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.

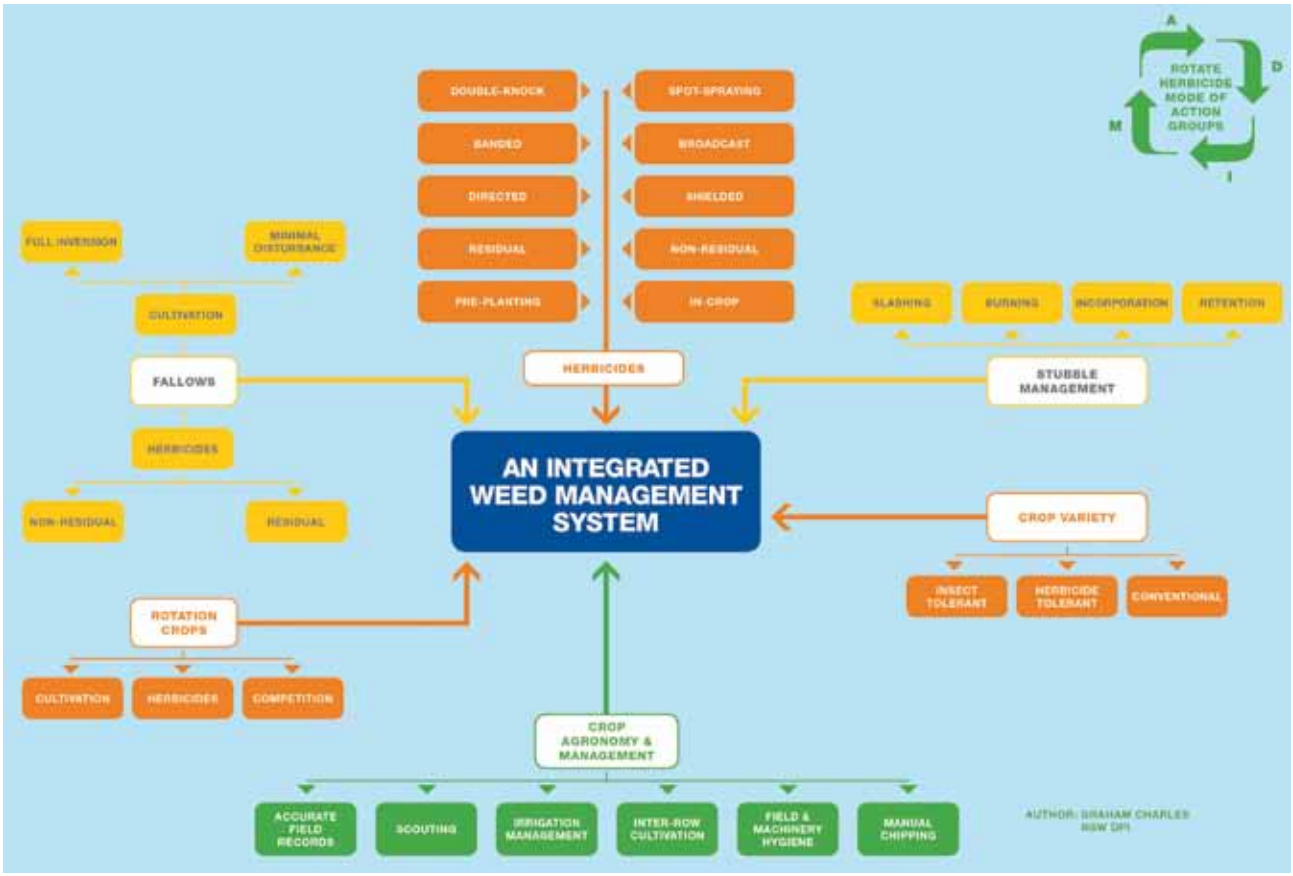
Why use IWM in cotton systems?

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.
- 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

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



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 and Roundup Ready Flex cottons. See pages 99 and 102 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.

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.

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 27 page 105. For additional information regarding the plant back restrictions of these products for cotton, refer to Tables 21 to 24 on pages 92 and 93.

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 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 on previous page.

Encourage insect predation

Insects 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 it 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 19 Impact of insecticides and miticides on predators, parasitoids and bees in cotton, pages 58–59, for insecticide ratings.

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

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)
	40	1–2 leaf	(131)	early flowering	(862)
Medium broadleaf weeds such as; bladder ketmia, mintweed, Boggabri weed	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)
	20	1–2 leaf	(139)	squaring	(627)
	40	1–2 leaf	(131)	squaring	(880)
Grass weeds such as; awnless barnyard grass, liverseed grass, Johnson's grass	20	–	–	–	–
	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)

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.

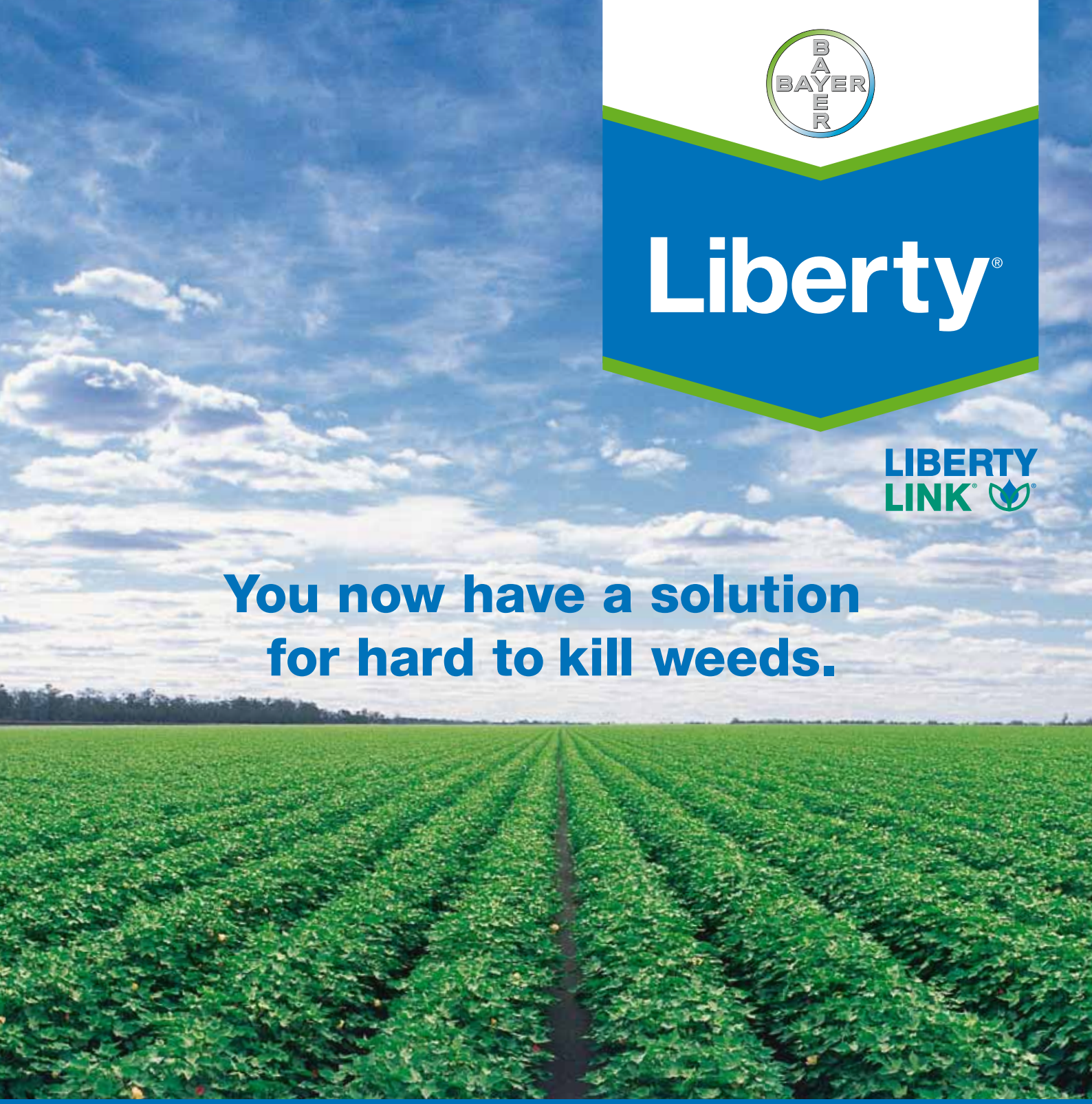
Prevent weed establishment

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 table above 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.



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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. 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; and,
- 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.

IWM Approach to problem weeds

Duncan Weir, DEEDI

Barnyard grass

Barnyard Grass – *Echinochloa crus-galli*
Awnless Barnyard Grass – *Echinochloa colona*

Identification

There are two species of this grass, barnyard grass (*Echinochloa crus-galli*) and awnless barnyard grass (*Echinochloa colona*). Barnyard grass has a purplish base, slender hairless stems, is tufted, and is usually erect growing to 0.9 m tall. Seeds have awns up to 50mm in length and are generally pale brown in colour. Awnless barnyard grass is semi-erect growing to 0.6 m tall, has a purplish base, is tufted and has slender hairless stems. The seed generally does not have awns, is white in colour and it can have purplish-red bands on its leaves. Both types do not have ligules.

Weediness

Barnyard grass germinates any time throughout spring and summer following heavy rain or flooding. They grow very rapidly following establishment, compete strongly with crops and seeding is prolific. They are spread by water through irrigation, flooding or the river. They will grow in a wide range of soil types particularly heavy soils which are periodically flooded.

There is a high risk of barnyard grass developing glyphosate resistance particularly when growers are using minimum or zero till systems. In some areas it has developed resistance to group C herbicides.

Control hints

- Target small weeds 2-3 leaves;
- Use a double knock technique especially for dense populations;
- Include crop rotations and different herbicide groups in its control; and,
- Include cultivation as a weed management tool.

Barnyard grass. (Michael Widderick, DEEDI)

Liverseed grass

Urochloa panicoide
Other common names: Urochloa

Identification

Liverseed grass has broad, pale yellow –green leaves with hairs on the leaf margins and sheath. Its stems tend to lie flat with the growing ends bending up into an erect position to a height of 80 cm. Can for tufts or dense leaf matt areas. It takes root where the stem nodes touch the ground. The seed head has two to seven spikes and is about 10 cm long.

Weediness

Liverseed grass generally emerges in one large flush in late spring following a good rainfall event. Once established it grows rapidly forming a dense mat competing strongly with crops. It readily sets seed in summer.

Liverseed grass has developed resistance to the Group C herbicide atrazine in southern Queensland.

Control hints

- Target small weeds 2-3 leaves;
- Use a double knock technique especially for dense populations;
- Include crop rotations and different herbicide groups in its control; and,
- Include cultivation as a weed management tool.

Liverseed grass. (Michael Widderick, DEEDI)

Cowvine

Ipomoea lonchophylla

Other common names: Peach vine, Bindweed

Seedling leaves are v shaped up to 35 mm long, young stems may be purplish in colour. Mature leaves tend to be triangle to egg shaped, have notched bases, wavy margins which tend to fold in and are up to 100mm long. Cowvine is a prostrate non twining vine with white, trumpet shaped flowers.

Weediness

Cowvine is a summer growing annual or biannual plant which can germinate all year round. Flowering starts very early and will continue all year. Prefers heavy clay soils and can for dense stands following floods or heavy rain. It is suited to irrigation cropping and angles in cultivation and harvesting equipment.

Control hints

- Target small weeds 2-3 leaves; and,
- Due to propensity to cause issues at harvest, consider manual chipping if problem develops.

Polymeria

Polymeria longifolia

Other common names: Peak Downs curse, Clumped bindweed

Identification

Seedlings have squarish leaves that are slightly notched at the tip and stem base. Main vein are predominant.. Leaves are long and narrow, grey-green to silver in colour with very short stalks. Plants are erect, up to 50cm high and have silky hairs. Flowers are bell shaped to 20mm and are generally pale pink. Polymeria also readily reproduces from vegetative fragments and can produce a deep extensive rhizome system.

Weediness

Polymeria is a perennial weed which can readily reproduce from small vegetative fragments as well as from seeds. It rapidly grows through spring and summer although can survive over winter under favourable conditions. Flowering can occur all year round and can produce large numbers of seeds. It is extremely drought resistant and forms dense patches. Very difficult to control by cultivation as it tends to spread the problem rather than control it.

Sowthistle. (Michael Widderick, DEEDI)

Sowthistle flower. (Michael Widderick, DEEDI)

Control hints

- Wide spread, on farm anecdotal observations suggest polymeria is best managed using repeated applications of glyphosate. The addition of a non-ionic surfactant or Pulse Penetrate may improve efficiency.

Common sowthistle

Sonchus oleraceus

Other common names: Milk thistle, Sowthistle, Milkweed

Identification

Seedling leaves are small and oval to 6mm round. First true leaves are round and have spines on the margins. Adult leaves are dark green, up to 35cm long, are well lobed and have small soft spines. Lower leaves for a rosette with the stem while upper leaves clasp the stem. Sowthistle produces a milky sap, has a deep tap root and can grow to 1.8m tall. Flowers are bright yellow and have a swollen base. Seeds have white silky hairs.

Weediness

Sowthistle is an annual plant normally growing through winter and spring. With the move to minimal or zero tillage systems, it has become a problem all year round particularly in fallow fields. Several populations have been identified showing resistance to Group B herbicides (chlorsulfuron). It is a very profuse seed producer and is spread widely by wind.

Control hints

- Implement an integrated weed management strategy;
- Rotate different herbicide groups to reduce the risk of resistance developing;
- Use a variety of cultural weed control tools ie different crops, tillage, chipping; and,
- Control survivors to prevent seed set

Nutgrass

Cyperus rotundus

Identification

Nutgrass normally reproduces from a tuber, new shoots are dark green in colour, narrow, erect and taper to a sharp point. Form grass like mats normally up to 30 cm high but can be higher. Produces extensive underground rhizomes and tubers. Seed heads are brown and are attached to a triangular stem with several leaves near the top. Tubers are brown, oval to round and vary in size up to 20mm long. Nut grass is susceptible to frost and will burn off in winter only to re-emerge in spring.

Weediness

Nutgrass spreads extremely quickly with each tuber producing as many as 2000 new tuber in a single season. Tubers are readily spread by cultivation and it competes strongly with crops.

Control hints

- A long term IWM plan must be applied to manage this weed;
- Nutgrass can be controlled using a combination of cultivation, residual herbicides, contact herbicides and crop competition;
- It is important that there is a whole of farm plan and a variety of control methods used; and,
- Farm hygiene plays a critical role in preventing the weed being move around the farm, in particular on machinery.

Feathertop Rhodes grass

Chloris virgata

Identification

Seedlings are erect with the stem having a flattened appearance. Leaf blade margins have tufts of long hairs and where the blade joins the leaf sheath. Mature plants are tufted with erect and semi erect branches. Stems are capable of producing roots when the stem joints touch the ground. Leaf blades are bluish-green up 25 cm long and the joints are hairless. Seed heads are erect and silvery white and are feathery in appearance. It can often be confused with barnyard grass during the pre-tillering stage.

Weediness

There are only a few herbicides registered for control of feathertop rhodes grass. It is not particularly susceptible to glyphosate particularly after it is established. Generally grows between spring and autumn but germinate all year around given favourable conditions. It tends to be a problem in zero till systems.

Control hints

- Control of feathertop rhodes grass requires an integrated approach as no single management application is completely effective;
- Targeting small actively growing plants gives the best chemical response however it is highly recommended that a double knock strategy is implemented to maximise effectiveness;
- Cultivation can be effective but care must be taken to prevent the plant from being transplanted; and,
- Seeds need to be buried more than 10 cm to be effective.

Feathertop Rhodes grass. (Michael Widderick, DEEDI)

Flaxleaf Fleabane

Conyza bonariensis

Identification

Seedling leaves are elongated oval (3 mm x 1 mm), bluish-green in colour and hairless. First true leaves are circular and covered in hairs. Leaves are elongated (up to 10cm), softly haired, wavy notched margins and form a rosette. Mature plants are erect, multi-branched and up to 1 m tall. Flowering heads are pale green, 10 mm wide and form fluffy white balls when open. Seed is very small and have white hairs for wind dispersion

Weediness

Flaxleaf Fleabane is relatively tolerant to glyphosate particularly when it is well established. Mature plants are very difficult to control. It produces huge numbers of seed (up to 110 000) per plant if left to mature. It will germinate through autumn, winter and spring, and will flower from spring to autumn. Flaxleaf Fleabane will germinate in the presence of light and emerge from the top 10mm of soil. It is becoming a very serious weed of minimal till, zero till systems.

Control hints

- Will require a integrated weed management program based on good agronomy;
- Closely monitor fields and treat seedlings early;
- Use a variety of chemistry and rotate herbicide groups and modes of action; and,
- Control survivors and prevent them from setting seed,

Flaxleaf fleabane. (Susan Maas, DEEDI)

TABLE 21. 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, barley, 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 Legume Crops: lupins Other Field Crops: forage sorghum, potatoes, TT canola, sugarcane Pastures: lucerne, grass pastures	6 months	Following treatments of up to 1.4kg/ha
			18 months	Following treatments of 1.4kg/ha to 3.3kg/ha
Primextra Gold	atrazine + s-metolachlor	Cereal Crops: sorghum, maize. Other Field Crops: sugarcane	6 months	When rates up to 3.2 L/ha are used.
			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 750SG	clopyralid	Cereal Crops: wheat, barley, oats, triticale Other Field Crops: canola Pastures and Fallows	3 months	When rates up to 30g/ha are used.
			6 months	When rates of >30g-120g/ha are used.
			24 months	When rates above 120g/ha are used. At least 100 mm rainfall during plant back period,
diuron	diuron	Cereal Crops: wheat, barley, oats, triticale, cereal rye Legumes: lupins Pastures: perennial grass seed crops, lucerne	Spring the following year	Cotton, corn and sorghum may be planted in spring of the following year
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	6 months	When rates up to 25g/ha are used
			9 months	When rates of up to 50g/ha are used On deep, black earth with no impermeable sub horizon on the top 30cm
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.
Spinnaker	imazethapyr	Legume Crops: chickpeas, faba beans, field peas, mungbeans, soybeans Other Field Crops: peanuts Pastures: lucerne, serradella, sub clovers	22 months.	Dryland cotton.,
			18 months.	Irrigated only. (Providing rainfall and irrigation exceeds 2000mm)
Tordon 75D	picloram + 2,4-D	Cereal Crops: wheat, barley, oats, triticale, sorghum, maize Other Field Crops: sugarcane Pastures: Pastures	12 months	Do not rotate susceptible plants until an adequately sensitive bioassay or chemical test shows that no detectable picloram is present within the soil.
Tordon 242	picloram + MCPA		12 months	Do not use on land to be cultivated for growing susceptible crops within 12 months of applying
simazine	simazine	Legume Crops: chickpeas, faba beans, lupins Fruit & vegetable crops, Forestry & Ornamental Other Field Crops: TT canola Pastures: lucerne, sub clover, perennial grasses	9 months	When up to 2.5kg/ha are used. When rates exceed 2.5kg/ha plantings may not be possible for very long periods afterwards.
Logran	triasulfuron	Cereal Crops: wheat, barley, oats	15 months Soil pH Less than 6.5	700 mm rainfall between application and sowing the plant back crop.
			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 22: 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			fluroxypyr 200 g/L			triclopyr 600 g/L
Rate L or g/ha	0.56	0.56-1.1	1.1-1.7	1.1	1.1-2.3	2.3-3.4	140	200	400	0.375	0.75	1.5	
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 23: Herbicides with unknown plant back periods to cotton

Trade name	Active ingredient	Registered for use in;
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 34 months, May be affected by Climatic conditions
Hussar	mefenpyr-diethyl + iodosulfuron-methyl sodium	Cereal Crops: wheat 12 months. Rainfall of less than 500mm following Hussar use may result in extended re-cropping intervals for summer crops sown in the following season.
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 12 months. Rainfall of less than 500mm following Atlantis use may result in extended re-cropping intervals for summer crops sown in the following year.
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 24: Cotton herbicide plant backs to rotation crops

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	Adzuki 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	8	FH	FH	8	FH	8	8	8	8
diuron	24	24	24	24	24	24	24	24	24	24	24	24	24	24	12	24	24	24	24	24	24	24
fluometuron	6	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	6
halosulfuron-methyl	24	2	24	24	2	24	3	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
metolachlor	6	0	6	6	01	6	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	NI	27	NI	9	NI	18	18	27
pendimethalin	6	0[3]	12	12	12	NI	NI	NI	NI	NI	NI	NI	NI	NI	6	NI	NI	NI	6	NI	NI	NI
prometryn	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
pyrithiobac sodium	5	22	NR	5	22	NR	5	NR	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	6	0	6	6	6	0
trifloxysulfuron sodium	6	22	22	6	22	22	6	22	18	22	7	22	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	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

The potential for herbicide resistance in cotton farming systems

Jeff Werth and David Thornby, Department of Employment, Economic Development and Innovation (DEEDI)
Tracey Leven, CRDC

Glyphosate tolerant technology (Roundup Ready and Roundup Ready Flex) has been in use in cotton systems for approximately 10 years and is now widely adopted. To date, there is only one documented case of a glyphosate resistant species in an Australian cotton farming system. This case of barnyard grass was found in a dryland cotton rotation system.

Although there is still a diversity of herbicides used in conjunction with cultivation and other cultural practices, there is an increasingly reliance on glyphosate for the majority of weed control in cotton production systems. This reliance not only occurs in Roundup Ready/Flex cotton but also in conventional cotton and other crops for fallow weed control. This reliance on glyphosate increases the risk of glyphosate resistance development.

The cotton growing regions are closely aligned with the northern grains region. Across this area, there are 16 weed species that have developed resistance to at least one herbicide mode of action. Most recently, liverseed grass with resistance to glyphosate has been confirmed. Table 25 summarises the herbicide resistance status of weeds in the north to each of the herbicide modes of action that are available for use in cotton. This list clearly illustrates that if strategies used for weed management in cotton become overly reliant on individual herbicides, resistance can occur.

Development of herbicide resistant weed populations has been most strongly associated with minimal or zero tillage cropping systems, and where there is only limited rotation between summer and winter crops. A recent risk assessment of species using characteristics that promote the development of resistance, identified a number of weeds considered to be at high risk of developing resistance (see page 95). These species generally produce a large amount of seed and are often present in high numbers in the field when they are sprayed. If one or only a few herbicide groups are continuously applied to a weed population, a high selection pressure is placed on that population thus increasing the risk of resistance development.

The population dynamics of two weed species, barnyard grass (*Echinochloa crus-galli*) and liverseed grass (*Urochloa panicoides*) were modelled under a range of weed management strategies in an irrigated cotton system. The model used the results from experiments investigating the seed producing capabilities of the two species and their responses to glyphosate. Outputs from the model showed that the largest factor affecting resistance development was management, shown in Figure 8, when a glyphosate-only approach to weed control was taken, resistance was likely to occur. Timeframes for resistance

TABLE 25: Australian weeds with resistance to the Mode of Action (MoA) groups used in cotton

Mode of Action Group		Examples of cotton herbicides with the MoA	Australian weeds with resistance to the MoA (not to specific herbicides)	NSW	Qld	Other States
A	fop	fluazifop-p, haloxyfop-r, propaquizafop	Annual ryegrass	✓		✓
			Barley grass	✓		✓
			Paradoxa grass			✓
			Wild oat	✓	✓	✓
	dim	butroxydim, clethodim, sethoxydim	Annual ryegrass	✓	✓	
			Barley grass			✓
			Paradoxa grass	✓		
			Wild oat	✓	✓	✓
B	sulfonylurea	halosulfuron-methyl, trifloxy-sulfuron sodium	Annual ryegrass	✓		✓
			Barley grass			✓
			Wild oat			✓
			Northern barley grass	✓		
			African turnip weed		✓	
			Black bindweed		✓	
			Charlock	✓		
			Common sowthistle	✓	✓	
			Dirty Dora	✓		✓
			Indian hedge mustard	✓	✓	✓
			Paterson's curse			✓
			Prickly lettuce			
			Turnip weed	✓	✓	
			Wild radish	✓		✓
			Wild turnip			✓
		imazapyr	Annual ryegrass	✓		✓
			Indian hedge mustard			✓
			Prickly lettuce			✓
			Wild radish			✓
		pyrithiobac sodium				
C	urea	diuron, fluometuron	Annual ryegrass			✓
			Liverseed grass		✓	
		prometryn				
D	dinitroaniline	pendimethalin, trifluralin	Annual ryegrass	✓		✓
	benzoic acid	clorthal dimethyl				
F		norflurazon				
G		carfentrazone ethyl, oxyfluorfen				
I	phenoxy	2,4-D	Indian hedge mustard			✓
			Wild radish			✓
		dicamba, triclopyr, fluroxypyr				
K		metolachlor, s-metolachlor	Wild oat	✓		
L		paraquat, diquat	Barley grass			✓
			Northern barley grass			✓
			Silver grass			✓
M		glyphosate	Annual ryegrass	✓	✓	✓
			Barnyard grass	✓		
			Liverseed grass	✓		
N		glufosinate-ammonium				
Q		amitrole + ammonium thiocyanate	Annual ryegrass			✓
Z		MSMA				

TOP 10 SPECIES AT RISK OF DEVELOPING HERBICIDE RESISTANCE		
Rank	**Common name**	**Species rating (out of 10)**
1.	Sweet summer grass	8.2
2.	Flaxleaf fleabane	7.6
3.	Liverseed grass	7.2
4.	Feathertop rhodes grass	7.0
5.	Sowthistle	6.9
6.	Awnless barnyard grass	6.9
7.	Crowsfoot grass	6.3
8.	Paradoxa grass	6.3
9.	Barley grass	6.3
10.	Annual ryegrass	6.1

developing to the point of field control failures was in the vicinity of 12-17 years. When Roundup Ready technology was used together with another herbicide option, resistance development was delayed.

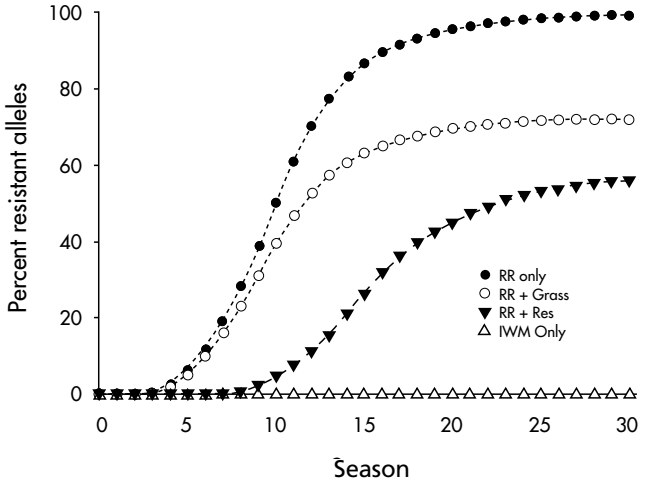
When it was used as part of a fully integrated weed management strategy, resistance was not predicted to develop over the 30 year period of the simulation. The weed management requirements of the Roundup Ready Flex Crop Management Plans (CMPs) are designed to ensure that the technology is used in an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

Making the fallows count

Generally, glyphosate is relied on more in the fallows than in Roundup Ready Flex cotton. No-till is now adopted widely in both cotton and grains systems, putting severe pressure on glyphosate to keep weeds, in particular grasses under control. Awnless barnyard grass (*Echinochloa colona*) a key weed of summer fallows and cotton crops, can have up to five or more emergences over the summer fallow period. If glyphosate alone was used to control each of these flushes, the timeframe for resistance development would be even lower than using glyphosate alone in Roundup Ready Flex.

The fallow creates an opportunity to use different herbicide groups. An example of this is the use of paraquat and

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



YEARS OF HERBICIDE APPLICATION BEFORE RESISTANCE EVOLVES		
Herbicide group	**Years of application**	**Herbicide resistance risk**
A (Fops, Dims, Dens).	6-8	High
B (SUs: Glean, Ally. IMIs: Flame, Spinnaker)	4	High
C (atrazine, prometryn, fluometuron).	10-15	Medium
D (trifluralin, pendamethalin)	10-15	Medium
F (norflurazon)	10	Medium
I (phenoxies)	not known	Medium*
L (paraquat/diquat)	15+	Medium*
M (glyphosate)	15+	Medium*
N (glufosinate)	not known	Medium*
Adapted from Preston et al, 1999		

paraquat+diquat as part of the "double knock" tactic. The double knock has various forms, however the main one for grass control is glyphosate followed by paraquat or paraquat+diquat up to 7 days later. This tactic as been proven effective on glyphosate resistant barnyard grass and can ensure that survivors of glyphosate applications are controlled. The ability of the double knock to prevent resistance is shown in Figure 9.

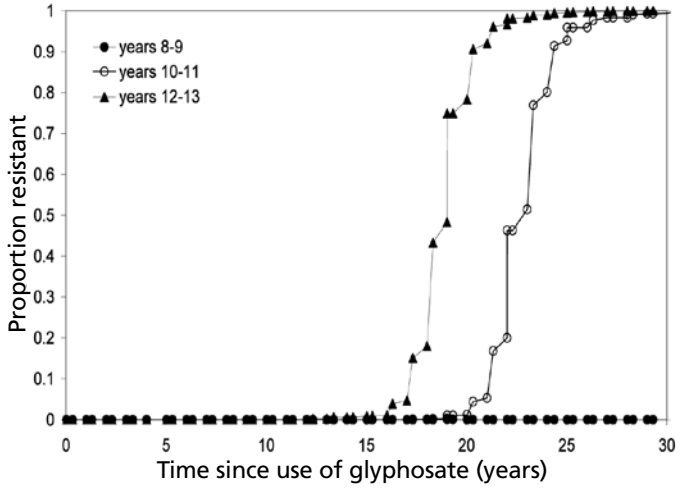
When the double knock is used each year on the main flush, the likelihood of resistance developing is almost eliminated. This makes it a valuable tactic to reduce the selection pressure on grasses in the fallow.

Putting it all together

When preparing a weed management plan it is important to consider the following points:

- What are the key weed species in each field, and how dense are they? Different species may require specific management. If the field is dense with weeds it is important that weed control does not rely on one herbicide (i.e. Roundup in Roundup Ready Flex cotton). If a field has a low weed pressure, careful monitoring also needs to be practiced.

FIGURE 9: Predicted evolution of glyphosate resistance in barnyard grass under zero-till summer fallows with reliance on glyphosate plus three double knock regimes: two years of double knock on every weed flush in the years specified, followed by double knock annually on the largest flush.



- What is the history of herbicide use in the field? Although glyphosate-tolerant cotton may have only been used in a field for a couple of years, it is important to know what herbicides have been used in other crops and fallows prior. Glyphosate may have been heavily relied upon in fallows long before the introduction of glyphosate-tolerant cotton.
- What herbicides are effective on the key weeds in each field, and when is the best time to use them? In the case of awnless barnyard grass, it is controlled well by glyphosate, paraquat, group A herbicides such as Verdict and some residual herbicides. In a rotation containing glyphosate-tolerant cotton, glyphosate will be used in-crop. However to minimise the glyphosate selection pressure, residual or post-emergent herbicides can also be used. It should also be noted that glyphosate should not be solely relied upon in fallow: this is an opportune time to use paraquat (group L) or perhaps even a residual (keeping in mind they have a medium resistance risk). The table on page 95 shows that Verdict (group A) has a high risk of developing resistance, so its use should be limited to in-crop applications rather than in fallow.
- Last but not least, when can tillage be used? There are a number of opportunities, particularly in irrigated cotton, where tillage can be used. These include pupae busting, incorporation of fertilisers, seed bed preparation and maintaining irrigation furrows. It is possible that these operations can be timed to combine with weed control measures. No herbicide resistance can evolve to 'cold hard steel'.

Looking for early signs of resistance

Herbicide resistance is normally present in 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 compared to 'normal' or susceptible individuals. 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 isolated 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 on this page. The more questions to which you have confidently answered 'Yes', the more a further investigation of possible resistance is warranted.

The online glyphosate resistance toolkit

You can now assess the level of risk of your own practices via the online risk assessment tool. This tool allows you to check what your current level of risk is for developing glyphosate-resistant weed populations on your farm. You can use it more than once, to rate different paddocks on your farm or to try out different scenarios. The tool allows you to enter information on your current practices (including crop rotation, crop density, and weed control tactics) and to identify which weed species you usually have to control. The tool will then calculate a glyphosate resistance risk score for the paddock, and a level of risk for each weed identified. The risk assessment tool can show you the areas of greatest risk in your crop rotation and

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

herbicide use, and whether there are any weed species you need to treat carefully. Use these suggestions to get the best results from any changes you make.

The toolkit is available online at the DEEDI website (*www.primary.industry.qld.gov.au*), click on: *Plants > Field crops and pastures > Broadacre field crops > Weed management > Preventing herbicide resistance*. The toolkit also contains a herbicide resistance quiz which explains the important drivers in herbicide resistance development.

If you have answered 'Yes' to most of the questions, including 8-10 on field history, or the glyphosate resistance toolkit has indicated your practices and/or species are at high risk, 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.

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 seedling/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:		Address:	
Consultant:		Telephone:	
Preferred contact:	Manager/Owner / Consultant	Email:	
	(details provided on right)	Fax:	
Sampling Details			
Weed species:		Sampled by:	
Field Name:		Sampling Date:	

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 in 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@plantscience consulting.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	☐
Group A – den	Axial	☐
Group A – dims	Sertin, Select, Achieve	☐
Group B – sulfonylureas	Ally, Glean, Logran, Hussar	☐
Group B – imidazolinones	Spinnaker, Midas, OnDuty	☐
Group B – triazolopyrimidines	Broadstrike, Eclipse	☐
Group C – triazines	Atrazine, Simazine	☐
Group D – dinitroanilines	Trifluralin (seed test only)	☐
Group F – nicotinanalides	Brodal, Jaguar, Tigrex	☐
Group I – phenoxys	2,4-D	☐
Group J – thiocarbamates	Avadex (seed test only)	☐
Group K – chloroacetamides	Dual Gold	☐
Group L – bipyridils	Paraquat, Diquat	☐
Group M – glycines	Glyphosate	☐
Cross Resistance		☐

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.

Herbicide tolerant technology

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 expresses 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.

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

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 usage. For fields with heavy weed burdens, or where there is not the capacity to treat all Liberty Linkcotton 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	– 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	– 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 Program 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 shown on page 99. 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.

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. (eg. 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

Roundup Ready Flex Technology

Monsanto Australia Limited,
Graham Charles and Tracey Leven, CRDC

How does Roundup Ready Flex cotton work?

The primary effect of glyphosate on plants is the inhibition of the production of EPSPS. EPSPS is an enzyme responsible for the production of amino acids essential for protein construction and plant growth. Monsanto identified a soil bacterium that produces a modified form of the EPSPS enzyme, the CP4 strain. The CP4 strain of EPSPS is not inhibited by Roundup Ready herbicide. Roundup Ready Flex cotton plants produce the modified form of EPSPS, so are able to continue producing amino acids and proteins after Roundup Ready herbicide has been applied. 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 in a total of 4 applications as illustrated in Figure 10. 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.

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® was first 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.

Weed management in Roundup Ready Flex

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 appropriate

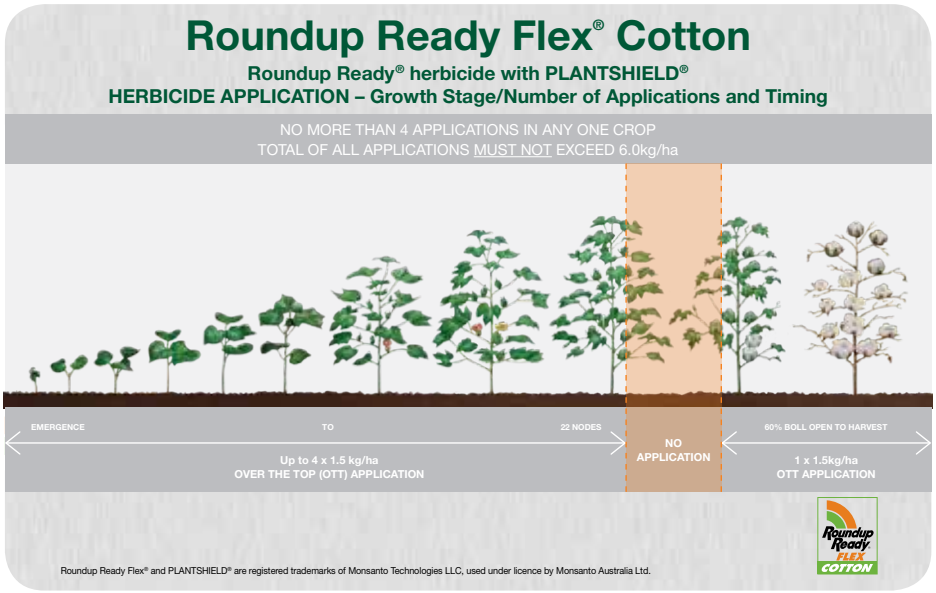


FIGURE 10: Application windows for over the top Roundup Ready Herbicide and Roundup Ready Herbicide with PLANTSHIELD.

herbicide and herbicide rate are chosen for the target weed species. By knowing field history, growers can determine which weed control tools they should use and when they should be employed to achieve the best results.

Pre-plant knockdown

Starting with a 'clean' field provides seedling cotton with the best possible conditions to emerge and to develop, unhindered by the competitive effects of weeds. Pre-plant weed control can be achieved using tillage and/or the appropriate registered herbicides. The use of glyphosate tank mixes or herbicides with other modes of action is encouraged prior to planting to strengthen the IWM program. It is important that any cotton volunteers are controlled at this stage.

The role of residual herbicides

Residual herbicides should be used where appropriate in the Roundup Ready Flex 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 field's 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 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.

Subsequent OTT (over-the-top) applications

After the first OTT application, the use of subsequent OTT applications (up to a 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(s) chosen. Select the timing and application rate of Roundup Ready Herbicide based upon the most difficult to control weed species in each field.

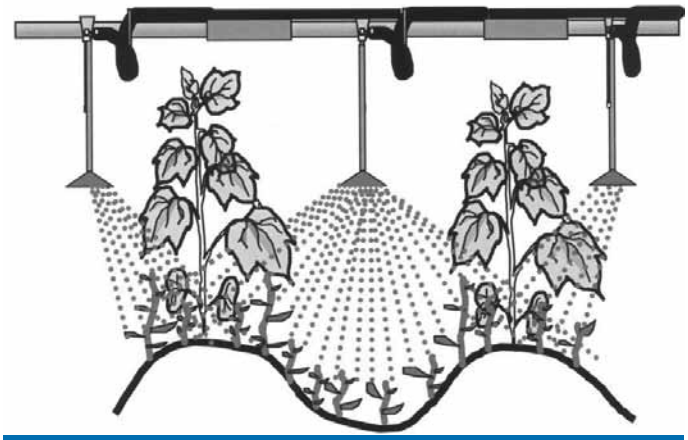
Inter-row cultivation

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



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

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 Post Spray Survey.

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 post spray surveys

Only accredited TSPs will be able to conduct the Weed Management Post Spray Survey.

TSPs will undertake the Post Spray Survey on a percentage of fields growing Roundup Ready Flex cotton in accordance with Table 1. TSPs will assess al weeds remaining ten to fourteen days after an "over the top" (OTT) application of Roundup Ready Herbicide or Roundup Ready Herbicide with PLANTSHIELD at a minimum of 6 nodes crop growth, and not exceeding 16 nodes.)

TABLE 1: Weed Survey requirements in field

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

Table 1 outlines how to assess the field for the presence of surviving weeds. The minimum distance between each assessment (ie 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 control options

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.

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 6.0kg of Roundup Ready Herbicide may be applied through all growth stages of Roundup Ready Flex cotton in any one growing season.

Tank-mixtures with other herbicides or insecticides are not recommended for over-the-top applications of Roundup Ready Herbicide or Roundup Ready Herbicide with PLANTSHIELD due to the potential for reduced weed control or crop injury to result. (Refer to Label for Directions for use – Roundup Ready Flex cotton).

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, a spray volume of 50-80 litres per sprayed hectare is recommended for optimum performance. Nozzles and pressure settings must be selected to deliver a minimum of a COARSE spray quality (American Society of Agricultural Engineers (ASAE) S572) at the target. For aerial application, nozzles and pressure settings must be selected to deliver a minimum of a COARSE spray quality (ASAE SS572) at the target. A minimum total application volume of 40L per hectare needs to be used. Do not apply Roundup Ready herbicide or Roundup Ready Herbicide with PLANTSHIELD by aircraft at temperatures above 30°C or if relative humidity falls below 35%.

Other Sources of Information:
Roundup Ready Flex Cotton Technical Manual, Version 1 – August 2006, Monsanto Australia Ltd.

Cotton Weed Control Guide

Tracey Leven, CRDC

Registration of a herbicide is not a recommendation 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 TABLES 26–32

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

TABLE 26A: 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	0.28–4.5/100 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, WG	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 WG	0.5–9.0 L/ha 1.6–7.2 L/ha 0.34–1.9 L/ha 1.35-6 L/ha 0.265–4.5 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. Do not allow water to return to channels for 4 days.
Imazapyr + glyphosate	B + M	150 g/L + 150 g/L LQ 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 26B: 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	2.0–9.0 L/ha 1.44–6.48 L/ha 1.35–6.0 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 27: 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 WG	0.16–0.56 L/ha 0.115–0.4 kg/ha	Up to 14 days plant back period.
Fluometuron	C	900 g/kg GR, WG	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, WG	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 WG	30 g/ha + tank mix parner 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, LQ, SL 450 g/L AC 470 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 WG	2.5-9 L/ha 0.4–2.4 L/ha 0.38–1.5 L/ha 0.37–2.25 L/ha 0.36–2.16 L/ha 0.34–1.9 L/ha 0.34–2.0 L/ha 0.322–1.9 L/ha 0.265–1.6 kg/ha	Controls most annual grasses and broadleaf weeds. Refer to label for rates on specified weeds and recommendations.
		690 g/kg WG	0.265–1.5 kg/ha	In Roundup Readycotton and Roundup Ready Flexcotton only.
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 GR	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 SL	1.2–2.4 L/ha	Controls many annual grass and broadleaf seedlings.
Paraquat + diquat	L	135 g/L + 115 g/L SL	1.2–2.4 L/ha	Controls most annual grasses and broadleaf weeds.
Pendimethalin	D	330 g/L EC 440 g/L 455 g/L AC	3.0 L/ha 2.25 L/ha 2.2 L/ha	Controls annual grasses and some broadleaf weed seedlings. Incorporate within 24 hours. Check label for details.
Prometryn	C	500 g/L AC, SL 900 g/kg DF, WG	2.2–4.5 L/ha 1.2–2.5 kg/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.
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 EC500 g/L EC	1.2–2.3 L/ha 1.1–2.25 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.

TABLE 28: Weed control at planting

Active ingredient	Mode of Action group	Concentration and formulation	Application rate of product	Comments
Chlorthal dimethyl	D	900 g/kg WG	5.0–12.5 kg/ha	Apply at time of planting. Use higher rate for areas underirrigation.
Diuron	C	900 g/kg DF, WG	1.0–2.0 kg/ha	Controls many broadleaf weeds and annual grasses. Do not apply more than once per season.
Fluometuron	C	500 g/L AC, SL 900 g/kg DF, WG	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 immediately after sowing as an overall or band treatment. Minimum band width 40cm. Use higher rate on heavier soils. Check label for details.
Fluometuron + prometryn	C	250 g/L + 250 g/L AC, SL 440 g/kg + 440 g/kg DF, WG	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 applicaton. 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. Rainor irrigation needed within 10 days of application or incorporate mechanically.
Paraquat + diquat	L	135 g/L + 115 g/L SL	0.8–2.4 L/ha	Controls most annual grasses and broadleaf weeds.
s-Metolachor	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 29: 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 SL 900 g/kg GR, WG	1.8–3.5 L/ha 1.0–2.0 kg/ha	Controls many broadleaf weeds and annual grasses. Avoid light soils. Do not apply more than once per season. Spray immediately after planting.
Fluometuron	C	500 g/L AC, SL 900 g/kg DF, WG	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, SL 440 g/kg + 440 g/kg DF, WG	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 SL	1.2–2.4 L/ha	Controls most annual grasses and broadleaf weed seedlings.
Paraquat + diquat	L	135 g/L + 115 g/L SL	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, SL 900 g/kg DF, WG	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 30: Weed control pre harvest

Active ingredient	Mode of Action group	Concentration and formulation	Application rate of product	Comments
Chlorthal dimethyl	D	900 g/kg WG	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, SL, LQ 450 g/L AC, LQ 480 g/L AC 500 g/L AC, EC 540 g/L AC 570 g/L AC 680 g/kg WG	1.25–2.5 L/ha 1.0–2.0 L/ha 1.0-2.025 L/ha 0.36–2.16 L/ha 0.84-1.7 L./ha 0.795–1.6 L/ha 0.66–1.30 kg/ha	Controls Bathurst burr, Noogoora burr, winter annual weeds. Use higher rates for Nutgrass control. May be applied alone orwith harvest aid. Apply when 60% bolls are open.
		690 g/kg WG	0.71–1.42 kg/ha	Registered for use in Roundup Readycotton and Roundup Ready Flex cotton. Apply when 60% bolls are open. For nutgrass supression use high rate only.
		510 g/L AC	0.96-1.9 L/ha	Not registered for the control of Nutgrass.

TABLE 31: Weed control after crop emergence (includes layby)

Active ingredient	Mode of Action group	Concentration and formulation	Application rate of product	Comments
Butroxydim	A	250 g/kg WG	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 WG	(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 SL 900 g/kg DF, WG	2.0–3.5 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, SL 900 g/kg DF, WG	1.3–2.8 L/ha 1.5–3.0 kg/ha	Controls many broadleaf weeds and annual grasses. 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, SL 440 g/kg + 440 g/kg DF, WG	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 WG	60 or 90 g/ha	Apply as a shielded spray. Do not contact cotton foliage.
Glufosinate-ammonium	N	200 g/L SL	3.75 L/ha in 100 L water	Only apply to Liberty Link cotton varieties. Maximum 2.25kg a.i./ha/season (3 applications). As a contact herbicide coverage is critical to effectiveness.
Glyphosate	M	360 g/L AC, EC, LQ, SL 450 g/L AC, L 480 g/L AC 500 g/L AC, EC 510 g/L AC 540 g/L AC 570 g/L AC 680 g/kg WG	2.5-9 L/ha 0.4–2.4 L/ha 0.375-2.25 L/ha 0.36–2.16 L/ha 0.34–1.9 L/ha 0.34–2.0 L/ha 0.322–1.9 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 WG	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 GR 750 g/kg WG	65–130 g/ha	Shielded srayer 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 LQ, SL 800 g/L LQ, SL	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, SL	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, SL 900 g/kg GR, WG	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 WG	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 32: Herbicide trade names and marketers – Registered chemicals as at 07 June 2010

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	Smash	ChemAg
		300 g/L AC	Aminoz CT	Sanonda
		300 g/L AC	2,4-D 300	Farmalinx
		300 g/L	2,4-D 300	Innova
		300 g/L AC	2,4-D 300	Ospray
		300 g/L	2,4-D Amine 300	United Farmers Co-op
		300 g/L	2,4-D IPA 300	Dow Agrisciences
		300 g/L	2,4-D IPA 300	Echem
		30 0 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	Amine 300	Agrismart
		300 g/L AC	Amine 300	Conquest
		300 g/L	Amine 300	Country
		300 g/L	Amine 300	Ruralchem
		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 Agrosciences
		300 g/L	Applause	Agriwest
		300 g/L AC	Cobber	Crop Care
		300 g/L AC	Crown 2,4-D IPA	Pacific Agrisciences
		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	Putra Amine 300	Hextar
		300 g/L AC	Rodamine 300	Rotam
		300 g/L AC	Smash 300	Imtrade
		300 g/L AC	Surpass 300	Nufarm
		300 g/L AC	Weeds Out 300	Biotis
		300 g/L AC	Zulu 300	Farmoz
		400 g/L	Abound	Dow Agrosciences
Amitrole + ammonium thiocyanate	Q	250 g/L + 220 g/L SL	Aggravate8	Agriwest
		250 g/L + 220 g/L SL	Amitrole T	ChemAg
		250 g/L + 220 g/L SL	Amitrole T	Nufarm
		250 g/L + 220 g/L SL	Weedeath	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	Bromox 200	Imtrade
		200 g/L EC	Bronco 200	Farmoz
		200 g/L EC	Bromicide 200	Nufarm
		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 WG	Factor WG	Crop Care
Carfentrazone-ethyl	G	240 g/L EC	Hammer	Crop Care
		240 g/L EC	Task	Nufarm
Chlorthal dimethyl	D	750 g/kg WG,	Clorthal dimethyl 750WG	Macphersons
		900 g/kg WG	Dacthal 900 WG	Crop Care

TABLE 32: Herbicide trade names and marketers – Registered chemicals as at 07 June 2010 (continued)

Active ingredient	Mode of Action group	Concentration and formulation	Trade name	Marketed by
Clethodim	A	240 g/L EC	Akodim	Aako
		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	Clethim	Farmalinx
		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	Agrismart
		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	Imtrade
		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	Clethodium 240 EC	Scal
		240 g/L EC	Clethodim 240 EC	Titan
		240 g/L EC	Grasidim	Sipcam
		240 g/L EC	Havoc	Cropcare
		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 herbicide	Aystra
		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	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	Ditch 500	Agri West
		500 g/L AC	Kamba 500	Nufarm
		700 g/kg WG	Cadence	Syngenta
		700 g/kg WG	Dicamba	Titan
Diuron	C	500 g/L SL	various for multiple products	various for multiple products
		900 g/kg DF	Diuron 900 DF	4 Farmers
		900 g/kg DF	Diuron DF	Nufarm
		900 g/kg WG	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

TABLE 32: Herbicide trade names and marketers – Registered chemicals as at 07 June 2010 (continued)

Active ingredient	Mode of Action group	Concentration and formulation	Trade name	Marketed by
Fluometuron	C	500 g/L LQ	Fluocam 500	Spicam
		500 g/L LQ	Reliance Liquid	Crop Care
		500 g/L SL	Cotoran SC	Farmoz
		500 g/L SL	Fluometuron 500 SC	CMStrade
		500 g/L SL	Fluometuron 500 SC	Agroreg
		500 g/kg WG	Fluometuron 500 WG	CMStrade
		900 g/kg WG	Cotoran 900 WG	Farmoz
		900 g/L WG	Fluometuron 900 WG	Agroreg
		900 g/kg WG	Fluometuron 900 WG	Farmoz
		900 g/L WG	Reliance 900 WG	Crop Care
		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 SL	Flupromix 500	Sipcam
		250 g/L + 250 g/L SL	Cotogard SC	Farmoz
		440 g/L + 440 g/L WG	Bandit WG	Crop Care
		440 g/L + 440 g/L DF	Convoy DF	Nufarm
		440 g/L + 440 G/L WG	Cotogard WG	Farmoz
		450 g/L + 450 g/L WG	Flupromix	Sipcam
Flumioxazin	G	500 g/kg WG	Pledge	Sumitomo Chemicals
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	Prostar	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 SL	Liberty 200	Bayer CropScience
Glyphosate	M	360 g/L AC, EC, LQ, SL	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 Agrosciences
		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
		500 g/L SL	Potassium Glyphosate 500	4Farmers
		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/L WG	Glister 680 WG	Sinon
		680 g/kg WG	Ken-up Dry	Biotis
		680 g/kg WG	Klin-Up	Biotis
		680 g/kg WG	Roundup Dry	Nufarm
		680 g/L WG	Set-up Dry 680	Wynca
		680 g/L WG	Suria 680 WG	Hextar
		680 g/kg WG	Wynca	Biotis
		690 g/kg WG	Roundup Ready Herbicide	Nufarm
		700 g/L WG	Clearup 700 Dri	Rygel
		700 g/L WG	Dri Glyphosate	Whitestar
		700 g/L WG	Glydry 700	Generex
		700 g/L WG	Glymac Dri 700	Macspred
		700 g/L WG	Glyphosate 700	Macphersons

TABLE 32: Herbicide trade names and marketers – Registered chemicals as at 07 June 2010 (continued)

Active ingredient	Mode of Action group	Concentration and formulation	Trade name	Marketed by
Halosulfuron–methyl	B	750 g/kg DF	Nut-buster	agVantage
		750 g/kg DF	Sempra	Nufarm
		750 g/kg WG	Halo 750 WG	ChemAg
		750 g/kg WG	Halosulfuron	Gullf Ag
Haloxyfop-p		130 g/L	Judgement 130	Chemag
		520 g/L	Haloxyfop	Whitestar
		520 g/L EC	Haloxyfop 520	Chem Ag
		520 g/L EC	Haloxyfop 520	Genfarm
		520 g/L EC	Haloxyfop 520	Grow Choice
		520 g/L EC	Haloxyfop 520	Generex
		520 g/L EC	Haloxyfop 520 EC	Imtrad
		520 g/L EC	Haloxyken 520	Kenso
		520 g/L EC	Harpoon	Agriwest
		520 g/L EC	Hermes	Titan
		520 g/L EC	Inquest	Sipcam
Haloxyfop-r	A	130 g/L EC	Asset	Nufarm
		130 g/L	Gallant West	Dow Agrosciences
		520 g/L EC	Convict	Ospray
		520 g/L EC	Expert 520	Crop Care
		520 g/L EC	Halomac 520	Macspread
		520 g/LEC	Halox 520	Echem
		520 g/L EC	Firepower	Farmoz
		520 g/L EC	Haloxyfop 520	4 Farmers
		520 g/L EC	Haloxyfop 520	Chemforce
		520 g/L EC	Haloxyfop 520	Farmalinx
		520 g/L EC	Haloxyken 520	Kenso
		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	Hook 720	Agronomics
		720 g/L EC	Metal 720	ChemAg
		720 g/L EC	Metachlor	Rygel
		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	Metaclor 720	Country
		720 g/L EC	Metolachlor 720	Grow Choice
		720 g/L EC	Metolachlor 720	United Farmers Co-op
		720 g/L EC	Metor	Farmalinx
		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
MSMA	Z	720 g/L LQ	Arena	Agricorp
		720 g/L SL	MSMA 720	Ancom
		800 g/L LQ	Megalith	Agriwest
Norflurazon	F	800 g/kg DF	Zoliar DF	Syngenta

TABLE 32: Herbicide trade names and marketers – Registered chemicals as at 07 June 2010 (continued)

Active ingredient	Mode of Action group	Concentration and formulation	Trade name	Marketed by
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	Oxyfan	Farmalinx
		240 g/L EC	Oxyfluorfen 240	Agrismart
		240 g/L EC	Oxyfluorfen 240	Country
		240 g/L EC	Oxyfluorfen 240 EC	4 Farmers
		240 g/L EC	Oxyfluorfen 240 EC	Agroreg
		240 g/L EC	Oxyfluorfen 240 EC	Genfarm
		240 g/L EC	Oxyfluorfen 240 EC	Innova
		240 g/L EC	Oxyfluorfen 240 EC	OzCrop
		240 g/L EC	Oxyfluorfen 240 EC	Titan
		240 g/L EC	Oxyfluorfen 240 EC	United Farmers Co-op
		240 g/L EC	Point	Kendon Chemicals
		240 g/L EC	Striker	Nufarm
		480 g/L EC	Goaltender	Dow Agrosciences
Paraquat	L	250 g/L SL	Biotis	Biotis Life Science
		250 g/L SL	Explode 250	Conquest
		250 g/L SL	Gramoxone 250	Syngenta
		250 g/L SL	Inferno	Sipcam Pacific
		250 g/L SL	Nuquat 250	Nufarm
		250 g/L SL	Para-Ken 250	Kenso Agcare
		250 g/L SL	Paraquat 250	4 Farmers
		250 g/L SL	Paraquat 250	Chemag
		250 g/L SL	Paraquat 250	Chem Force
		250 g/L SL	Paraquat 250	Country
		250 g/L SL	Paraquat 250	Farmalinx
		250 g/L SL	Paraquat 250	Farmcochem
		250 g/L SL	Paraquat 250	Forward Australia
		250 g/L SL	Paraquat 250	Genfarm
		250 g/L SL	Paraquat 250	Grow Choice
		250 g/L SL	Paraquat 250	Halley
		250 g/L SL	Paraquat 250	Ospray
		250 g/L SL	Paraquat 250	Ruralchem
		250 g/L SL	Paraquat 250	Rygel
		250 g/L SL	Paraquat 250	Titan
		250 g/L SL	Paraquat 250	United Farmers
		250 g/L SL	Quash	Hextar
		250 g/L SL	Sinmosa	Sinon Australia
		250 g/L SL	Shirquat 250	Crop Care
		250 g/L SL	Sprayquat 250	Kendon
		250 g/L SL	Spraytop 250 SL	Farmoz
		250 g/L SL	Uniquat 250	UPL

TABLE 32: Herbicide trade names and marketers – Registered chemicals as at 07 June 2010 (continued)

Active ingredient	Mode of Action group	Concentration and formulation	Trade name	Marketed by
Paraquat + diquat	L	135 g/L + 115 g/L AC	Alarm	Sipcam Pacific
		135 g/L + 115 g/L AC	Blowout	CMS
		135 g/L + 115 g/L AC	Brown Out 250	4Farmers
		135 g/L + 115 g/L AC	Combik 250	Sinon Australia
		135 g/L + 115 g/L AC	Di–Par 250	Genfarm
		135 g/L + 115 g/L SL	EOS	Titan Ag
		135 g/L + 115 g/L SL	Paradym 250	Macphersons
		135 g/L + 115 g/L SL	Premier 250	Halley
		135 g/L + 115 g/L SL	Revolver	Nufarm
		135 g/L + 115 g/L SL	Rygel Pre-Seed	Rygel
		135 g/L + 115 g/L SL	Scorcher 250	Conquest
		135 g/L + 115 g/L SL	Speedy 250	Kenso
		135 g/L + 115 g/L SL	Spray & Sow	Farmoz
		135 g/L + 115 g/L SL	Spray.Seed 250	Syngenta
		135 g/L + 115 g/L SL	Spraykill 250	Chem Ag
		135 g/L + 115 g/L AC	Sprayplant 250	Sipcam
		135 g/L + 115 g/L SL	Uni-Spray	United Phosphorus Limited
		135 g/L + 115 g/L SL	Wildfire	United Farmers
Pendimethalin	D	330 g/L EC	Charger 330 EC	Conquest
		330 g/L EC	Cyclone 330	Imtrade
		330 g/L EC	Fist 330	United Phosphorus
		330 g/L EC	Imethalin 330	I.Pi.C.i
		330 g/L EC	Panida Grande	Sipcam Pacific
		330 g/L EC	Pendi 330	Kenso Agcare
		330 g/L EC	Pendimethalin 330	Dow Agrosciences
		330 g/L EC	Pendimethalin 330 EC	4 Farmers
		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	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	Argo 440 EC	Campbell
		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
		475 g/L	Panida Max	Rallis
Prometryn	C	500 g/L SL	Gesagard 500 SC	Syngenta
		500 g/L SL	Promesip 500	Sipcam
		500 g/L SL	Prometrex 500 SC	Farmoz
		500 g/L SL	Prometryn 500	Agroreg
		500 g/L SL	Prometryn 500	Ospray
		500 g/L SL	Prometryn 500 SC	CMStrade
		900 g/kg DF	Prometryn 900 DF	Nufarm
		900 g/kg WG	Gesagard 900 WG	Syngenta
		900 g/kg WG	Prometrex 900 WG	Farmoz
		900 g/kg WG	Proton 900 WG	Crop Care
Propaquizafop	A	100 g/L EC	Correct 100 EC	Bayer CropScience
Pyrithiobac 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

TABLE 32: Herbicide trade names and marketers – Registered chemicals as at 07 June 2010 (continued)

Active ingredient	Mode of Action group	Concentration and formulation	Trade name	Marketed by
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 E C	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 WG	Envoke	Syngenta
Trifluralin	D	480 g/L EC	Treflan 480	Crop Care
		480 g/L EC	various for multiple products	various for multiple products
		500 g/L EC	Trilogy xtra	Farmoz
		500 g/L WP	Credit Selective	Nufarm
		500 g/L EC	Triflur xcel	Nufarm
		530 g/L EC	Trifluralin 530	Country
		600 g/L EC	Treflan 600	Dow Agrosciences