyr 600 g/L
Rate L or g/ha	0.56	1.1	1.7	0.35	0.7	1.1	140	200	400	0.375	0.75	1.5	0.080–0.100
Plant back ¹ (days)	10	14	21	10	14	21	7	7	14	14	14	28	14

¹ If applied to dry soil, at least 15 mm rain is required before plant back period begins.

Table 21. Herbicides with unknown plant back periods to cotton

Trade name	Active ingredient	Registered for use in;
Spinnaker®	imazethapyr	Legume Crops: chickpeas, faba beans, field peas, mungeans, soybeans Other Field Crops: peanuts Pastures: lucerne, serradella, sub clovers
Raptor®	imazamox	Legume Field Crops: field peas, soybeans Other Field Crops: peanuts Pastures: lucerne, legume-based pastures
Midas®	imazapic + imazapyr + MCPA	Cereal Crops: Clearfield® wheat
Hussar®	mefenpyr-diethyl + iodosulfuron-methyl sodium	Cereal Crops: wheat
metribuzin	metribuzin	Cereal Crops: wheat, barley, oats Legume Crops: chickpeas, faba beans, lentils, vetch, lupins, field peas, soybeans (irrigated) Other Field Crops: potatoes
Ally®	metsulfuron methyl	Cereal Crops: wheat, barley, triticale Legume Crops: chickpeas (desiccant) Other Field Crops: Clearfield® canola
Harmony® M	metsulfuron methyl + thifensulfuron	Cereal Crops: wheat, barley, triticale
Atlantis®	metsulfuron methyl + mefenpyr-diethyl	Cereal Crops: wheat
Monza®	sulfosulfuron	Cereal Crops: wheat, triticale
Express®	tribenuron methyl	Fallows

Where fields have been treated with herbicides with no plant back recommendations to cotton, firstly determine the tolerance of cotton grown through to maturity on a smaller scale before sowing larger areas.

Table 22. Cotton herbicide plant backs to rotation crops Updated 2009

Herbicide active ingredient	Plant backs from cotton to rotation crops (months)																					
	Cereal grain crops							Legume crops								Other crops						
	Barley	Maize	Millet	Oats	Sorghum	Triticale	Wheat	Azuki bean	Chickpea	Cow pea	Fab bean	Field pea	Lab Lab	Lupin	Lucerne	Mungbean	Pigeon pea	Soybean	Canola	Safflower	Linseed	Sunflower
chlorthal dimethyl	8	8	8	8	8	8	8	8	8	8	8	8	8	FH	FH	8	FH	8	8	8	8	
diuron	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	
fluometuron	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	
fluometuron + prometryn	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	
halosulfuron-methyl	24	2	24	24	2	24	3	24	24	24	24	24	24	24	24	24	24	24	24	24	24	
metolachlor	6	0	6	6	0 ¹	6	6	6	6	6	6	6	6	6	6	6	0	6	6	6	0	
norflurazon ²	30	27	NI	30	27	30	30	NI	9	NI	30	NI	NI	NI	27	NI	9	NI	12	9	27	
pendimethalin	6	0 ³	12	12	12	FH	FH	FH	FH	FH	FH	FH	FH	6	FH	FH	FH	6	FH	FH	FH	
prometryn	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	
pyrithiobac sodium	5	22	NR	5	22	NR	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	22	NR	NR	NR	22	
s-metolachlor	6	0	6	6	0 ¹	6	6	6	6	6	6	6	6	6	6	6	0	6	6	6	0	
trifloxysulfuron sodium	6	22	22	6	22	22	6	22	18	22	7	22	22	22	9	15	15	22	22	22	22	
trifluralin	12	12	12	12	12	12	12	FH	FH	FH	FH	FH	FH	FH	FH	FH	FH	FH	FH	FH	FH	

¹ Concep® II treated seed only.

² For rates up to 3.5 kg/ha. Where higher rates, up to 4.2 kg/ha are used, increase plant back period by 6 months.

³ Maize can be resown immediately after use in a failed crop provided the seed is sown below the treated band of soil. Further information in Weed control in Summer and Winter Crop Publications from Industry & Investment NSW

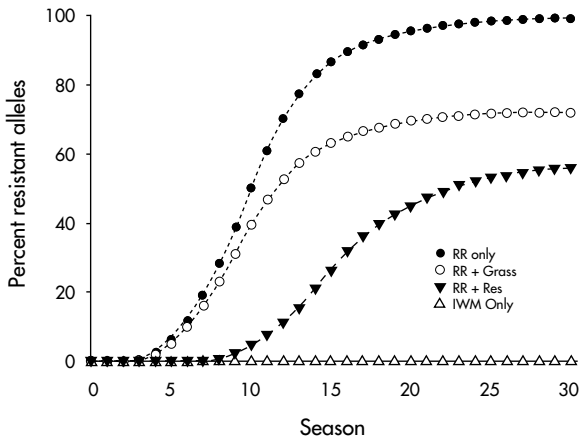
FH = following cotton harvest

NR = not recommended

NI = no information

S = in the spring following application

Figure 8. Simulated accumulation of glyphosate resistance alleles in a barnyard grass population under four weed management strategies.



resistance development was delayed. When it was used as part of a fully integrated weed management strategy, resistance did not develop over the 30 year period of the simulation. The weed management requirements of the Roundup Ready® Crop Management Plans (CMPs) are designed to ensure that Roundup Ready® is used in an integrated strategy. It is essential that the industry follows the CMPs and is proactive in preventing the development of herbicide resistance.

Looking for the early signs of resistance

Herbicide resistance is normally present at very low frequencies in weed populations before the herbicide is first applied. Using the herbicide creates the selection pressure that increases the resistant individuals' likelihood of survival. The underlying frequency of resistant individuals within a population will vary greatly with weed species and herbicide mode of action. Resistance can begin with the survival of one plant and the seed that it produces. Early in the development of a resistant population, resistant plants are likely to occur only in small patches. This is the critical time to identify the problem. Options are much more limited if resistance is first diagnosed over large areas.

Many of the symptoms of herbicide resistance can also be explained by other causes of spray failure. Evaluate the likelihood of other possible causes of herbicide failure. Start by taking the self assessment at the top of the page. The more questions to which you have confidently answered 'Yes', the more a further investigation of possible resistance is warranted. If you have answered 'Yes' to most of these questions, including questions 8–10 on field history, take action;

- Collect samples and send for testing.
- Remove surviving plants from the field to limit the amount of seed going into the soil seed bank.
- Develop a management plan for continued monitoring of the sites and the use of alternative weed control strategies.

Self Assessment – Likelihood of herbicide resistance		Y/N
1.	Was the rate of herbicide applied appropriate for the growth stage of the target weed?	<input type="checkbox"/>
2.	Are you confident you were targeting a single germination of weeds?	<input type="checkbox"/>
3.	Were the weeds actively growing at the time of application?	<input type="checkbox"/>
4.	Having referred to your spray log book, were weather conditions optimal at the time of spraying so that herbicide efficacy was not compromised?	<input type="checkbox"/>
5.	Are you confident the suspect plants haven't emerged soon after the herbicide application?	<input type="checkbox"/>
6.	Is the pattern of surviving plants different from what you associate with a spray application problem?	<input type="checkbox"/>
7.	Are the weeds that survived in distinct patches in the field?	<input type="checkbox"/>
8.	Was the level of control generally good on the other target species that were present?	<input type="checkbox"/>
9.	Has this herbicide or herbicides with the same mode of action been used in the field several times before?	<input type="checkbox"/>
10.	Have results with the herbicide in question for the control of the suspect plants been disappointing before?	<input type="checkbox"/>

Options for herbicide resistance testing

Testing a plant population for the presence of herbicide resistant individuals involves growing large numbers of plants in 'ideal' conditions then at particular growth stages applying the herbicide at a range of rates and observing the responses. Generally, seed is collected from the suspect plants and is sent for testing. However the dormancy mechanism in some species, such as barnyard grass, creates problems with this process. It is difficult to get sufficient quantities of seed to germinate uniformly in short time frames. An alternative sampling method is to collect actual plants out of the field for the Quick test. This process is limited to seedlings/ small plants as large numbers need to be collected and posted. Upon arrival they are potted and once re-established, herbicide treatments are applied. In mid-summer conditions plants are less likely to survive the trip than if collected in cooler times of the year. It is recommended to take seed samples from the surviving plants in summer and mark these sites to enable seedling collections in the following autumn or spring if they are needed.

The timeline for obtaining results from sending seed samples can be several months. Results are usually available by the end of April when samples are received before January. When plants are sent for Quick tests results are usually available within 4–8 weeks.

Sampling information sheet for herbicide resistance testing

Contact Details				
Farm Manager/Owner:	<input type="text"/>	Address:	<input type="text"/>	
Consultant:	<input type="text"/>	Telephone:	<input type="text"/>	
Preferred contact:	Manager/Owner / Consultant (details provided on right)	Email:	<input type="text"/>	
		Fax:	<input type="text"/>	
Sampling Details				
Weed species:	<input type="text"/>	Sampled by:	<input type="text"/>	
Field Name:	<input type="text"/>	Sampling Date:	<input type="text"/>	
Field History				
Season	Crop	Herbicides	Timing	Control Level (good/average/poor)
2008				
2007/08				
2007				
2006/07				
2006				
2005/06				
2005				
2004/05				
2004				
2003/04				

Collecting seed samples:

- Collect 2000–3000 seeds from plants you suspect are resistant. Barnyard grass = 1 cup full. Wild oats = 5–6 cups full.
- If testing >3 modes of action, collect additional seed.
- Avoid collecting large amounts of seed from just a few large plants.
- Follow a 'W' shaped pattern stopping every ~20 m if survivors are widespread. If survivors are localised, collect from within this area.
- Bash seed heads into a bucket to ensure only ripe seed is collected.
- Store samples in a paper bag at room temperature, away from sunlight, moisture and heat. Post as soon as possible.

Collecting plant samples for the Quick test:

- For each mode of action to be tested: collect 50 plants/field from areas where you suspect resistance.
- Gently pull out plants and wash roots.
- Wrap in moistened paper towel.
- Place in waterproof plastic bag.
- Keep in fridge and Express Post on the next Monday.

Sending samples to resistance testing services

Follow the instructions above and send samples together with a completed information sheet to either of the testing services below.

Dr Peter Boutsalis (seed or Quick test)

Plant Science Consulting

22 Linley Avenue,

Prospect SA 5082

Phone: 0400 664 460

Email: info@plantscienceconsulting.com

Website: www.plantscienceconsulting.com

John Broster (seed test only)

Charles Sturt University

Herbicide Resistance Testing
Service, PO Box 588

Wagga Wagga NSW 2678

Phone: (02) 6933 4001

Email: jbroster@csu.edu.au

Select Herbicide Modes of Action for Testing		
Mode of Action	Example Herbicides	✓
Group A – fops	Topik, Wildcat, Verdict	<input type="checkbox"/>
Group A – den	Axial	<input type="checkbox"/>
Group A – dims	Sertin, Select, Achieve	<input type="checkbox"/>
Group B – sulfonylureas	Ally, Glean, Logran, Hussar	<input type="checkbox"/>
Group B – imidazolinones	Spinnaker, Midas, OnDuty	<input type="checkbox"/>
Group B – triazolopyrimidines	Broadstrike, Eclipse	<input type="checkbox"/>
Group C – triazines	Atrazine, Simazine	<input type="checkbox"/>
Group D – dinitroanilines	Trifluralin (seed test only)	<input type="checkbox"/>
Group F – nicotinanalides	Brodal, Jaguar, Tigrex	<input type="checkbox"/>
Group I – phenoxy	2,4-D	<input type="checkbox"/>
Group J – thiocarbamates	Avadex (seed test only)	<input type="checkbox"/>
Group K – chloroacetamides	Dual Gold	<input type="checkbox"/>
Group L – bipyridils	Paraquat, Diquat	<input type="checkbox"/>
Group M – glycines	Glyphosate	<input type="checkbox"/>
Cross Resistance		<input type="checkbox"/>

These are 'user pays' testing services. Indicative prices; 1 MoA – \$110; 2 MoA – \$170; 3 MoA – \$225; 4 MoA – \$275; 5 MoA – \$305. 4 MoA packages including cross resistance also available from \$325.

Using Liberty Link® technology

Developed by Bayer CropScience in association with the Weeds Subcommittee of the Transgenic and Insect Management Strategies Committee of the Cotton Australia.

LIBERTY® 200 HERBICIDE MODE OF ACTION

In plants, the glutamine synthetase enzyme combines ammonium with glutamate to form glutamine which can then be used by plants in photosynthetic processes. The active ingredient of Liberty® 200 Herbicide, glufosinate-ammonium, inhibits the actions of the glutamine synthetase enzyme, stopping the plant from utilising ammonium. Soon after application of Liberty® 200 Herbicide, plant growth ceases and symptoms appear within a couple of days. Initially there is a general yellowing before damaged patches appear which enlarge as the plant wilts and collapses. Within 1–3 weeks the plant dies from the combined effects of ammonia building up to toxic levels within the cells and the breakdown of photosynthesis.

Liberty® 200 Herbicide is a broad spectrum, post-emergent herbicide that is active against green plant tissue. It has no soil or residual activity. A range of broadleaf weed species are listed on the label. The label recommends weeds be targeted at 2–6 leaf growth stages. As there is only very limited systemic movement of the product through the plant, high water volumes of at least 100 L/ha should be used to ensure thorough coverage. Liberty® 200 Herbicide has shown activity on a number of other weeds including summer grasses, common thornapple, bathurst burr and common vetch. However further investigation is required before label claims could be made.

For resistance management purposes Liberty® 200 Herbicide is a Group N herbicide. This is the first Group N herbicide to be made available for use in cotton. When used in accordance with the label and the Crop Management Plan, weed populations are unlikely to develop resistance to Liberty® 200 Herbicide. The use of Liberty Link® technology in rotation with non-herbicide tolerant cotton and Roundup Ready® technology can help to reduce the selection pressure on weeds from currently used herbicides.

HOW DOES LIBERTY LINK® COTTON WORK?

Liberty Link® cotton contains the bar gene which allows it to express a protein that blocks the action of Liberty® 200 Herbicide. The protein, known as phosphinothricin acetyltransferase (PAT) attaches an acetyl group to the glufosinate ammonium molecules, rendering them ineffective.

The expression of PAT allows Liberty Link® cotton to continue producing glutamine when glufosinate-ammonium is present. The bar gene is derived from the common soil bacterium, *Streptomyces hygroscopicus*.

HOW TOLERANT IS LIBERTY LINK® COTTON TO LIBERTY® 200 HERBICIDE?

Liberty Link® cotton is tolerant to repeated applications of Liberty® 200 Herbicide when used in accordance with label recommendations. A maximum of three over-the-top applications can be made each season. Applications can be made up until 10 weeks prior to harvest.

WEED MANAGEMENT WITH LIBERTY LINK®

Before growing Liberty Link® cotton, develop and document a weed control strategy for each field, including a rotation program for crop and herbicide useage. For fields with heavy weed burdens, or where there is not the capacity to treat all Liberty Link® cotton in a timely manner, Bayer CropScience recommends the use of residual herbicides prior to or at planting. Below are two example weed situations and suggested integration of Liberty Link® technology into the weed management strategies.

Weed situation	IWM strategy
Light infestation of broadleaf	<ul style="list-style-type: none">– Glyphosate herbicide pre-plant– Liberty® 200 Herbicide applied over-the-top of the established Liberty Link® crop (1–3 applications)– Inter-row cultivation– Layby or selective herbicides if required
Heavy infestation of broadleaf weeds, especially peach vine, bladder ketmia and dwarf amaranth	<ul style="list-style-type: none">– Residual herbicide incorporated pre or at planting– Liberty® 200 Herbicide applied over-the-top of the established Liberty Link® crop (1–3 applications)– Inter-row cultivation– Layby or selective herbicides if required

MANAGING LIBERTY LINK® VOLUNTEERS

Control of cotton volunteers is an important component of rotational flexibility and an essential component of farm hygiene. Cultivation and herbicides are the two most common methods of controlling volunteer cotton. Cultivation is an effective and efficient method of managing all types of volunteer cotton. Seedling, established and ratoon growth stages of conventional, Roundup Ready® and Liberty Link® varieties can be controlled with cultivation. Herbicides are only able to effectively control seedling volunteers. Liberty Link® seedling volunteers are susceptible to Roundup Ready® herbicide. Alternative herbicide options are Spray.Seed®, Hammer® and Pledge®.

Where Liberty Link® seedling volunteers are present in a Liberty Link® crop, the options for their control are the same as those for removing conventional cotton volunteers from conventional cotton. Refer to WEEDpak for strategies to control cotton volunteers.

AUDIT REQUIREMENTS IN THE LIBERTY LINK® CROP MANAGEMENT PLAN

Growers holding a Liberty Link® licence are required to conduct a weed audit in each field of Liberty Link® cotton that has been treated with Liberty® 200 Herbicide. The weed audit should take place prior to crop canopy closure and from 14–18 days after an application of Liberty® 200 Herbicide. The person conducting the audit is required to have undertaken the optional, additional module covering Weed Audits as part of successfully completing the Liberty Link® Cotton and Liberty® 200 Herbicide Accreditation Programme with Bayer CropScience.

To sample the field, use Audit Method A where the distribution of weeds within the field prior to applying Liberty® 200 Herbicide is known. Sample using Audit Method B where weed distribution prior to application is unknown. Methods A and B are presented below. Within the sample areas, identify surviving weeds and volunteers. For each survivor, rate the infestation severity. Complete a Liberty® Link Cotton Weed Management Audit form to capture the observations of the audit sampling, general comments on weed control and remedial action taken to control any surviving weeds prior to seed set. Return completed forms to Bayer CropScience by 31 December. Audit data will be collated and reported to the TIMS Weeds Subcommittee.

Sampling options when conducting weed audits in Liberty Link® cotton.

Audit Method A

Divide the field into quarters. Within each quarter, select 2 × 50 m linear row (≥ 20 m apart) that are representative of the weed burden prior to application. After application, assess these areas in at least three quarters of the field.

Audit Method B

Field Size	Sample size	Distance between each sampling site
<50 ha	4 x 100 m linear row	Minimum 100 rows
51–100 ha	6 x 100 m linear row	Minimum 100 rows
101–200 ha	8 x 100 m linear row	Minimum 100 rows
>200 ha	2 x 200 m linear row	Minimum 100 rows

APPLICATION GUIDELINES

The Liberty® 200 Herbicide is not significantly translocated as an active herbicide throughout the plant and therefore will only kill that part of the green plant that is contacted by the spray. Best results are achieved when applications are made to young weeds that are actively growing under warm, humid conditions. (e.g. temperatures below 33°C and relative humidity above 50%.)

Pre-plant paddock preparation

Control all existing weeds by cultivation or by using a knockdown herbicide such as glyphosate or paraquat.

Over-the-top applications

Liberty® 200 Herbicide can be applied over-the-top of Liberty Link® cotton from emergence through to 10 weeks prior to harvest. Application can only be made using a ground boom sprayer. Application volumes of at least 100 L water/ha through flat fan nozzles with droplet size of 200–300 microns are recommended for most situations. Up to 3 over-the-top applications can be made each season.

Tank mixes with Liberty® 200 Herbicide

Liberty® 200 Herbicide may be tank mixed with some other herbicides and insecticides. Check with your local Bayer CropScience representative for tank mixing compatibilities.

KEEPING GOOD FIELD RECORDS

It is essential that farmers keep records of the crops planted, the weeds present and the weed control methods each growing season. Such information is vital when planning crop and herbicide rotations to manage weeds, volunteers and herbicide resistance. Ensure good records are kept in relation to Liberty Link® cotton and can be made available to Bayer CropScience or the regulatory authorities as required. Keep records for at least 2 years after harvest.

As a minimum, maintain records of;

- Paddock History – crop rotation, weeds present, herbicide applications, the use of non-herbicide weed controls, other management practices influencing weed control.
- A farm map with field reference numbers and varieties sown.
- Seed bag labels and accompanying information, especially seed lot numbers.

FURTHER INFORMATION

Website: www.bayercropscience.com.au

Technical enquiries: 1800 804 479

Liberty® and Liberty Link® are Registered Trademarks of Bayer.

Roundup Ready Flex® technology

Craig McDonald, Monsanto Australia Limited, Bill Gordon, Bill Gordon Consulting, Graham Charles, Industry & Investment NSW

HOW DOES ROUNDUP READY FLEX® DIFFER FROM ROUNDUP READY® COTTON?

Roundup Ready Flex® cotton contains two copies of the CP4 EPSPS gene and a new promoter sequence resulting in expression in both the vegetative and reproductive parts of the plant. Roundup Ready Flex cotton is therefore able to tolerate applications of glyphosate in its vegetative (pre-squaring) and reproductive (squaring, flowering, boll development and maturation) stages. Roundup Ready herbicide may be applied over the top (OTT) of Roundup Ready Flex cotton up to four times between emergence and 22 nodes, while one application is allowed between 60% bolls open and harvest. However, the total amount of herbicide applied to any one crop must not exceed 6 kg/ha as illustrated in Figure 9. Crops that are intended for seed production must not have an application of Roundup Ready Herbicide past the 60% bolls open stage.

The full-plant glyphosate tolerance of Roundup Ready Flex means that applications of glyphosate can be made irrespective of the rate of crop growth or the number of days between applications.

HOW TOLERANT IS ROUNDUP READY FLEX® TO ROUNDUP READY® HERBICIDE?

Trials examining plant growth, development, yield and fibre quality were conducted in Australia by Monsanto as part of the phenotypic evaluation of Roundup Ready Flex cotton. These trials were conducted at eight locations over two seasons to assess whether Roundup Ready Herbicide applied to Roundup Ready Flex cotton at different growth stages altered the agronomic characteristics of the plant when grown under Australian conditions. Very high levels of crop safety were observed. There were no significant differences in first position fruit retention, yield, micronaire or fibre length between unsprayed Roundup Ready Flex, unsprayed conventional cotton and Roundup Ready Flex cotton treated with up to three times the registered quantity of herbicide. A new formulation of Roundup Ready Herbicide is now registered for use in Roundup Ready Flex and Roundup Ready cotton. The new formulation contains Plantshield®, a crop safener for improved performance in humid conditions. Roundup Ready Herbicide with Plantshield will be available during the 2009–10 cotton season. The new formulation contains the same quantity of active ingredient (690 g/kg), as the previous formulation and has been extensively tested over several seasons and at multiple locations to ensure maximum crop safety and efficacy.

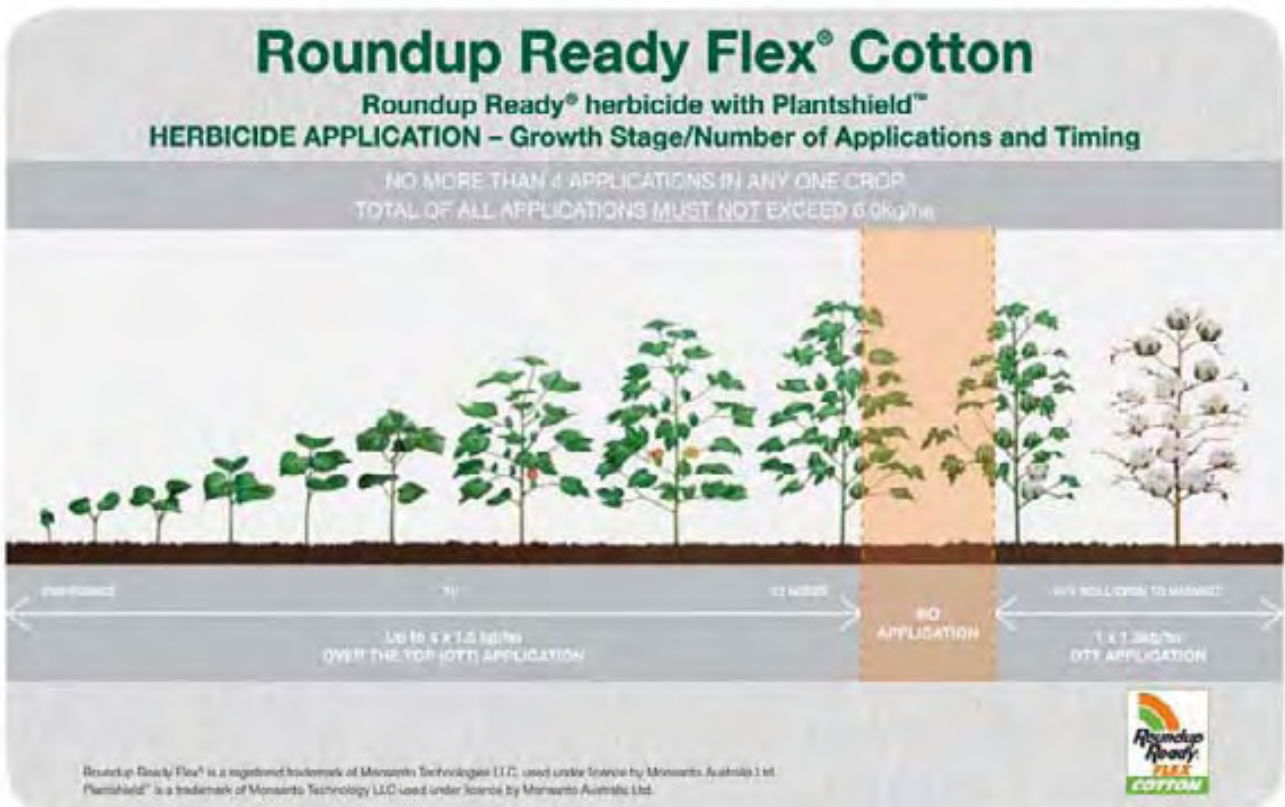


Figure 9. Application windows for over the top Roundup Ready Herbicide.

WEED MANAGEMENT IN ROUNDUP READY FLEX® CROPS

Roundup Ready Flex cotton offers growers an increased margin of crop safety, a more flexible window for OTT applications of Roundup Ready Herbicide, and the potential to improve the efficacy of weed control. However Roundup Ready Flex cotton should be viewed as a component of an Integrated Weed Management (IWM) system, not as a solution to all weed management scenarios. Weeds species with natural tolerance to glyphosate will be selected for with repeated glyphosate applications, resulting in species shift. The most effective, economic and sustainable weed management system for growers will, therefore, be achieved using an integrated (IWM) approach.

Know your field history

A combination of the relative effectiveness of previous herbicide programs and other agronomic practices employed on a farm is likely influence the weed species present in any field. The correct identification and a basic understanding of the biology and ecology of the weeds present in a field are essential elements in the design of a successful weed management program. It is critical that the correct herbicide and herbicide rate is chosen for the target weed species. By knowing field history, growers can determine which weed control tools they should use and at what time they should be employed to achieve the best results.

Pre-plant knockdown

Starting the crop 'clean' gives seedling cotton good conditions to emerge and develop unhindered by the competitive effects of weeds. Pre-plant weed control can be achieved using tillage and/or appropriate registered herbicides. Using glyphosate tank mixes or herbicides with other modes of action is encouraged at this stage to strengthen the IWM program. It is important to consider the control of cotton volunteers at this stage.

The role of residual herbicides

Residual herbicides should be used where appropriate in the Roundup Ready Flex weed control system. The nature of pre-emergence residual herbicides often requires that they be applied in anticipation of a weed problem. Consideration for the use of residual herbicides in a weed control program for any given field should be determined based on the knowledge of the fields history.

The first OTT (over-the-top) application

Cotton is a very poor competitor and is sensitive to early season weed competition. The longer OTT window with Roundup Ready Flex may tempt



Directed application between 16 and 22 nodes targets weeds along the plant line.

Monsanto Australia Ltd. Roundup Ready Flex® cotton Technical Manual. Version 1 – August 2006.

growers to delay the first OTT application of Roundup Ready Herbicide in the hope that multiple weed germinations can be controlled with a single spray. Whilst competitive affects will vary according to weed species and weed density, it is commonly recognised that good weed control in the first 6-8 weeks following crop emergence maximises cotton yield potential. Delaying the initial OTT application may result in growers having to target weeds later in the season that are beyond the growth stage for optimum control.

There are no label recommendations for any tank mixtures with Roundup Ready® Herbicide OTT of Roundup Ready Flex® cotton.

Subsequent OTT applications

After the first OTT application, the use of subsequent OTT applications (maximum of four), should be made according to the presence of new weed germinations. In any field, a mix of weed species will commonly exist. Correct identification of weeds is very important as this will have a direct impact on the rate selection and application timing chosen. Select the timing and application rate of Roundup Ready Herbicide based upon the most difficult to control weed species in each field.

Inter-row cultivation

Inter-row cultivation is a relatively cheap and non-selective method of weed control. In irrigated cotton, it also assists in maintaining furrows to facilitate efficient irrigation. In a Roundup Ready Flex crop, inter-row cultivation contributes to the diversity of weed control methods being employed and, as such, is a valuable component of an IWM strategy.

Lay-by residual application

Growers and their advisors are encouraged to scout fields prior to row closure and to combine these observations with their historical knowledge of

individual fields to ascertain the need for a lay-by herbicide application. A lay-by application should be used on fields where there is an expectation of a significant emergence of weeds later in the season.

Pre-harvest application

One application of Roundup Ready Herbicide may be made OTT between 60% boll open and harvest. In most circumstances, good weed control earlier in the crop should render the pre-harvest application redundant. However, if late season weeds are present, a pre-harvest application can be used to reduce seed set and improve harvest efficiency. Pre-harvest applications of glyphosate will not provide regrowth control in Roundup Ready Flex cotton.

AUDIT REQUIREMENTS IN THE ROUNDUP READY FLEX® CROP MANAGEMENT PLAN

A legal requirement of the approved release of Roundup Ready Flex cotton is that all persons growing and managing Roundup Ready Flex cotton crops comply with the Crop Management Plan (CMP). Within the CMP, there are the requirements for a Planting Audit and a Weed Management Audit.

Planting Audit

The Technology Service Provider (TSP) is responsible for completion of the planting audit by no later than December 15, as set down in the Technology User's Agreement (TUA). The information required includes;

- Number of hectares sown,
- Location of Roundup Ready Flex cotton on the farm unit, and
- Date/s of sowing.

Weed Management Audit

Only accredited TSPs will be able to conduct the Weed Management Audit.

The Weed Management Audit must be completed by the TSP and provided to Monsanto prior to January 15. (Except the Burdekin region)

Details required for Roundup Ready Flex cotton include:

- Assessment of all weeds remaining 10 to 14 days after an 'over the top' (OTT) application of Roundup Ready Herbicide at a minimum of 6 nodes of crop growth, and not exceeding 16 nodes. The table below outlines how to assess the field for the presence of surviving weeds;

Field Size	Assessment of Surviving Weeds
< 50 ha	4 x 100 metres linear row
51–100 ha	6 x 100 metres linear row
101–151 ha	8 x 100 metres linear row
> 150 ha	8 x 200 metres linear row

The minimum distance between each assessment (i.e. each 100 metres linear row) must be 100 rows. In addition to the assessment of surviving weeds, the TSP is required to record;

- any remedial action taken to stop seed set of surviving weeds. Weeds identified to have survived Roundup Ready Herbicide applications must be controlled by an alternative management strategy in order to prevent those weeds from setting seed.
- Comments about the level of weed control achieved in Roundup Ready Flex cotton, including the efficacy of remedial actions undertaken.
- Adverse event reporting. Growers and TSPs are required to report any adverse event, such as suspected weed resistance, to Monsanto as soon as it is identified.

Monsanto will discuss the data collected with relevant industry weed scientists and any findings will be reported to the TIMS Herbicide Tolerant Crop Technical Panel.

MANAGING ROUNDUP READY FLEX VOLUNTEERS

A major consideration in the development of an IWM plan for Roundup Ready Flex is the management of herbicide tolerant cotton volunteers. Plans need to be made to use cultural control options and herbicides with alternate modes of action in fallows and subsequent crops to control volunteers.

Cultural controls

Minimising the presence of lint/seed from last year's crop on this year's plant line will assist in managing cotton volunteers. Operations such as moisture seeking, bed renovation and fertiliser application all assist in redistributing cotton lint away from the plant line and into the furrow where inter-row cultivation and/or shielded spraying can be used for control.

Pre-watering stimulates volunteer germination and emergence prior to crop establishment, providing the opportunity to target volunteers with broad spectrum herbicides.

Herbicide options

Currently there are four registered herbicide options for the control of volunteer cotton;

1. Paraquat/Diquat (Spray.Seed®, Revolver®)
2. Bromoxynil (Bromicide® 200)
3. Carfentrazone ethyl (Hammer® 240 EC)
4. Paraquat/Amitrole- (Alliance®)

These options are all effective in controlling volunteer cotton, however the following points should be considered;

- The effectiveness of these herbicides on conventional, Roundup Ready and Roundup Ready Flex cottons is generally limited to volunteers no more than 4–6 leaf. The size of the volunteers needs to be assessed before a herbicide selection is made.
- Larger plants will be more difficult to control with a single pass.
- Using the recommended water volumes for application is imperative for effective control.
- Other weeds within the field should be taken into consideration when making a herbicide selection.
- Bromoxynil and Carfentrazone ethyl can be mixed with glyphosate, which may assist when a range of other weeds is also present.
- It is important to read all labels to confirm the correct application timings and rates. Label directions must be followed.

Ratoon Cotton

Ratoon or 'stub' cotton is cotton that has 're-grown' from root stock still in the ground from the previous season. Ratoon cotton is more common in minimum tillage systems. These plants are inherently difficult to control with herbicide due to their large root mass and often relatively small leaf area. Ratoon conventional, Roundup Ready and Roundup Ready Flex cotton plants will not be controlled by Roundup Ready Herbicide or glyphosate products. The most effective means of controlling ratoon cotton is achieved through effective root cutting of cotton stalks, followed by 'centre-busting'. Care needs to be taken that during 'centre-busting' to ensure the tool does not run off the bed centre and miss stalks that may regrow in the following spring.

OTHER SOURCES OF INFORMATION

Roundup Ready Flex® Cotton Technical Manual, Version 1 – August 2006, Monsanto Australia Ltd.

CSD website: www.csd.net.au

APPLICATION GUIDELINES

Timing options

The Roundup Ready Herbicide label permits;

- Applications in fallow, prior to sowing the Roundup Ready Flex crop, with the maximum rate applied dependent on the targeted weed/s. Application may be made by ground rig sprayer or by aircraft.
- Up to four applications of Roundup Ready Herbicide between crop emergence and 22 nodes of crop growth, with a maximum of 1.5 kg/ha being applied in any single spray event.
- An option for a pre-harvest application, alone or in tank mix with Dropp®, once the crop is 60% open and immature bolls cannot be cut with a sharp knife. The maximum herbicide rate for pre-harvest use is 1.5 kg/ha. Application may be made by ground rig sprayer or by aircraft.
- Not more than four applications and 6.0 kg of Roundup Ready Herbicide may be applied through all growth stages of Roundup Ready Flex cotton in any one growing season.

Over-the-top applications

Before an over-the-top application, it is absolutely essential to thoroughly decontaminate the sprayer of any products which might damage the crop, particularly sulfonylurea and phenoxy herbicides.

For ground rig sprayers, the use of flat, tapered fan nozzles or low drift nozzles is recommended.

Operate the sprayer at pressures up to 250 kPa with a spray output of up to 80 L/ha. Avoid spraying a fine mist. Aim for a minimum VMD 300 microns plus. Select nozzle types that produce a minimum Coarse spray quality (ASAE S572) **For aerial application**, use CP nozzles with the appropriate reduced swath width for the aircraft type and apply in appropriate conditions to produce a VMD of 300 microns or greater. Use a minimum spray volume of 40 L/ha. Do not apply Roundup Ready herbicide by aircraft at temperatures above 30°C or if relative humidity falls below 35%.

Air Induction Nozzles

If using air induction nozzles to produce a coarse spray quality or larger, the nozzle must be operated in such a way as to include adequate air inclusion within the droplets which will assist with retention of the herbicide mix on the target.

Low Pressure Air Induction Nozzles

To ensure adequate air inclusion typically requires operating low pressure air induction nozzles at approximately 3–4 bar (provided they can achieve a coarse spray quality or larger at that pressure),

and if operating these nozzles with an automatic rate controller, not allowing the pressure to drop below 2 bar (hence, careful selection of nozzle size is required to ensure overdosing does not occur when speed is reduced, if a minimum pressure setting/hold is used).

High pressure air induction nozzles

These should typically be operated at approximately 5-6 bar (provided they can achieve coarse droplets at that pressure), and if operating an automatic rate controller, not allowing the pressure to drop below 3-4 bar (hence, careful selection of nozzle size is also required to ensure overdosing does not occur when speed is reduced).

Preventing off-target drift

Drift can be influenced by incorrect droplet sizing, spray tip height, operating speed, wind velocity, air temperature and humidity. Drift can be successfully prevented by adhering to the above recommendations and waiting for appropriate weather conditions. Be prepared to stop spraying if conditions change and become unsuitable. Refer to SPRAYpak for detailed information on choosing the appropriate spray equipment and determining low risk weather conditions. Communication between growers, neighbours, consultants, farm workers and applicators is also essential for preventing spray drift damage to sensitive crops and vegetation.

Consider using an on-site weather station to continually monitor conditions during spraying and cease spraying if conditions become unsuitable. Always keep accurate records of the prevailing conditions during spraying.

Plants without the Roundup Ready technology will be destroyed or seriously damaged if Roundup Ready Herbicide comes in contact with them.

Other Sources of Information

Roundup Ready® Cotton Technical Manual, Monsanto Australia Ltd.

WEEDpak a guide for integrated weed management in cotton, Australian Cotton CRC.

SPRAYpak cotton grower's spray application handbook 2nd Edition, Cotton Research and Development Corporation.

Suspension of 2,4-D High Volatile Ester (HVE) products

Based on the APVMA's 'Notice of continued suspension of products containing 2,4-D ethyl, butyl and isobutyl esters and all associated label approvals.'

The APVMA has taken the decision to continue the suspension of registration and label approvals of products containing high volatile ester (HVE) forms of 2,4-D, namely the ethyl, butyl and isobutyl esters. These suspensions are in effect until 30 April 2010. This suspension does not affect the availability of 2,4-D low volatile ester or 2,4-D amine formulations.

DURING THE PERIOD OF SUSPENSION

During the period of suspension new instructions for use apply to all products containing 2,4-D HVEs. Where the new instructions are inconsistent with the label instructions on the container, the new instructions in the Notice must be followed.

A summary of the new directions for use are below.

Directions for use: for products containing 2,4-D ethyl, butyl or isobutyl ester.

RESTRAINTS:

This is a PHENOXY HERBICIDE that can cause severe damage to native vegetation and susceptible crops such as cotton, grapes, tomatoes, oilseed crops and ornamentals.

DO NOT apply this product between 1 September and 30 April. Use only within the SPRAY WINDOW between **1 May and 31 August**.

DO NOT apply this product by air.

DO NOT apply this product

- in aquatic situations
- to sugar cane
- to rights of way
- as a harvest aid / salvage spray

DO NOT apply more than 800 g 2,4-D active equivalents per hectare (1L/ha).

DO NOT apply if crop or weeds are stressed due to dry or excessively moist conditions.

DO NOT use unless wind speed is more than 3 km /hour and less than 15 km /hour as measured at the application site.

DO NOT apply with smaller than **Coarse to Very Coarse spray quality** according to the ASAE S572 definition for standard nozzles.

DO NOT use if rain is likely within 6 hours.

Within 24 hours of completing a 2,4-D HVE application all users must make and **keep a record of each application**. The details required include;

- Information about the farm owner and applicator, notification of neighbours and area treated.
- Crop situation and pest details.
- Weather conditions at the application site, such as temperature, humidity, wind speed and direction at the beginning and end of the application.
- Application details including details of the equipment used, ground speed, product rate and application volumes and the use of spray additives.
- A statement saying the information on this record is accurate and correct, followed by the signature of the user.

For convenience, a 2,4-D record-keeping form can be obtained from the APVMA website – www.apvma.gov.au/chemrev/downloads/2_4_d_sprayrecord.pdf

BUFFER ZONES:

There must be a buffer zone of 100m between field edges and downwind water bodies, native vegetation and sensitive crops.

PERMISSIBLE DATES OF APPLICATION OF 2, 4-D VOLATILE ESTERS:

Application of 2, 4-D ethyl ester, butyl ester or isobutyl ester must only take place during a spray window between **1 May and 31 August**.

Victoria, Western Australia, Tasmania and Queensland currently have mechanisms whereby the use of specific chemicals (including 2,4-D) is restricted to geographical areas and/or time zones due to the higher risk for adverse off-target crop or environmental effects. These state restriction on 2, 4-D use may place additional requirements on users within this spray equipment. Users must consult their local authority or department of agriculture to ensure they meet state requirements.

WHY HAVE 2,4-D HVEs BEEN SUSPENDED?

The high volatile ester forms of 2,4-D have been suspended because they are likely to have unintended harmful effects on non-target vegetation (crops and native vegetation) and/or aquatic organisms. During the suspension the APVMA required active constituent approval holders to provide new data on the physio-chemical properties of high volatile (short chain) esters. The APVMA has assessed the data provided and has decided to extend the suspension period. Registrants are

now required to generate and provide additional environmental fate and environmental effects data for assessment.

IS VOLATILISATION THE SAME AS DRIFT?

No. The concepts are often confused. Spray drift refers to the physical movement of spray droplets (and their dried remnants) through the air from the nozzle to any off-target site *at the time of application*. Volatilisation is a process whereby chemical is applied to a target site but evaporates *at the time of application* or enters the air stream as a vapour. Once in the airstream, the vapour can be blown in the wind and settle on crops and vegetation many kilometres away.

ARE THERE ALTERNATIVES TO 2,4-D HVEs?

The APVMA recognises that the availability of alternatives is important to users. There are many other herbicides registered for the same uses as the HVEs including several other forms of 2,4-D. The APVMA has been advised that the HVEs are generally cheaper than the alternatives, however the cost benefit of chemicals is not a criterion on which the APVMA can make a decision.

Cotton Weed Control Guide – Registered chemicals as at 15 October 2009

Tracey Farrell, formerly Industry & Investment NSW

Registration of a herbicide is not a recommendation from I&I NSW for the use of a specific herbicide in a particular situation. Growers must satisfy themselves that the herbicide they choose is the best one for the crop and weed. Growers and users must also carefully study the container label before using any herbicide, so that specific instructions relating to the rate, timing, application and safety are noted. This publication is presented as a guide to assist growers in planning their herbicide programs.

IMPORTANT— AVOID SPRAY DRIFT

Take every precaution to minimise the risk of causing or suffering spray drift damage by:

- Planning your crop layout to avoid sensitive areas, including homes, school bus stops, waterways, grazing land and non-target crops.
- Ensuring that all spray contractors have details of any sensitive areas near spray targets.
- Consulting with neighbours to minimise risks from spraying near property boundaries. Keep

neighbours informed of your spraying intentions near property boundaries. Make it clear that you expect the same courtesy from them.

- Carefully following all label directions.
- Paying particular attention to wind speed and direction, air temperature and time of day before applying pesticides using buffer zones as a mechanism to reduce the impact of spray drift or overspray.
- Keeping records of chemical use and weather conditions at the time of spraying.

SPRAY LOG BOOKS

To assist in record keeping for pesticide applications, Spray Log Books can be purchased from:

DEEDI, cost \$6.60 plus postage and handling.

Contact DEEDI in Toowoomba – 07 4688 1415 or in Dalby – 07 4669 0800 to place an order.

I&I NSW, cost \$12.00 plus postage and handling.

Contact I&I NSW, Yanco – 1800 138 351.

ABBREVIATIONS USED IN THE TABLES 24–30

AC = Aqueous concentrate	L = Liquid	SP = Soluble powder
DF = Dry flowable granule	SC = Suspension concentrate	WDG = Water dispersible granule
EC = Emulsifiable concentrate	SoC = Soluble concentrate	WP = Wettable powder

Table 24a. Control of weeds in dry channels

Active ingredient	Mode of Action Group	Concentration and formulation	Application rate of product	Comments
Amitrole + ammonium thiocyanate	F	250 g/L + 220 g/L SC	0.28–4.5 L/100 L water	Controls a wide range of plants from seedling grasses, at low water rates, to perennial grasses, at high rates. Controls some young broadleaf weeds.
Diuron	C	500 g/L SC 500 g/L SC 900 g/kg DF, WDG	72–144 L/ha 20–40 L/ha 22 kg/ha (Qld) 40 kg/ha (NSW)	QLD registration. NSW registration. Channels must be flushed after application.
Glyphosate	M	360 g/L AC, L, SC 450 g/L AC 510 g/L AC 540 g/L AC 680 g/kg WDG	0.5–9.0 L/ha 1.6–7.2 L/ha 0.34–1.9 L/ha 1.32–5.855 L/ha 1.0–4.5 kg/ha	Controls most weeds. Low rates for annual grasses. High rates for perennials and broadleaf weeds. Mix only as directed on the label. Check label for details.
Imazapyr + glyphosate	B + M	150 g/L + 150 g/L SC	5.0 L/ha	For best results apply in early autumn with minimal weed growth. Allow six weeks before channel is re-used.
Pendimethalin	D	330 g/L EC 440 g/L AC	4.5–9.0 L/ha 3.4–6.75 L/ha	If 25–50 mm rain has not fallen within 14 days flush channel (1 day) and drain off.

Table 24b. Control of weeds around aquatic areas

Active ingredient	Mode of Action Group	Concentration and formulation	Application rate of product	Comments
Glyphosate	M	360 g/L AC 500 g/L AC, EC 540 g/L AC	3.0–9.0 L/ha 1.44–8.48 L/ha 1.3–6.0 L/ha	Rate varies with species present. Choose a glyphosate product that has a specific aquatic weed control registration. See label for details for application around aquatic areas.

Table 25. Weed control before planting

Active ingredient	Mode of Action Group	Concentration and formulation	Application rate of product	Comments
2,4-D as the iso-propylamine salt	I	225 g/L AC 300 g/L AC	0.8–3.6 L/ha 0.66–2.7 L/ha	For use with glyphosate at recommended rates. Check label for details.
Amitrole + paraquat	Q + L	250 g/L + 125 g/L	2–4 L/ha	Sowing can occur immediately after application.
Bromoxynil	C	200 g/L EC	1.4–2.1 L/ha	Controls peachvine, climbing buckwheat and cotton volunteers. Spray volumes above 50 L/ha are recommended. Complete coverage is essential.
Carfentrazone-ethyl	G	240 g/L EC	0.025–0.1 L/ha	Apply as a tankmix with glyphosate or products containing paraquat.
Dicamba	I	500 g/L AC 700 g/kg WDG	0.16–0.56 L/ha 0.115–0.4 kg/ha	Up to 14 days plant back period.
Fluometuron	C	900 g/kg DF, WDG	1.5–3.1 kg/ha	Controls many broadleaf weeds. Apply just prior to incorporation. High rate for heavier soils. Will require further band application on top of hill immediately after planting. See label.
Fluometuron + prometryn	C	250 g/L + 250 g/L AC, SC 440 g/kg + 440 g/kg DF, WDG	2.5–5.0 L/ha 1.4–2.9 kg/ha	Controls many annual grasses and broadleaf weeds. Incorporate to 5 cm. Will require further band application on top of hill immediately after planting.
Flumioxazin	G	500 g/kg WDG	30 g/ha + tank mix partner 45 g/ha	Addition to knockdown products will increase the speed of activity and may improve final control. For control of volunteer cotton. Always apply with a recommended adjuvant.
Fluroxypyr	I	200 g/L EC	0.75–1.5 L/ha	Controls certain broadleaf weeds post-emergent. See label for details of mixtures with glyphosate and plant back restrictions.
Glyphosate	M	360 g/L AC, EC, L, SC	2.0–3.0 L/ha	Controls most annual grasses and broadleaf weeds. Refer to label for rates on specified weeds and recommendations.
		450 g/L AC	0.4–2.4 L/ha	
		470 g/L AC	0.38–1.5 L/ha	
		480 g/L AC	0.37–2.25 L/ha	
		500 g/L AC, EC	0.33–2.16 L/ha	
		510 g/L AC	0.34–1.4 L/ha	
		540 g/L AC	0.32–2.0 L/ha	
		570 g/L AC	0.322–1.27 L/ha	
680 g/kg WDG	0.265–1.6 kg/ha	In Roundup Ready® cotton and Roundup Ready Flex® cotton only.		
690 g/kg WDG	0.265–1.5 kg/ha			
Metolachlor	K	720 g/L EC	2.0 L/ha	Controls certain annual grasses and Wandering Jew. Rain or irrigation needed within 10 days of application or incorporate mechanically.
Norflurazon	F	800 g/kg DF	2.3–4.2 kg/ha	Controls many annual grasses and broadleaf weeds including nutgrass. Refer to label for plant back period.
Oxyfluorfen	G	240 g/L EC	0.075 L/ha	Use with glyphosate at recommended rates.
Paraquat	L	250 g/L SC	1.6–2.4 L/ha	Controls many annual grass and broadleaf seedlings.
Paraquat + diquat	L	135 g/L + 115 g/L SC	1.2–2.4 L/ha	Controls most annual grasses and broadleaf weeds.
Pendimethalin	D	330 g/L EC	3.0 L/ha	Controls annual grasses and some broadleaf weed seedlings. Incorporate within 24 hours. Check label for details.
		440 g/L	2.25 L/ha	
		455 g/L AC	2.2 L/ha	
Prometryn	C	500 g/L AC, SC	2.2–4.5 L/ha	Apply as pre-emergent treatment onto bare, moist soil or as an early post-emergent treatment to weeds after cultivation. Use low rate for short-term weed control.
		900 g/kg DF, WDG	1.2–2.5 kg/ha	
s-Metolachlor	K	960 g/L EC	1.0 L/ha	Rain/irrigation needed within 10 days of application or incorporate mechanically. Controls most annual grasses.
Triclopyr	I	600 g/L EC	0.08–0.16 L/ha	Melon weed control. 14 days plant back for cotton.
Trifluralin	D	480 g/L EC	1.2–2.3 L/ha	Rate is soil type dependent. Incorporate within 4 hours. Controls seedling and annual grasses and some broadleaf weeds. See label for additional options for winter fallow control.
		500 g/L EC	1.1–2.25 L/ha	

Table 26. Weed control at planting

Active ingredient	Mode of Action Group	Concentration and formulation	Application rate of product	Comments
Chlorthal dimethyl	D	900 g/kg WDG	5.0–12.5 kg/ha	Apply at time of planting. Use higher rate for areas under irrigation.
Diuron	C	900 g/kg DF, WDG	1.0–2.0 kg/ha	Controls many broadleaf weeds and annual grasses. Plant injury can occur if heavy rain follows application. Do not apply more than once per season.
Fluometuron	C	500 g/L AC, SC 900 g/kg DF, WDG	1.8–3.6 L/ha 0.945–2.0 kg/ha	Controls many broadleaf weeds and annual grasses. Apply just prior to incorporation. Use in conjunction with pre-plant application. Apply as a band (minimum band width 40 cm) or blanket application. Use higher rate on heavier soils. Check label for details.
Fluometuron + prometryn	C	250 g/L + 250 g/L AC, SC 440 g/kg + 440 g/kg DF, WDG	3.0–5.0 L/ha 1.7–2.9 kg/ha	Controls many broadleaf weeds and annual grasses. Apply just prior to incorporation. Use in conjunction with pre-plant application. Apply as a band (minimum band width 40 cm) or blanket application. High rate on heavier soils. Check label for details.
Metolachlor	K	720 g/L EC	2.0 L/ha	Controls certain annual grasses and Wandering Jew. Rain or irrigation needed within 10 days of application or incorporate mechanically.
Paraquat + diquat	L	135 g/L + 115 g/L SC	0.8–2.4 L/ha	Controls most annual grasses and broadleaf weeds.
s-Metolachlor	K	960 g/L EC	1.0 L/ha	Controls most annual grasses. Rain or irrigation needed within 10 days of application or incorporate mechanically.

Table 27. Weed control after planting and before crop emergence

Active ingredient	Mode of Action Group	Concentration and formulation	Application rate of product	Comments
Diuron	C	500 g/L SC 900 g/kg DF, WDG	1.8–3.5 L/ha 1.0–2.0 kg/ha	Controls many broadleaf weeds and annual grasses. Plant injury can occur if heavy rain follows application. Avoid light soils. Do not apply more than once per season. Spray immediately after planting.
Fluometuron	C	500 g/L AC, SC 900 g/kg DF, WDG	4.5–7.2 L/ha 2.4–4.0 kg/ha	Controls many broadleaf weeds and annual grasses. Minimum band width 40 cm. Apply to moist soil or significant rain or irrigation required within 3–5 days of application. Severe plant injury may result if heavy rain occurs between sowing and emergence. High rates apply to heavier soils.
Fluometuron + prometryn	C	250 g/L + 250 g/L AC, SC 440 g/kg + 440 g/kg DF, WDG	3.0–5.0 L/ha 1.7–2.9 kg/ha	Controls many broadleaf weeds and annual grasses. Apply to moist soil, significant rain or irrigation required within 3–5 days of application. Severe plant injury may result if heavy rain occurs between sowing and emergence. Do not use on light sandy soils or soils with low organic content. Check label for details.
Metolachlor	K	720 g/L EC	2.0 L/ha	Controls certain annual grasses and Wandering Jew. Rain or irrigation needed within 10 days of application or incorporate mechanically.
Paraquat	L	250 g/L SC	1.2–2.4 L/ha	Controls most annual grasses and broadleaf weed seedlings.
Paraquat + diquat	L	135 g/L + 115 g/L SC	0.8–2.4 L/ha	Controls most annual grasses and broadleaf weeds.
Pendimethalin	D	330 g/L EC 440 g/L EC 455 g/L AC	4.5 L/ha 3.4 L/ha 3.3 L/ha	Controls annual grasses and certain broadleaf weeds. Use when incorporation prior to sowing is impractical and where the seedbed tilth is fine and free of large stones and trash. Apply within 48 hours after sowing.
Prometryn	C	500 g/L AC, SC 900 g/kg DF, WDG	3.3–4.5 L/ha 1.8–2.5 kg/ha	Controls many broadleaf weeds and thins annual grasses. Apply onto bare moist soil or irrigate within three days after application.
s-Metolachlor	K	960 g/L EC	1.0 L/ha	Controls most annual grasses. Rain or irrigation needed within 10 days of application or incorporate mechanically.

Table 28. Weed control after crop emergence (includes layby)

Active ingredient	Mode of Action Group	Concentration and formulation	Application rate of product	Comments
Butoxydim	A	250 g/kg WDG	0.12 kg/ha or 0.18 kg/ha	Low rate for grass seedlings pre-tillering and high rate for 2–3 tillers. Always add the recommended spray adjuvant.
Chlorthal dimethyl	D	900 g/kg WDG	(6.0–11.0 kg/ha)	Layby only. Do not apply after bolls open.
Clethodim	A	240 g/L EC	0.25–0.375 L/ha	Apply at 2–5 leaf stage. Read label for details.
Diuron	C	500 g/L SC 900 g/kg DF, WDG	1.8–3.5 L/ha 1.0–2.0 kg/ha	Controls many broadleaf weeds and annual grasses. Cotton should be at least 30 cm high. Use as a directed spray. Avoid spray drift. Do not apply more than once per season.
Fluazifop-p	A	212 g/L EC	0.75–1.0 L/ha	High rate for actively growing weeds, 5 leaf – early tillering.
Fluometuron	C	500 g/L AC, SC 900 g/kg DF, WDG	1.3–2.8 L/ha (2.8–5.6 L/ha) 0.72–1.5 kg/ha (1.5–3.0 kg/ha)	Controls many broadleaf weeds and annual grasses. Rates in brackets for lay-by spraying. Crop should be more than 15 cm high. Weeds should be less than 5 cm high for early directed spraying and less than 8 cm high for lay-by treatments. Use with recommended surfactant.
Fluometuron + prometryn	C	250 g/L + 250 g/L AC, SC 440 g/kg + 440 g/kg DF, WDG	1.5–2.5 L/ha (2.0–3.5 L/ha) 0.855–1.4 kg/ha (1.1–1.9 kg/ha)	QLD registration only for low rate, early spray. Rates in brackets for lay-by spraying. Controls many broadleaf weeds and annual grasses. Crop should be 30–50 cm high, weeds not more than 8 cm. Use as a directed spray with recommended surfactant.
Flumioxazin	G	500 g/kg WDG	60 or 90 g/ha	Apply as a shielded spray. Do not contact cotton foliage.
Glufosinate-ammonium	N	200 g/L SC	3.75 L/ha in 100 L water	Only apply to Liberty Link® cotton varieties. Maximum 2.25 kg a.i./ha/season (3 applications). As a contact herbicide coverage is critical to effectiveness.
Glyphosate	M	360 g/L AC, EC, L, SC 450 g/L AC, L 490 g/L AC 480 g/L AC 500 g/L AC, EC 510 g/L AC 540 g/L AC 570 g/L AC 680 g/kg WDG	2.0–3.0 L/ha 0.4–2.4 L/ha 0.35–2.0 L/ha 0.375–2.25 L/ha 0.33–2.16 L/ha 0.34–1.4 L/ha 0.32–2.0 L/ha 0.322–1.27 L/ha 0.265–1.6 kg/ha	Apply with shielded sprayer. Do not apply in cotton less than 20 cm high.
		690 g/kg WDG	0.52–1.5 kg/ha	Only apply over-the-top to Roundup Ready® cotton varieties up to 4 leaf stage and to Roundup Ready Flex® cotton varieties up to 16 node stage of growth.
Halosulfuron-methyl	B	750 g/kg DF 750 g/kg WDG	65–130 g/ha	Shielded sprayer application in irrigated cotton only. Apply in crops at least 20 cm high but before first flower. Contact with cotton may cause severe injury. See label for details.
Haloxyfop-r	A	130 g/L EC 520 g/L EC	0.4–0.6 L/ha 0.1–0.15 L/ha	Actively growing seedling grasses from 2 leaf to tillering up to 15 cm. Always use the recommended spray oil.
MSMA	Z	720 g/L L, SC 800 g/L L, SC	3.1 L/ha 2.8 L/ha	Controls Nutgrass, Xanthium burrs and Johnson grass. Apply as a band or as a directed spray after cotton is 7 cm high but before first flower opens.
Paraquat	L	250 g/L AC, SC	1.2–2.4 L/ha	Inter-row weed control, shielded spray. Use low rates for seedling weeds. Use high rates for mature stages.
Prometryn	C	500 g/L AC, SC 900 g/kg DF, WDG	1.1–2.2 L/ha (2.2–4.4 L/ha) 0.61–1.2 kg/ha (1.2–2.5 kg/ha)	Controls many broadleaf weeds and thins annual grasses. Rates in brackets are for lay-by spraying. Weeds should be less than 8 cm high. Use as a directed spray with recommended surfactant.
Propaquizafop	A	100 g/L EC	0.2–0.9 L/ha	Apply when weeds are actively growing. Always apply with an adjuvant. Refer to label for further details.
Pyrithiobac sodium	B	850 g/kg SP	0.03–0.12 kg/ha 0.06–0.09 kg/ha	Ground application only. Aerial application for a salvage treatment for sesbania pea. NSW (Macintyre Valley) and QLD registration only.
Sethoxydim	A	186 g/L EC	1.0 L/ha	Apply when most grass weeds are in the 2–6 leaf stage and are actively growing. Refer to label for details.
Trifloxysulfuron sodium	B	750 g/kg WDG	0.015 kg/ha or 0.03 kg/ha	Controls certain broadleaf weeds and suppresses Nutgrass. Use the low rate for over-the-top application from 2–8 leaf stage or as a directed spray until row closure. Apply the high rate as a directed application only.

Table 29. Weed control pre harvest

Active ingredient	Mode of Action Group	Concentration and formulation	Application rate of product	Comments
Chlorthal dimethyl	D	900 g/kg WDG	6.0–11.0 kg/ha	Controls some annual grasses and a wide range of broadleaf weeds. The higher range is recommended for heavier soil types. Refer to label.
Glyphosate	M	360 g/L AC, EC, SC, L	1.25–2.5 L/ha	Controls Bathurst burr, Noogoora burr, winter annual weeds. Use higher rates for Nutgrass control. May be applied alone or with harvest aid. Apply when 60% bolls are open.
		450 g/L AC, L	1.0–2.0 L/ha	
		480 g/L AC	0.375–2.25 L/ha	
		500 g/L AC, EC	0.33–2.16 L/ha	
Glyphosate	M	540 g/L AC	0.32–2.0 L/ha	Registered for use in Roundup Ready® cotton and Roundup Ready Flex® cotton. Apply when 60% bolls are open. For nutgrass suppression use high rate only.
		570 g/L AC	0.725–1.6 L/ha	
		680 g/kg WDG	0.66–1.30 kg/ha	
Glyphosate	M	690 g/kg WDG	0.71–1.42 kg/ha	Registered for use in Roundup Ready® cotton and Roundup Ready Flex® cotton. Apply when 60% bolls are open. For nutgrass suppression use high rate only.
		510 g/L AC	0.34–1.4 L/ha	

Table 30. Herbicide trade names and marketers — Registered chemicals as at 15 Oct 2009

Active ingredient	Mode of Action Group	Concentration and formulation	Trade name	Marketed by
2,4-D present as the isopropylamine salt	I	225 g/L AC	Aminoz	Sanonda
		225 g/L AC	Smash	ChemAg
		300 g/L AC	2,4-D 300	Ospray
		300 g/L AC	2,4-D Amine 300	United Farmers Co-op
		300 g/L AC	2,4-D IPA 300	Halley
		300 g/L AC	2,4-D IPA 300	Rygel
		300 g/L AC	2,4-D IPA 300	Tradelands
		300 g/L AC	Amine 300	Conquest
		300 g/L AC	Amine 300	Sipcam
		300 g/L AC	Amine 300	Titan
		300 g/L AC	Amine 300	Genfarm
		300 g/L AC	Abound	Dow Agrosiences
		300 g/L AC	Cobber	Crop Care
		300 g/L AC	Crown 2,4-D IPA	Pacific Agrosiences
		300 g/L AC	Glymate 300	Generex
		300 g/L AC	Inca 300	Proterra
		300 g/L AC	Ken-Star 300	Kenso
		300 g/L AC	Mate 300	Growchoice
		300 g/L AC	Pura Amine 300	Hextar
		Amitrole + ammonium thiocyanate	Q	250 g/L + 220 g/L SC
250 g/L + 220 g/L SC	Amitrole T			Nufarm
250 g/L + 220 g/L SC	Weeddeath			Cyndan
Amitrole + paraquat	Q + L	250 g/L + 125 g/L	Alliance	Crop Care
Bromoxynil	C	200 g/L EC	Bromo 200	Agriwest
		200 g/L EC	Bromicide 200	Nufarm
		200 g/L EC	Bromox 200	ChemAg
		200 g/L EC	Bromoxynil 200	4Farmers
		200 g/L EC	Bromoxynil 200	Accensi
		200 g/L EC	Bromoxynil 200	Genfarm
		200 g/L EC	Bromoxynil 200	Titan
		200 g/L EC	Firefighter	Ozspray
Butroxydim	A	250 g/kg WDG	Factor WG	Crop Care



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Herbicides

Table 30. Herbicide trade names and marketers (continued)

Active ingredient	Mode of Action Group	Concentration and formulation	Trade name	Marketed by
Carfentrazone-ethyl	G	240 g/L EC	Hammer	Crop Care
		240 g/L EC	Task	Nufarm
Chlorthal dimethyl	D	900 g/kg WDG	Dacthal 900 WG	Crop Care
Clethodim	A	240 g/L EC	Blade 240	United Farmers
		240 g/L EC	Cleodim	Grow Choice
		240 g/L EC	Cletho 240	Sanplus
		240 g/L EC	Cletho 240 EC	Kenso Agcare
		240 g/L EC	Clethodim	Chemforce
		240 g/L EC	Clethodim	Generex
		240 g/L EC	Clethodim	Rygel
		240 g/L EC	Clethodim	Whitestar Ag Product Services
		240 g/L EC	Clethodim 240	Genfarm
		240 g/L EC	Clethodim 240 EC	4Farmers
		240 g/L EC	Clethodim 240 EC	Agri West
		240 g/L EC	Clethodim 240 EC	Agroshine
		240 g/L EC	Clethodim 240 EC	Nisso BASF
		240 g/L EC	Clethodim 240 EC	Crop Smart
		240 g/L EC	Clethodim 240 EC	Innova
		240 g/L EC	Clethodim 240 EC	Ospray
		240 g/L EC	Clethodim 240 EC	Titan
		240 g/L EC	Grasidim	Sipcam
		240 g/L EC	Innova	Syngenta
		240 g/L EC	Nissodim	Nisso BASF
		240 g/L EC	Nitro 240	Conquest
		240 g/L EC	Platinum	Farmoz
		240 g/L EC	Select	Sumitomo Chemicals
		240 g/L EC	Sequence	Nufarm
240 g/L EC	Status	Sumitomo		
240 g/L EC	Uproot	UPL		
Dicamba	I	500 g/L AC	Cutlass 500	Farmoz
		500 g/L AC	Conquesta 500 AC	Conquest
		500 g/L AC	Dicamba 500	Accensi
		500 g/L AC	Dicamba 500	ChemAg
		500 g/L AC	Dicamba 500	Choice
		500 g/L AC	Dicamba 500	Genfarm
		500 g/L AC	Dicamba 500	Kenso Agcare
		500 g/L AC	Dicamba 500	Ospray
		500 g/L AC	Dicamba 500	Titan
		500 g/L AC	Kamba 500	Nufarm
		700 g/kg WDG	Cadence	Syngenta
		700 g/kg WDG	Cambagran	Tradelands
700 g/kg WDG	Dicamba	Titan		
Diuron	C	500 g/L SC	various for multiple products	various for multiple products
		900 g/kg DF	Diuron 900 DF	4Farmers
		900 g/kg DF	Diuron DF	Nufarm
		900 g/kg WDG	various for multiple products	various for multiple products
Fluazifop-p	A	128 g/L EC	Fusilade Forte	Syngenta
		212 g/L EC	Flazz	Agriwest
		212 g/L EC	Fluazifop	Genfarm
		212 g/L EC	Fuziler	Ospray
		212 g/kg WDG	Fluazifop-P	Tradelands
Fluometuron	C	500 g/L SC	Cotoran SC	Farmoz
		500g/L SC	Fluometuron 500 SC	CMStrade
		500 g/kg WDG	Fluometuron 500 WG	CMStrade
		900 g/kg WDG	Cotoran 900 WG	Farmoz
		900 g/kg WDG	Fluometuron 900 WDG	Farmoz
		900 g/kg DF	Nu-Tron 900 DF	Nufarm
Fluometuron + prometryn	C	250 g/L + 250 g/L AC	Bandit Liquid	Crop Care
		250 g/L + 250 g/L AC	Convoy	Nufarm
		250 g/L + 250 g/L SC	Flupromix 500	Sipcam
		250 g/L + 250 g/L SC	Cotogard SC	Farmoz
		440 g/L + 440 g/L WDG	Bandit WG	Crop Care
		440 g/L + 440 g/L DF	Convoy DF	Nufarm
		440 g/L + 440 G/L WDG	Cotogard WG	Farmoz
		450 g/L + 450 g/L WDG	Flupromix	Sipcam
Flumioxazin	G	500 g/kg WDG	Pledge	Sumitomo Chemicals

Table 30. Herbicide trade names and marketers (continued)

Active ingredient	Mode of Action Group	Concentration and formulation	Trade name	Marketed by
Fluroxypyr	I	200 g/L EC	Acclaim	Sipcam Pacific
		200 g/L EC	Comet 200	Nufarm
		200 g/L EC	Decoy 200	Crop Care
		200 g/L EC	Flagship 200	Farmoz
		200 g/L EC	Fluroken 200	Kenso Agcare
		200 g/L EC	Fluroxypyr 200	Genfarm
		200 g/L EC	Fluroxypyr 200	Innova
		200 g/L EC	Fluroxypyr 200	Ospray
		200 g/L EC	Fluroxypyr 200	Titan
		200 g/L EC	Neon 200	Conquest
		200 g/L EC	Prostas	Proterra
		200 g/L EC	Restrain	Grow Choice
		200 g/L EC	Staroxy 200	eChem
		200 g/L EC	Uni-Rane	UPL
		333 g/L EC	Starane Advanced	Dow AgroSciences
400 g/L EC	Comet 400	Nufarm		
Glufosinate–ammonium	N	200 g/L SC	Liberty 200	Bayer CropScience
Glyphosate	M	360 g/L AC, EC, L, SC	various for multiple products	various for multiple products
		450 g/L AC, L	various for multiple products	various for multiple products
		470 g/L AC	Glyphosate 470	4Farmers
		480 g/L AC	Ripper	Dow Agrosiences
		490 g/L AC	various for multiple products	various for multiple products
		500 g/L AC	Ken-Up Gold 500	Kenso Agcare
		500 g/L EC	Touchdown Hitech	Syngenta
		510 g/L AC	various for multiple products	various for multiple products
		540 g/kg AC	various for multiple products	various for multiple products
		570 g/ka AC	Eradicator Power	Chemag
		680 g/kg WDG	Ken-up Dry	Biotis
		680 g/kg WDG	Klin-Up	Biotis
		680 g/kg WDG	Roundup Dry	Nufarm
680 g/kg WDG	Wynca	Biotis		
690 g/kg WDG	Roundup Ready Herbicide	Nufarm		
Halosulfuron–methyl	B	750 g/kg DF	Nut-buster	agVantage
		750 g/kg DF	Sempra	Nufarm
		750 g/kg WDG	Nutgrass Killer	ChemAg
		750 g/kg WDG	Halo 750 WG	ChemAg
		750 g/kg WDG	Halosulfuron	Gulf Ag
Haloxypop-p		520 g/L EC	Halomac	Macsread
		520 g/L EC	Haloxypop 520	ChemAg
		520 g/L EC	Haloxypop 520	Grow Choice
		520 g/L EC	Haloxypop 520	Generex
		520 g/L EC	Haloxyken 520	Kenso
		520 g/L EC	Harpoon	Agriwest
		520 g/L EC	Inquest	Sipcam
Haloxypop-r	A	130 g/L EC	Asset	Nufarm
		520 g/L EC	Haloxypop 520	4Farmers
		520 g/L EC	Haloxypop 520	Chemforce
		520 g/L EC	Haloxypop 520 EC	Ospray
		520 g/L EC	Recon 550	Conquest
		520 g/L EC	Verdict 520	Dow AgroSciences
Imazapyr + glyphosate	B + M	150 g/L + 150 g/L AC	Arsenal Xpress	Nufarm
Metolachlor	K	720 g/L EC	Chaser	Ospray
		720 g/L EC	Clincher	Farmoz
		720 g/L EC	Bouncer	Nufarm
		720 g/L EC	Metal 720	ChemAg
		720 g/L EC	Metoken 720	Kenso Agcare
		720 g/L EC	Metolachlor 720	4Farmers
		720 g/L EC	Metolachlor 720	Chem force
		720 g/L EC	Metolachlor 720	Conquest
		720 g/L EC	Metolachlor 720	Grow Choice
		720 g/L EC	Metolachlor 720	United Farmers Co-op
		720 g/L EC	Spruka 720	Proterra
		720 g/L EC	Strada	Sipcam
		720 g/L EC	Forge	Genfarm
		960 g/L EC	Clincher Plus	Farmoz
960 g/L EC	Metolachlor 960	Titan		

Table 30. Herbicide trade names and marketers (continued)

Active ingredient	Mode of Action Group	Concentration and formulation	Trade name	Marketed by
MSMA	Z	720 g/L EC	MSMA	Barmac
		800 g/L L	Daconate	Crop Care
		800 g/L L	Megalith	Agriwest
		800 g/L SC	MSMA	ChemAg
MSMA	Z	720 g/L EC	MSMA	Barmac
		800 g/L L	Daconate	Crop Care
		800 g/L L	Megalith	Agriwest
		800 g/L SC	MSMA	ChemAg
Norflurazon	F	800 g/kg DF	Zoliar DF	Syngenta
Oxyfluorfen	G	240 g/L EC	Convert 240 EC	Ospray
		240 g/L EC	Cavalier	Farmoz
		240 g/L EC	Encore 240	Conquest
		240 g/L EC	Goal	Dow AgroSciences
		240 g/L EC	Govern	Sipcam Pacific
		240 g/L EC	Ox 240	Kenso Agcare
		240 g/L EC	Oxen	Chemag
		240 g/L EC	Oxxel	Agriwest
		240 g/L EC	Oxy 240 EC	CMStrade
		240 g/L EC	Oxyfluorfen 240 EC	4 Farmers
		240 g/L EC	Oxyfluorfen 240 EC	Genfarm
		240 g/L EC	Oxyfluorfen 240 EC	Innova
		240 g/L EC	Oxyfluorfen 240 EC	Ospray
		240 g/L EC	Oxyfluorfen 240 EC	OzCrop
		240 g/L EC	Oxyfluorfen 240 EC	Titan
		240 g/L EC	Oxyfluorfen 240 EC	Accensi
		240 g/L EC	Oxyfluorfen 240 EC	United Farmers Co-op
		240 g/L EC	Point	Kendon Chemicals
		240 g/L EC	Striker	Nufarm
		Paraquat	L	250 g/L SC
250 g/L SC	Explode 250			Conquest
250 g/L SC	Gramoxone 250			Syngenta
250 g/L SC	Inferno			Sipcam Pacific
250 g/L SC	Nuquat 250			Nufarm
250 g/L SC	Para-Ken 250			Kenso Agcare
250 g/L SC	Paraquat 250			4 Farmers
250 g/L SC	Paraquat 250			ChemAg
250 g/L SC	Paraquat 250			Chem Force
250 g/L SC	Paraquat 250			Farmcochem
250 g/L SC	Paraquat 250			Forward Australia
250 g/L SC	Paraquat 250			Genfarm
250 g/L SC	Paraquat 250			Grow Choice
250 g/L SC	Paraquat 250			Halley
250 g/L SC	Paraquat 250			Summit Agro
250 g/L SC	Paraquat 250			Ospray
250 g/L SC	Paraquat 250			Rygel
250 g/L SC	Paraquat 250			Titan
250 g/L SC	Paraquat 250			United Farmers
250 g/L SC	Quash			Hextar
250 g/L SC	Sinmosa	Sinon Australia		
250 g/L SC	Shirquat 250	Crop Care		
250 g/L SC	Sprayquat 250	Kendon		
250 g/L SC	Spraytop 250 SL	Farmoz		
Paraquat + diquat	L	135 g/L + 115 g/L AC	Revolver	Nufarm
		135 g/L + 115 g/L AC	Spray.Seed 250	Syngenta
		135 g/L + 115 g/L AC	Spraykill 250	Chem Ag
		135 g/L + 115 g/L AC	Sprayout 250	Ospray
		135 g/L + 115 g/L AC	Di-Par 250	Genfarm
		135 g/L + 115 g/L SC	Combik 250	Sinon Australia
		135 g/L + 115 g/L SC	Brown Out 250	4Farmers
		135 g/L + 115 g/L SC	Di-Par 250	Genfarm
		135 g/L + 115 g/L SC	Alarm	Sipcam Pacific
		135 g/L + 115 g/L SC	EOS	Titan Ag
		135 g/L + 115 g/L SC	Paradym 250	Ronic Internationals
		135 g/L + 115 g/L SC	Premier 250	Halley
		135 g/L + 115 g/L SC	Rygel Pre-Seed	Rygel
		135 g/L + 115 g/L SC	Scorcher 250	Conquest
		135 g/L + 115 g/L SC	Speedy 250	Kenso
		135 g/L + 115 g/L SC	Spray & Sow	Farmoz
135 g/L + 115 g/L SC	Uni-Spray	United Phosphorus Limited		
135 g/L + 115 g/L SC	Wildfire	United Farmers		

Table 30. Herbicide trade names and marketers (continued)

Active ingredient	Mode of Action Group	Concentration and formulation	Trade name	Marketed by
Pendimethalin	D	330 g/L EC	Charger 330 EC	Conquest
		330 g/L EC	Cyclone 330	ChemAg
		330 g/L EC	Panida Grande	Sipcam Pacific
		330 g/L EC	Pendi 330	Kenso Agcare
		330 g/L EC	Pendimethalin 330 EC	4 Farmers
		330 g/L EC	Pendimethalin 330 EC	Allfire
		330 g/L EC	Pendimethalin 330 EC	Halley
		330 g/L EC	Pendimethalin 330 EC	Ospray
		330 g/L EC	Pendimethalin 330 EC	Rallis India
		330 g/L EC	Pendimethalin 330 EC	Summit Agro
		330 g/L EC	Pendimethalin 330 EC	Titan
		330 g/L EC	Pendimethalin 330 EC	United Farmers
		330 g/L EC	Pendimethex	Farmoz
		330 g/L EC	Rifle 330	Nufarm
		330 g/L EC	Stomp 330 EC	Crop Care
		440 g/L EC	Cyclone 440	ChemAg
		440 g/L EC	Rifle 440	Nufarm
440 g/L EC	Stomp 440	Crop Care		
455 g/L AC	Stomp*Xtra	Crop Care		
Prometryn	C	500 g/L SC	Gesagard 500 SC	Syngenta
		500 g/L SC	Promesip 500	Sipcam
		500 g/L SC	Prometrex 500 SC	Farmoz
		500 g/L SC	Prometryn 500	Farmoz
		500 g/L SC	Prometryn 500	Ospray
		500 g/L SC	Prometryn 500 SC	CMStrade
		900 g/kg DF	Prometryn 900 DF	Nufarm
		900 g/kg WDG	Gesagard 900 WG	Syngenta
		900 g/kg WDG	Prometrex 900 WDG	Farmoz
900 g/kg WDG	Proton 900 WG	Crop Care		
Propaquizafop	A	100 g/L EC	Correct 100 EC	Bayer CropScience
Pyriithiobac sodium	B	850 g/kg SP	Staple	DuPont
Sethoxydim	A	186 g/L EC	Sertin 186 EC	Bayer CropScience
s-Metolachlor	K	960 g/L EC	Dual Gold	Syngenta
Triclopyr	I	600 g/L EC	Garlon 600	Dow AgroSciences
		600 g/L EC	Grando 600	Crop Care
		600 g/L EC	Hurricane 600	ChemAg
		600 g/L EC	Invader 600	Nufarm
		600 g/L EC	Maca 600	Conquest
		600 g/L EC	Melon 600	Agronomics
		600 g/L EC	Pyrmac	Macspread
		600 g/L EC	Triclon 600	Grow Choice
		600 g/L EC	Triclopyr 600	4Farmers
		600 g/L EC	Triclopyr 600	Chemforce
		600 g/L EC	Triclopyr 600	Crop Smart
		600 g/L EC	Triclopyr 600	Generex
		600 g/L EC	Triclopyr 600	Halley
		600 g/L EC	Triclopyr 600	Innova
		600 g/L EC	Triclopyr 600	Kenso Agcare
		600 g/L EC	Triclopyr 600	Ospray
		600 g/L EC	Triclopyr 600	Superway
600 g/L EC	Triclopyr 600	Titan		
600 g/L EC	Triclopyr 600	United Farmers		
600 g/L EC	Trident 600	Genfarm		
Trifloxysulfuron sodium	B	750 g/kg WDG	Envoke	Syngenta
Trifluralin	D	480 g/L EC	Treflan 480	Crop Care
		480 g/L EC	various names for multiple products	various names for multiple products
		500 g/L EC	Triflur xcel	Nufarm