

Herbicide resistance management

The Australian lettering mode of action (MoA) classification system for herbicides changed in 2021 to match the international numbering system. Both systems are included in this edition for ease of reference. A searchable database of Australian herbicide classifications is available at

croplife.org.au/resources/programs/resistance-management/herbicide-moa-alignment

Weed populations are naturally genetically diverse, so it is likely that a small number of individuals may exist that are able to survive exposure to a particular herbicide mode of action (MoA). When a herbicide from this MoA is used upon the population, individuals that have this gene present may survive and set seed, whereas the majority of plants without the gene (susceptible plants) are killed. While it might only be one or two individuals surviving at first, continued use of the same herbicide MoA will result in an ever-increasing proportion of the population being able to survive those herbicide applications. In Australia, herbicides are currently grouped according to their MoA which is represented by a number code on the label and are ranked according to their resistance risk. Research has shown that weeds can develop resistance to any single control tactic used alone, not only herbicidal ones. For example, regular mowing of annual bluegrass, *Poa annua*, in golf courses selected strains for lower grass seed heads, which is essentially a resistance to mechanical control.

By Mid-2025, there were 534 unique cases (species x mode of action) of herbicide resistant weeds recorded globally across 273 species. Weeds have evolved resistance to 21 of the 31 known herbicide sites of action and to 168 different herbicides, and herbicide-resistant weeds have been reported in 101 crops in 72 countries.

While historically the Australian cotton industry has had a strong integrated weed management system, the extensive use of herbicide tolerant cotton varieties since 2006 has led to an over-reliance on glyphosate. More than half of the confirmed glyphosate-resistant weed species in Australia listed in Table 25 occur widely in cotton farming systems.

TABLE 25: Glyphosate-resistant weeds in Australia

Grasses	First documented
Annual ryegrass (<i>Lolium rigidum</i>)	1996*
Awnless barnyard grass (<i>Echinochloa colona</i>)	2007*
Liverseed grass (<i>Urochloa panicoides</i>)	2008
Windmill grass (<i>Chloris truncata</i>)	2010
Great brome (<i>Bromus diandrus</i>)	2011
Red brome (<i>Bromus rubens</i>)	2014
Sweet summer grass (<i>Brachiaria eruciformis</i>)	2014
Feathertop Rhodes grass (<i>Chloris virgata</i>)	2015*
Winter grass (<i>Poa annua</i>)	2017
Northern barley grass (<i>Hordeum glaucum</i>)	2018
Wild oats (<i>Avena</i> spp.)	2018
Johnson grass (<i>Sorghum halapense</i>)	2019
Broadleaf weeds	
Flaxleaf fleabane (<i>Conyza bonariensis</i>)	2010*
Wild radish (<i>Raphanus raphanistrum</i>)	2010
Sowthistle (<i>Sonchus oleraceus</i>)	2014*
Prickly lettuce (<i>Lactuca serriola</i>)	2014
Tridax daisy (<i>Tridax procumbens</i>)	2016
Tall fleabane (<i>Conyza sumatrensis</i>)	2017
Willow-leaved lettuce (<i>Lactuca saligna</i>)	2017
Capeweed (<i>Arctotheca calendula</i>)	2021

*Resistance documented at more than 100 sites within Australia.

An industry-wide strategy

Experience with conventional insecticide resistance has encouraged a proactive culture to resistance issues within the Australian cotton industry. The Herbicide Resistance Management Strategy (HRMS) draws together available information, enabling growers and agronomists to understand and manage the risks of herbicide resistance in Australian cotton farming systems.

The HRMS enables you to determine which other weed control tactics can be incorporated into your management system by providing guidance on how much extra time they will give you until resistance develops, and demonstrating the effect they will have on the weed seed bank, which is critical to effectively managing resistance.

Non-cropping areas and the HRMS

Areas adjacent to cotton fields such as irrigation channels, head ditches, tail drains, roadways, fence lines and areas next to stock routes can be a significant entry source for resistant weed seeds. Where possible, use a range of tactics to manage weeds in these areas, and do NOT rely on glyphosate to manage weeds in these areas. Prevent survivors of herbicide application from setting seed.

TABLE 26: Species that have developed resistance to paraquat (Group 22/L) in Australia

Species	Common name	Year	State	Crop	Resistance to other MoAs/herbicides
<i>Hordeum glaucum</i>	Northern barley grass	1983	Vic	Lucerne	Diquat (22/L)
<i>Arctotheca calendula</i>	Capeweed	1984	Vic	Lucerne	Diquat (22/L)
<i>Hordeum leporinum</i>	Barley grass	1988	Vic	Lucerne	Diquat (22/L)
<i>Vulpia bromoides</i>	Silver grass	1990	Vic	Lucerne	Diquat (22/L)
<i>Mitracarpus hirtus</i>	Small square weed	2007	Qld	Mangoes	Diquat (22/L)
<i>Lolium rigidum</i>	Annual ryegrass	2010	SA	Pasture seed	1(A)/9(M) – 2 populations
<i>Gamochaeta pensylvanica</i>	Cudweed	2015	Qld	Tomatoes, sugarcane	
<i>Solanum nigrum</i>	Blackberry nightshade	2015	Qld	Tomatoes, sugarcane	
<i>Eleusine indica</i>	Crowsfoot grass	2015	Qld	Tomatoes, sugarcane	
<i>Conyza bonariensis</i>	Flaxleaf fleabane	2016	NSW	Grape vines	
<i>Conyza sumatrensis</i>	Tall fleabane	2018	Qld	Wheat/fallow	



WeedSmart BIG 6



SCAN QR



Rotate crops and pastures

Crop and pasture rotation is the recipe for diversity

- Use break crops and double break crops, fallow and pasture phases to drive the weed seed bank down.
- In summer cropping systems, use diverse rotations of crops including cereals, pulses, cotton, oilseed crops, millets and fallows.
- Add greater diversity to weed management strategies by adopting herbicide tolerance traits.

Increase crop competition

Optimise crop growth

- Adopt at least one competitive strategy, but two is better.
- Target higher plant populations using increased seeding rates, weed-free seed tested for germination, vigour and 1,000 seed weight.
- Aim for even seed distribution and establishment.
- Sow competitive crop types and varieties.
- Improve soil health (fertility and structure) and crop nutrition, e.g., soil amelioration (if necessary), no-till, stubble retention, nutrient budgeting.
- Utilise early sowing and adopt East/West sowing if practical.
- Reduce row spacing where possible.

Mix and rotate herbicides

Rotating buys you time, mixing buys you shots

- Rotate between herbicide modes of action.
- Mix different modes of action within the same herbicide mix or in consecutive applications.
- Always use full label rates.
- Incorporate multiple modes of action in a double knock e.g., glyphosate/ Group 1/Group 2 knockdown followed by paraquat and Group 14 and pre-emergent herbicide.
- Test weeds for resistance to know what herbicides will and won't work for you.
- In cotton systems, aim to target both grasses and broadleaf weeds using two non-glyphosate tactics in crop and two non-glyphosate tactics during the summer fallow, and always remove any survivors (2 + 2 & no survivors).

Optimise spray efficacy

Make every droplet count

- To maximise efficacy and reduce spray drift, follow spray application guidelines and ensure the correct speed, nozzles, water volume, boom height, and adjuvants are used. Avoid antagonistic tank mixes.
- Always use the largest spray droplet feasible that gives the highest efficacy and consider water quality.
- Avoid spraying during inversions (particularly from evening through to early morning), in high temperatures, frost and dew conditions, and when the wind speed is below 5km/h or above 20km/h.

Stop weed seed set

Take no prisoners

- Aim for 100% control of weeds and diligently monitor for survivors in all post weed control inspections.
- Crop top or pre-harvest spray in crops to manage weedy paddocks.
- Consider hay or silage production, brown manure or long fallow in high-pressure situations.
- Use all appropriate strategies in the pasture phase to reduce the weed seed bank prior to cropping phase.
- Consider shielded spraying, optical spot spraying technology, targeted tillage, inter-row cultivation or chipping.
- Windrow (swath) to collect early shedding weed seed.
- Use two or more different weed control tactics (herbicide or non-herbicide) to control survivors.
- In cotton farming systems, consider late season strategic tillage operations for better overall weed and Helicoverpa pupae control.

Implement harvest weed seed control

Capture weed seed survivors

- Capture weed seed survivors at harvest using weed seed impact mills, chaff lining, chaff tramlining/ decking, chaff carts, narrow windrow burning, or bale direct.
- Ensure optimal harvester set-up.



TABLE 27: Weed species with populations resistant to 2,4-D (Group 4/I)

Species	Year	State	Crop	Herbicide	Also resistant to MoAs
Wild radish <i>Raphanus raphanistrum</i>	1999	WA	Winter cereal	2,4-D	
	2006	SA	Winter cereal	2,4-D, MCPA	2(B), 12(F)
	2009	Vic	Winter cereal	2,4-D	2(B)
	2010	WA	Winter cereal	2,4-D	2(B), 12(F), 9(M)
	2011	Vic	Winter cereal	2,4-D	
	2011	NSW	Winter cereal	2,4-D	
	2013	NSW	Winter cereal	2,4-D	
Indian hedge mustard <i>Sisymbrium orientale</i>	2005	SA	Winter cereal	2,4-D, MCPA	2(B)
	2015	SA	Winter cereal	2,4-D	12(F)
	2016	Vic	Winter cereal	2,4-D	
	2016	Vic	Winter cereal	2,4-D	2(B), 12(F)
Sowthistle <i>Sonchus oleraceus</i>	2015	Vic	Winter cereal	2,4-D	
	2015	SA	Winter cereal	2,4-D, dicamba, clopyralid	
Capeweed <i>Arctotheca calendula</i>	2015	SA	Winter cereal	2,4-D	

Why does the strategy include weed seed bank as well as herbicide resistance risk?

The key to good weed management is having low weed seed bank numbers. Not only does this reduce impact on the crop, but it also reduces the herbicide resistance risk. The more weed seeds present, the more likely that an individual containing herbicide resistance genes will be present and hence become a problem.

Strategies should be aimed at driving down the seed bank and preventing seed bank replenishment. See tables B and C in the HRMS for information on seedbank levels and management options.

Do I have to adhere to the HRMS?

The HRMS is not intended to be prescriptive, and is aimed to be an industry mechanism for communicating the herbicide resistance risks from different tactics. It has been designed to present the risk related to a range of combinations of tactics, to allow growers and consultants to make their own informed decisions.

What does herbicide resistance look like?

Resistance begins 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. These are often surrounded by dead 'susceptible' plants of the same species, or other species usually controlled by the herbicide applied. This is the critical time to identify the problem.

For other resistance mechanisms, the symptoms may appear as a 'sick' plant that subsequently recovers and may look similar to 'underdosing' or poor application. If a



Surviving glyphosate resistant awnless barnyard grass plants amongst dead susceptible plants and dead plants of other species.

Assessing your own risk

For a more detailed assessment of the glyphosate resistance risks for individual paddocks, use Qld DPI's Online Glyphosate Resistance Toolkit



cottoninfo.com.au/glyphosate-resistance-toolkit

This tool allows you to check what your current level of risk is for developing glyphosate-resistant weed populations on your farm. 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. It will then calculate a glyphosate resistance risk score for the paddock, and a level of risk for each weed identified.

The **Barnyard Grass Understanding and Management (BYGUM)** tool enables the resistance risk from summer weed control to be considered in the context of economics and seed bank management.



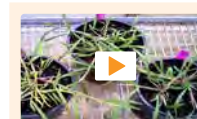
This weed management scenario testing tool combines biological, agronomic and economic factors to examine the economics of current summer grass management strategies and compare with new tactics.

cottoninfo.com.au/barnyard-grass-understanding-and-management-bygum

higher application rate is required to kill these individuals in subsequent years this indicates non-target site resistance is present.

Many of the symptoms of herbicide resistance can also be explained by other causes of spray failure. Regularly maintain and calibrate spray equipment, spray under appropriate conditions and keep good records to ensure maximum spray efficacy.

Resistant weed seeds can also be transported into fields and other farm areas through irrigation channels, vehicle tyres, or blow in on the wind (in the case of species such as fleabane), and consequently can be relatively widespread before they are noticed.



A demonstration of
weed resistance

youtu.be/y73j1laiSLk



Why should I get weeds tested?

Testing plant populations for the presence of herbicide resistant individuals is an important tool for growers and advisors, as the results can confirm if there is still efficacy within some of the MoA groups. Generally, seed is collected from the suspect plants and is sent for testing (see below). It can take several months to receive results from seed samples. Results are usually available by the end of April when samples are received before January.

An alternative 'quick test' method uses actual plants from the field. The quick test is limited to grass weeds only and is best targeted at seedlings or small plants as large numbers need to be collected and posted. Upon arrival they are potted up 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. When plants are sent for Quick Tests, results are usually available within 4-8 weeks.

It is recommended to take seed samples from surviving plants in summer and mark the sites to enable seedling collections the following autumn or spring if required.

Collecting samples (seed test):

- Collect 2000-3000 seeds from plants you suspect are resistant (e.g. for barnyard grass this is about 1 cup full).
- If testing for more than 3 modes of action, collect additional seed.
- Shake seed heads into a bucket to ensure only ripe seed is collected.
- 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.
- Store samples in a paper bag at room temperature, away from sunlight, moisture and heat.
- Post as soon as possible.

Collecting plant samples (quick test):

- For each mode of action to be tested: collect 50 plants per field from areas where you suspect resistance.
- Gently pull out plants and wash roots.
- Wrap in paper towel. Do not moisten.
- Place in waterproof plastic bag.
- Collect weeds early in the week, and Express Post as soon as possible. Do not store or post over the weekend. If plants cannot be posted on the same day, store overnight in the fridge.

Sending samples to testing services

Contact one of the testing services below so they know to expect the sample. Follow the collecting instructions above and send samples together with a sample registration form (noting testing required), field and weed management history, and your contact details to:

 **Dr Peter Boutsalis**
Plant Science Consulting (Seed or Quick test)
22 Linley Avenue, Prospect SA 5082
0400 664 460
info@plantscienceconsulting.com
csu.edu.au/weedresearchgroup/herbicide-resistance

 **Dr John Broster**
Charles Sturt University (Seed test only)
Herbicide Resistance Testing Service,
PO Box 588, Wagga Wagga NSW 2678
(02) 6933 4001
jbroster@csu.edu.au

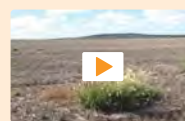


An annual ryegrass survivor. © Eric Koetz, CottonInfo/NSW DPIRD

How do I manage resistant weeds?

The strategy to **manage** weeds resistant to glyphosate (or other herbicide products) is similar to the strategy to **prevent** resistance – integrate a range of different tactics throughout the weed lifecycle to rapidly deplete the soil weed seed bank, and prevent further seed set/recruitment. This means that the HRMS is just as relevant to managing resistant weeds as it is preventing them.

If detected early, managing known patches of herbicide resistant weeds by applying an intensive program of different tactics and ensuring weeds do not set seed, may be effective in preventing the problem from spreading.



Minimising glyphosate resistance

youtu.be/cke-mamGe2o



This infestation 'blow-out' of glyphosate resistant barnyard grass was due to an extremely wet summer that prevented access to the paddock and hence there was no effective treatment at an early growth stage. © T.Cook, NSW DPIRD

Information on resistant weeds has been partially sourced from I.Heap, The International Survey of Herbicide Resistant Weeds, June 2025. Visit the international herbicide-resistant weed database at: www.weedscience.org

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USEFUL RESOURCE:



Weedsmart

weedsmart.org.au



TABLE 28: Resistance risk for herbicides used in cotton

Herbicide active ingredient	Pre plant	At plant	Post plant	Mode of action	Years to resistance	Resistance status
Amitrole + paraquat	Y	N	N	34(Q) + 22(L)	>15	Rare
Amitrole + ammonium thiocyanate	Y	N	N	34(Q)	>15	Rare
S-Metolachlor or Metolachlor	Y	Y	Y ¹	15(K)	>15	Rare
Saflufenacil	Y	N	N	14(G)	>15	Rare
Glufosinate-ammonium	Y	N	N ²	10(N)	10-15	Rare
Dicamba ³	Y	N	N ²	4(I)	10-15	Rare
Fluroxypyr	Y	N	N	4(I)	10-15	Rare
Fluroxypyr+ aminopyralid	Y	N	N	4(I)	10-15	Rare
Diuron	Y	Y	Y	5(C)	10-15	Rare
Fluometuron + prometryn	Y	Y	Y	5(C)	10-15	Rare
Prometryn	Y	Y	Y	5(C)	10-15	Rare
Triclopyr	Y	N	N	4(I)	10+	Rare
Triclopyr + picloram	Y	N	N	4(I)	10+	Rare
Triclopyr + picloram + aminopyralid	Y	N	N	4(I)	10+	Rare
Carfentrazone-ethyl	Y	N	N	14(G)	10	Rare
Flumioxazin ⁴	Y	N	Y	14(G)	10	Rare
Oxyfluorfen	Y	N	N	14(G)	10	Rare
Isoxaflutole ³	Y	N	N	27(H)	10	Rare
Paraquat	Y	Y	Y	22(L)	>15	Occasional
Paraquat + diquat	Y	Y	N	22(L)	>15	Occasional
2,4-D ³	Y	N	N	4(I)	10-15	Occasional
Pendimethalin	Y	Y	Y ⁵	3(D)	10-15	Occasional
Trifluralin	Y	Y	N	3(D)	10-15	Occasional
Bromoxynil	Y	N	N	5(C)	10-15	Occasional
Glyphosate ⁶	Y	Y	Y	9(M)	>12	Widespread
Butroxydim	N	N	Y	1(A)	6-8	Widespread
Clethodim	N	N	Y	1(A)	6-8	Widespread
Fluazifop-p	N	N	Y	1(A)	6-8	Widespread
Haloxyfop	N	N	Y	1(A)	6-8	Widespread
Propaquizafop	N	N	Y	1(A)	6-8	Widespread
Halosulfuron-methyl	N	N	Y	2(B)	4	Widespread
Trifloxysulfuron sodium	N	N	Y	2(B)	4	Widespread

Lowest resistance risk
Moderate resistance risk
Highest resistance risk

Note that Group 1(A) herbicides already exhibit widespread resistance in several species. Controlling survivors is essential.

Always read the label for detailed use patterns and application rates.

¹ Dual Gold® formulation.

² XtendFlex® varieties only, using specific formulation registrations.

³ See label for rainfall required before plant-back period begins.

⁴ Valor® formulation only.

⁵ Rifle® formulations.

⁶ Roundup Ready Flex® varieties only.

Refer to Tables 21, 22 and 24 for plant-back periods.

Herbicide Resistance Management Strategy 2025/26

An integrated weed management system relies on a large number of complementary components, including chemical and non-chemical control tactics combined with cultural practices such as crop competition, rotation, farm hygiene and crop scouting. Effective strategies to delay herbicide resistance and manage resistant populations are essential for long-term sustainability of cotton farming.



Apply 6 different modes of action on grasses and broadleaves every 2 years, and allow NO SURVIVORS to set seed

CHOOSE 6 TACTICS	Fallow Strategic cultivation Double knock Optical sprayers Patch management Cover crops	Pre/at plant Cultivation Double knock Knockdowns Group 5/C bromoxynil Group 14/G pyraflufen, flumioxazin, saflufenacil, oxyfluorfen, carfentrazone Group 4/I dicamba, fluroxypyr Group 22/L paraquat, diquat Group 22-L/34-Q amitrole/paraquat Group 10/N glufosinate Group 9/M glyphosate Residuals³ Group 5/C prometryn, terbutylazine, diuron Group 3/D pendimethalin, trifluralin Group 15/K S-metolachlor, metolachlor	Post-emergent In-crop cultivation Manual chipping Rogueing Spot spraying Post-emergent OTT Group 1/A ² sethoxydim, clethodim, butoxydim, haloxyfop, propaquizafop Group 15/K ⁴ S-metolachlor Lay-by, directed or shielded spray Group 5/C prometryn, terbutylazine, diuron Group 3/D pendimethalin Group 14/G ⁴ flumioxazin Group 15/K ⁴ S-metolachlor	Maturing crops Cultivation Chipping Rogueing Spot spraying <i>Aim for 100% control of survivors</i>
	Fallow herbicides Group 9/M glyphosate Group 5/C bromoxynil, terbutylazine Group 14/G flumioxazin, pyraflufen, saflufenacil Group 27/H isoxaflutole Group 22/L paraquat, diquat Group 22/L+34/Q paraquat+amitrole Group 10/N glufosinate Group 4/I 2,4-D, dicamba, fluroxypyr Rotation Crops³ Crop competition Rotate modes of action Plant back restrictions Cover crops			
NO SURVIVORS	Target survivors — aim for 100% control			
	In fallow survivor control Cultivation, chipping or spot spraying (refer above for options) Optical sprayer	Pre-plant survivor control Cultivation, chipping or spot spraying flumioxazin pyraflufen-ethyl (added to complementary product) carfentrazone-ethyl bromoxynil	Post-emergent Inter-row cultivation, chipping or spot spraying	Post-harvest Root cutting for crop destruction Cultivation, chipping or spot spraying carfentrazone-ethyl, pyraflufen-ethyl bromoxynil fluroxypyr
COMMENTS	- Survivors MUST be controlled with a different MOA prior to seed set. - Read and follow all label directions. - Rotate herbicide mode of action (MoA). - Come Clean. Go Clean. to avoid importing weed seeds. - Scout fields regularly for weeds and monitor after spraying for survivors. - Keep accurate field records. - Ensure volunteers/ratoons are controlled. - DO NOT rely solely on glyphosate or any other in-crop herbicide for non-field weed control. - Take a farming systems approach to weed management, considering winter, summer and non-field area weed control.			
	Footnotes: 1. APVMA permits: 88120, 90223 for fallow use. 2. Group 1/A herbicides already exhibit widespread resistance. Controlling survivors is essential. 3. Refer to label for plant-back restrictions to following crop. 4. Limited formulations are registered for this use. Please check label.			

Revised Herbicide Resistance Management Strategy (HRMS) explained

The HRMS is designed as a tool to manage the risk of herbicide resistance in irrigated and dryland farming systems incorporating herbicide tolerant cotton. The strategy has been developed in response to the escalating problem of herbicide resistance across multiple weed species to a number of herbicide modes of action (MoA). This is the second version of the HRMS, following on from the original 2+2+0 strategy that saw the cotton industry adopt world's best, and most effective, glyphosate resistance management. This version of the HRMS focuses on a glyphosate, glufosinate and dicamba tolerant cotton system (XtendFlex® cotton); however, we are constantly alert to the fact that other herbicides could become at-risk for resistance if used more than once every year. Many herbicides, including the ones listed, already have a history of use in cotton fields, indicating that some selection for resistance for any registered herbicide could already have occurred.

A sustainable system requires a high level of diversity and zero tolerance for survivors of herbicide sprays. Using 6 different methods/modes of action across every 2 years (such as 3 in fallow plus 3 in crop, for a dryland situation), plus additional actions if required to prevent seed set on survivors, provides a sustainably low risk (but not zero risk) system.

The formula to delay or manage resistance

The most effective way to delay the evolution of herbicide resistance is to target weed control across the whole farming system with a diversity of tactics. A focus on reducing weed numbers in fallows or rotation crops will reduce the reliance on in-crop weed control. Aim to drive down weed numbers and ensure no weeds set seed after herbicide applications, and use a diverse program of 6 modes of action every 2 years. This can be done by using:

- a minimum of 3 different weed control tactics effective on the weeds being controlled in crop, and 3 more in summer fallows (or non-cotton crops). If more controls are needed, make use of fallow periods to get access to a range of products that can be used where no crop is present needing protection. Take note: where both grasses and broadleaves are present, 'three different modes of action' must apply to both types of weed species, meaning more than three in total may need to be applied. Check the tables in this guide for the wide range of available tactics at different crop stages.
- AND ensure that no survivors set seed. Effective post-spray monitoring (with follow-up action) is critical for ensuring control of survivors.

Examples of the influence of various weed management tactics on herbicide resistance risk are provided in Table A.

Table A: Risk reducers and risk promoters for herbicide resistance

Effect on resistance risk	Tactic	Notes
Strongly reduces risk	Spot-spray glyphosate at high rates through optical detection system	Glyphosate at the highest allowable rate, applied to small proportions of the field, remains very effective for seedbank and resistance management, including protecting other herbicide groups under pressure of resistance.
Strongly reduces risk	Apply glyphosate as part of double knock	Whenever there is the opportunity to follow glyphosate with a fast-acting knockdown herbicide, it should be taken. In the absence of paraquat, glufosinate or cultivation can be useful double knock partners. Other suitable sequences of tactics may be used.
Reduces risk	Late season survivor control	Additional tactics used specifically to control survivors in crop prior to seed set are fundamentally important.
Reduces risk	Apply glufosinate as part of double knock	Glufosinate is a moderately at risk herbicide for resistance. Preserve its susceptibility by attempting to use it as part of mixed strategies with other modes of action.
Reduces risk	Apply key herbicides in mixtures	Glufosinate and dicamba are at risk for resistance. Using them in mixtures with compatible products can help reduce resistance risk.
Increases risk	Weed species known for evolving resistance (annual ryegrass, barnyard grass, feathertop Rhodes grass, flaxleaf fleabane)	Several such species are present in various regions. Currently susceptible biotypes of key species should be treated as being at risk of resistance in the short to medium term. Consult your agronomist about the herbicide resistance history of your weed species.
Highly increases risk	Cross-seasonal species (often germinates out of expected season)	Adaptable species such as annual ryegrass can generate large seedbanks by appearing out of their expected season, and going uncontrolled.
Highly increases risk	Multiple generations per year	These highly fecund species can evolve very rapidly, and must be controlled with multiple modes of action.
Highly increases risk	Relying on 1-2 herbicides	

Increased time to resistance

Research into glyphosate resistance has indicated that typically glyphosate failure may appear in grass weeds after approximately 13 years (dryland) and 19 years (irrigated) in a glyphosate only system. Resistance to glyphosate in broadleaf weeds can be slower to emerge and usually takes around 18 years in both irrigated and dryland systems. Some non-glyphosate modes of action share similar or slightly longer timeframes (e.g. Group 4 herbicides, glufosinate), while others have substantially shorter timeframes (Group 1, Group 2 herbicides). However, it is important to remember that the most reliable herbicides in our system, including but not limited to glyphosate, have now been in frequent use for one to two decades in nearly all cropping situations in Australia. This means that time frames to resistance for populations on farm could appear to be much shorter, since we are unlikely to be starting with a truly wild type, unselected population. It is helpful to know your herbicide use history on weeds that have been on farm for many years. Assume that resistance could appear much more quickly than these indicative timeframes, if the system begins to favour a particular herbicide.

Herbicide resistance can be delayed by 4-6 years with good survivor control and product rotations and mixtures, and the same strategies are very effective for managing resistant populations that do occur. To drive down weed numbers and eradicate resistant biotypes, additional tactics such as intensive patch management are required.

Other management considerations

Any rotation or cover crop should be managed similarly to a fallow, with at least 3 modes of action recommended. Rotation and cover crops provide an opportunity to incorporate other tactics, rotate to herbicide groups not used in cotton, vary the time of year crop competition suppresses weeds, and produce stubble loads or mulch that can reduce subsequent weed germinations.

Aim for 100% control of survivors after each herbicide application. Effective post-spray monitoring to detect survivors is critical. The use of cultivation to control any survivors after a herbicide application is predicted to achieve 80% survivor control, whereas cultivation plus follow-up chipping is predicted to achieve close to 100% survivor control. Other tactics for survivor control can be equally effective, such as shielded or spot-spraying with an effective knockdown herbicide. Even very small mature weeds may produce viable seeds, and if those carry resistance genes, a long-term problem can begin to emerge. Get suspect weed survivors tested for resistance.

Residual herbicides need back up, such as tillage, chipping and knockdown herbicide applications to control survivors. When using residual herbicides, consider plant-back periods and crop safety. Be aware that prolonged dry periods may extend plant-back periods.

Control weeds in adjacent areas (channels, tail drains, fencelines and roadsides) to minimise the seed bank and eliminate unknown weed seed sources. Do NOT rely solely on glyphosate to manage weeds in non-crop areas.

Be aware of weed seed contamination sources (e.g. waterways, vehicle/machinery, and farm inputs).

Establish and maintain Come Clean. Go Clean. to prevent the introduction and transport of resistant seeds.

Use patch management strategies – control any weeds in and around problem patches with a different mode of action from ones that the patch may have recently survived. Be ready for the tendency of patches to spread if not controlled well.

Use IWM best practice when employing tactics, including:

- Optical Spot Spray Technology, particularly where spot spraying allows for high herbicide rates on a small proportion of the paddock.
- Regular scouting and ensuring correct weed identification. Check with an agronomist if you are unsure of a weed's identification. Be on the lookout for any new weeds and eradicate problematic new weeds before they become an issue.
- Frequent post-spray monitoring.
- Good record keeping.
- Timely implementation of tactics – hitting weeds when they're small and vulnerable.
- Rotate and mix herbicide mode of action groups.
- Always follow label recommendations.
- Consider other aspects of crop agronomy.

Poor seedbank control over 5-10 years strongly correlates with increased herbicide resistance risk.

The medium-term success of moderate-high resistance risk strategies depends greatly on the history of exposure to the MOAs used in crop. If a weed population is already at 1-10% resistance due to historical practice, full-blown resistance can appear within 3-4 years of even a moderate risk strategy.

The success of moderate risk strategies is highly responsive to summer fallow actions in dryland cotton. Crops grown 1 year in 3 with a very low-risk, robust summer fallow program can sustain somewhat less diverse in-crop strategies. Back-to-back irrigated crops, where summer fallow control is not available, should stick with low risk strategies in crop.

Assessing your own risk

Refer to pages 92-95 of this publication for information on recognising potential herbicide resistance how to get weeds tested.

More information and tools related to herbicide resistance and weed management in cotton is available from:

 cottoninfo.com.au or  weedsmart.org.au

The HRMS in practice

Implementing the HRMS in cotton requires fitting a range weed control tactics into real situations with lots of variables. Finding room for 6 different tactics every two years is feasible but can be challenging. A few of the important considerations are:

- What weed species are you actually dealing with?
- What's your crop rotation?
- When, and how often, can you include soil disturbance for weed management?

Tables B and C include some example IWM strategies in-crop and during fallows, rated for resistance risk and seedbank control. The most diverse strategies (at the top of each table) maximise seedbank control and minimise resistance risk, but potentially have the highest input costs.

In order to fit the HRMS requirements of 6 different tactics every 2 years, aim for a strategy similar to those in the green rows (low or low-moderate risk). Avoid high or very high risk strategies where possible, and remember that if high risk strategies are used in one part of your rotation (e.g. in-crop), you'll need an even greater focus on reducing risk in the following year to reach the HRMS target.

Table B: Example IWM strategies for in-crop weed management

Resistance risk level	Strategy	#MoA/season	Seedbank control*	Comments
Low	2-3 OTT glyphosate + double knock prior to planting + 2 different residuals (at/near planting, layby) + OTT dicamba + double knock glyphosate/glufosinate OTT + tillage/spot spraying late season for survivor control	5-6	Very high	Fallow choices for broadleaf control are important (avoid 2,4-D). In the absence of paraquat, double knock with glyphosate fb glufosinate or other suitable sequences
Low-moderate	2-3 OTT glyphosate + 2 different residuals at planting and layby + double knock glyphosate/glufosinate OTT + inter-row cultivation + spot spraying for survivor control	5	High	Glufosinate is best used as part of double knocks, from the point of view of overall resistance management
Low-Moderate	2 OTT glyphosate + double knock prior to planting + residual at planting + up to 2 dicamba and glufosinate OTT	4	High-moderate	Not ideal for cross-season species or species producing multiple generations per year. Can be very successful when supplemented with best practice summer fallows.
Moderate-high	2 OTT glyphosate + residual at planting + up to 2 dicamba and glufosinate OTT	4	Moderate	Requires very aggressive summer fallow program for sustainability
High	2-3 OTT glyphosate 2-3 OTT dicamba and glufosinate	3	Moderate-low	Especially susceptible to dicamba resistance if 2,4-D or similar products used in fallow
Very high	Glyphosate alone or with occasional clean-up tactics	1-2	Moderate-low	History demonstrates glyphosate alone is too high risk for resistance to be recommended in any situation

Table C: Example IWM strategies for summer fallows

Resistance risk level	Strategy	#MoA/season	Seedbank control*	Comments
Low	Glyphosate (applied in double knocks or at high rates via optical sprayer wherever possible) x2-3 + 2 different residual MoAs, early and mid-fallow + broadleaf herbicide ¹ + consistent survivor control + includes cultivation ²	5-6	High	In the absence of paraquat, use glufosinate as a double knock partner – but preferably only as part of double knocks in fallow. Aim to use double knocks for half of all glyphosate applications.
Low-moderate	Glyphosate (broadacre) x2-3 + early season residual + grass selective + glufosinate + late survivor control with spot spraying	4-5	Generally high	
Moderate	Glyphosate (mostly applied in double knock/optical sprayer) x3 + 2 different residuals	3	Moderate-high	Seedbank control is variable, depending on residual choice and existing glyphosate resistance. Choose residuals not used in crop if possible. Be aware of plantback restrictions.
Moderate	Glyphosate x2-3 always applied as double knocks + early residual		Variable	
High	Glyphosate x2-3 + 2,4-D or other group 4 + glufosinate used alone		Moderate	Seedbank control depends on resistance level and can be lost quickly.
High	Glyphosate alone, with occasional cleanup tactics		Moderate-low	Seedbank control depends on resistance level – generally good for various susceptible species and very poor for any resistant ones.

¹ It is preferable to avoid, or carefully manage, broadleaf herbicides with known cross-resistance effects to dicamba, including 2,4-D, clopyralid and fluroxypyr in fallow. Follow any applications from this group with monitoring and robust survivor control.

² Incorporating cultivation somewhere in fallow can be beneficial for seedbank control of surface germinating species. Consider residuals incorporated by tillage.

*Seed bank control key (seeds/m²): Very high <10; High 10-100; Moderate 100-500; Low 500-1500; Very low >1500.

Herbicide tolerance technology:

XtendFlex® cotton Bayer Crop Science

Cotton varieties containing the XtendFlex® herbicide tolerance trait (XtendFlex® cotton) are tolerant to glyphosate, dicamba, and glufosinate-ammonium herbicides. This provides growers with multiple modes of action to target glyphosate-resistant and hard-to-kill weed species.

Weed resistance management in XtendFlex® cotton

Herbicide resistant weeds have been a reality in Australia for decades – no herbicide is immune, and while the problem is significant, it is also manageable. Prudent management of XtendFlex® cotton technology and mitigation of resistance risks, will ensure these options for weed control are available to Australian cotton growers well into the future.

Growing XtendFlex cotton

There are several requirements that growers need to be aware of when planting XtendFlex cotton. These registered products are: Roundup Ready® herbicide with PLANTSHIELD®, Roundup Ready PL herbicide with Plantshield Technology, XtendiMax® 2 herbicide with VapourGrip® Technology (XtendiMax 2), Roundup Xtend® 2 herbicide with VapourGrip Technology and Nufarm BIFFO® herbicide.

The requirements are designed to support the longevity and effectiveness of the trait and herbicides, which include:

- Completion of an XtendFlex® cotton accreditation course prior to planting cotton containing the XtendFlex® herbicide tolerance trait for the first time.
- Reporting any suspected glyphosate, dicamba or glufosinate resistant weed species to a Bayer representative or Nufarm where Nufarm BIFFO® herbicide has been used.
- Implementing an integrated weed management (IWM) strategy.

- Completion of the XtendFlex® cotton spray applicator training when applying XtendiMax® 2 herbicide in XtendFlex® cotton.



XtendFlex® guides are downloadable from crop.bayer.com.au/products/biotechnology-traits/xtendflex-cotton



Reporting suspected resistance

Naturally occurring populations of some weeds may possess biotypes with resistance to glyphosate, dicamba or glufosinate. Growers should be aware of this prior to using any of the registered over the top (OTT) herbicides in XtendFlex® cotton and should aim to decrease the development and spread of resistant populations. If you suspect resistant biotypes are present, they should be sampled and tested. Contact your local Bayer Territory Business Manager for assistance with this process.

The weed resistance management plan (WRMP) aims to reduce the likelihood of weed resistance to glyphosate, dicamba or glufosinate herbicides developing, it does not guarantee that resistance will not occur.

Understanding your herbicide resistance risk

Each field planted to XtendFlex® cotton has its own unique risk of weed populations resistant to dicamba, glufosinate or glyphosate developing, based on herbicide usage history, the weeds present and their population density, and other historical rotations and agronomic management strategies employed.

As a part of any sound IWM plan, growers are encouraged to assess their resistance risk prior to planting XtendFlex® cotton when making decisions about weed management strategies.

 XTENDFLEX® COTTON   XTENDFLEX® COTTON 			
XTENDFLEX COTTON HAS TOLERANCE TO THE FOLLOWING REGISTERED OVER-THE-TOP HERBICIDES 	GLYPHOSATE  ACTIVE CONSTITUENT 540 g/L glyphosate as potassium salt	LOW VOLATILITY DICAMBA + VOLATILITY REDUCTION AGENT  ACTIVE CONSTITUENT 480 g/L dicamba as monoethanolamine salt	GLUFOSINATE-AMMONIUM  ACTIVE CONSTITUENT 200 g/L glufosinate-ammonium

On-farm factors that change resistance risks

Factors that decrease resistance risk:

- Monitoring and preventing herbicide weed control escapes from setting seed.
- Planning and implementing an IWM strategy to reduce the weed seed-bank.
- Strategic use of alternative knockdown herbicides and tillage in fallows prior to sowing.
- Use of alternate herbicide modes of action including residual herbicides in crops and fallows.
- Use of a double-knock glyphosate followed by tillage or an appropriate double-knock product such as paraquat (Group 10) based products at effective rates.
- Applying stewardship plans when growing herbicide tolerant crops.
- Farm hygiene to prevent importing and moving herbicide resistant weed seeds.

Factors that increase resistance risk:

- Frequent glyphosate, glufosinate, or dicamba-based chemical fallow applications not followed by double-knocks to ensure no weed survivors.
- Continuous reliance on glyphosate, glufosinate, and mixtures with dicamba as a knockdown prior to sowing.
- Lack of tillage.
- Lack of use of alternative herbicide modes of action in fallows and crops.
- Allowing survivors of glyphosate, dicamba or glufosinate applications to set seed.
- High weed numbers.
- Lack of crop competition on weeds.
- Over-reliance on herbicide tolerant crops as a weed control mechanism.

Resistance management principles for XtendFlex® cotton

Incorporating a range of cultural and herbicide management practices will maximise the control of any potential herbicide resistant weed populations. The implementation of these practices should also result in a reduction in the weed population entering the XtendFlex® cotton cropping phase.

Key IWM principles for XtendFlex® cotton are:

1. Aim to enter the XtendFlex® cotton cropping phase of your rotation with a low weed burden.
2. Integrate as many different weed control options (chemical and cultural) as possible through all phases of the crop rotation.
3. Make every herbicide application count – use registered rates at the correct application growth stage and always assess its effectiveness.
4. Rotate herbicides with different modes of action throughout the fallow and crop rotation.
5. Regularly monitor the effectiveness of resistance management practices.
6. Test weed populations for herbicide resistance status as a part of ongoing IWM.
7. If planting into a paddock with suspected glyphosate, dicamba or glufosinate resistant weed populations growers must have a plan to manage such weeds.
8. Stop weed seed set by aiming for 100% control of any survivors.

Growers should aim to prevent seed set from any weeds surviving glyphosate, dicamba or glufosinate herbicide applications to prevent resistance development and

spread – never use the same herbicide/herbicide group twice on the same weed, or weeds growing from seed produced by a surviving weed.

Table 29 outlines some key principles for weed control at different stages through the cotton season.

Bayer strongly recommends that growers consult an agronomist when designing an IWM strategy for their property. For further resources and information see weedsmart.org.au.



Resources on weed management and minimising the risk of resistance can be found at weedsmart.org.au



Monitoring herbicide efficacy

All growers or agronomists should inspect fields between 14 and 28 days after spraying with glyphosate, dicamba or glufosinate to monitor the effectiveness of the herbicide application. During an inspection, any surviving weeds that are normally susceptible to the herbicide/s used should be identified. The outcomes of any inspection and any remedial application used should be recorded. Any case of suspected resistance should be reported immediately to Bayer (Nufarm for glufosinate) for further investigation.

Growing Roundup Ready Flex® cotton?

If you are planning to grow Roundup Ready Flex® cotton in the 2025/26 cotton season, please refer to the Roundup Ready Flex® Weed Resistance Management Plan (see link below) or refer to the 2025/26 Bayer Technology User Agreement document.

Roundup Ready Flex® Weed RMP:

crop.bayer.com.au/-/media/bcs-inter/ws_australia/use-our-products/product-resources/cotton-traits/rrflex-cotton-weed-rmp-m0181.pdf



XtendFlex®, Roundup Ready®, XtendiMax®, PLANTSHIELD® and VapourGrip® are Registered Trademarks of the Bayer Group; BIFFO® is a Registered Trademark of Nufarm Australia Ltd. III

USEFUL RESOURCE:

For stewardship and resistance management information regarding these technology traits and related products visit crop.bayer.com.au



TABLE 29: Key principles for weed control in XtendFlex® cotton crops

PRE-PLANT KNOCKDOWN	• Always start clean by planting into a weed-free field using either tillage or an effective herbicide application. • Know your field history in order to identify whether any volunteer cotton present is XtendFlex® cotton. • Consider using approved tank mixes when applying any of the OTT registered products in XtendFlex® cotton (do not mix any ammonium containing products e.g. ammonium sulfate, glufosinate-ammonium or glyphosate ammonium salts).
RESIDUAL HERBICIDES	• Residual herbicides should be used where appropriate in an XtendFlex® cotton system. • Consider using residual herbicides where weed pressure is high, or weeds will not be adequately controlled by the OTT products registered for use in XtendFlex® cotton. • The residual herbicide can be applied as a pre-emergence application (either a pre-plant incorporated application, or at planting application). • Use the recommended label rate and timing of the residual herbicide.
IN-CROP WEED CONTROL	• Refer to the XtendiMax® 2 product label for use patterns and application timing restrictions for use in XtendFlex® cotton. • Select the timing and application rate of sprays based on the most difficult to control weed species in each field in accordance with the label. • Post-directed sprays should be used to achieve more thorough coverage on weeds. • Refer to the 'Weeds Controlled' table on the label for the rate recommendations on specific weeds for products registered for OTT use in XtendFlex® cotton. • Aim for 100% control of weeds. Monitor and where required implement additional tactics such as inter row cultivation, and/or alternative modes of action to control survivors. • Be aware of any potential contamination of spray application equipment (including mixing stations). • Ensure all equipment is thoroughly cleaned and free of residues. • Only tank mix with products that are approved according to the label. • Do not mix products containing ammonium ions with dicamba, including ammonium sulfate (AMS), glufosinate-ammonium and ammonium salts of glyphosate. • Ensure all applications are made according to label guidelines on water volume, droplet size and environmental conditions and appropriate boom heights and application speeds are maintained. • Be aware of off-target drift to susceptible crops and fields with both aerial and ground applications. Do not apply herbicides by aircraft unless approved on label. • Monitor predicted conditions to manage the possibility of dicamba volatility and drift up to 72 hours post application (refer label). • Growers should use registered herbicides other than glyphosate, glufosinate or dicamba where required to increase diversity of weed control tactics.
LAY-BY APPLICATIONS	• If you currently use lay-by herbicides, then consider maintaining this program. • A robust lay-by program can provide residual control of weeds not controlled by glyphosate, dicamba or glufosinate. • Use the recommended label rate and timing of the residual herbicide.
PRE- HARVEST APPLICATION	• An over-the-top application of a Roundup Ready® Herbicide is possible, if required, before harvest and after cotton reaches 60% open bolls, as one of the 4 glyphosate applications. Rate: 1.5 kg/ha for Roundup Ready® Herbicide with PLANTSHIELD® or 1.9 L/ha for Roundup Ready® PL Herbicide with PLANTSHIELD® Technology. • This application can be used to control late season weeds and improve harvest efficiency. • Compatible with commonly used defoliant (see Roundup Ready® Herbicide with PLANTSHIELD® and Roundup Ready® PL with PLANTSHIELD® Technology labels). • Do not use on crops intended for planting seed production.

Management of volunteer and ratoon cotton

Controlling unwanted cotton is an essential part of good integrated pest and disease management and general farm hygiene. Volunteer (established unintentionally) and ratoon (regrown from surviving root stock) plants can:

- create problems for Bt resistance management
- physically block row access
- act as a 'green bridge' or as early hosts for pests such as spider mites, aphids and cotton bunchy top (mealybug hotspots are often associated with ratoon cotton plants)
- interfere with disease management strategies
- reduce seed purity.

Unwanted cotton can occur in fields that have previously grown cotton, elsewhere on the farm, or even further afield (e.g. along irrigation channel or road corridors). Questions to ask when planning your IWM strategy include:

1. Are the volunteers/ratoons likely to be varieties that possess herbicide tolerance genes?
2. If a rotation or cover crop is planned, will there be problems managing unwanted cotton within it?

Do not allow established volunteers or ratoons to set seed as this will potentially create additional volunteers.

Volunteers

The majority of volunteers come from seed cotton that falls out of the boll early or is lost during picking or module assembly/transport, although plastic-wrapped round modules tend to have lower losses than tarped rectangular modules. Plants can also establish directly from fuzzy seed escapes while being transported to crushing plants or stock feed areas, or from planting seed accidentally spilled on route to or within fields.

Volunteers that emerge pre-planting may allow the early establishment of in-field pests populations and promote disease incidence. Volunteers are also more likely to be impacted by seedling diseases and cool conditions, and rarely contribute to crop yield.

Reduce the amount of viable cotton seed left in fields (via clean pick and stubble management) and around the farm (cleaning up after module removal and spillages) to minimise the volunteers germinating next season.

Best practice...

- Control volunteer and ratoon cotton plants in crop and non-cropping areas as part of an integrated weed management strategy.
- Target plants when small, using physical methods or an appropriate herbicide.
- Read and follow all label directions before use to confirm timing and rates and use sufficient spray volume to achieve good coverage.
- Undertake crop destruction operations as soon as practical after picking to prevent ratoon cotton.
- Ensure implements are set up to cultivate both hill and furrow; avoid leaving uncultivated strips.
- Manual removal (i.e. chipping) may be necessary where isolated plants remain in non-field areas.



Cultivation and herbicides are the most common methods of volunteer cotton control. Both require the plants to have germinated and emerged (following pre-irrigation or sufficient rainfall). Cultivating is a good IWM fit, as it readily controls seedlings (and also manages other weeds). However, it is only fully effective when applied across the entire field (both furrow and hill). It is also relatively slow, can lead to soil damage (if conducted at an inappropriate time) or erosion, and increases soil moisture losses (a problem in rain-grown farming systems).

Seedling volunteers can also be controlled reasonably well with less invasive physical removal such as Kelly chains, which break the young stems and can be used relatively close to planting. In-crop cultivation with sweeps is also effective on small volunteer cotton plants.

Most herbicides work best on young cotton seedlings (up to 4 nodes). Larger plants are usually much harder to kill, even when using double knocks.

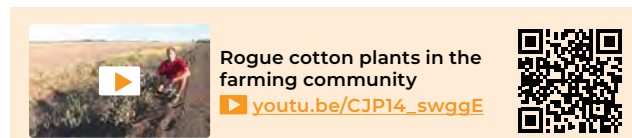
Tables 30 and 31 provide a list of herbicide actives registered for volunteer control, including established plants. Note that glufosinate will not be effective in controlling XtendFlex® cotton volunteers.

Refer to product labels for specific use information as not all products containing these actives have volunteer cotton on the label. Use different modes of action than utilised in-crop where possible, to help prevent resistance in other weed species that may be present, ensure any plant-back intervals fit with your proposed planting schedule, and take precautions to minimise drift.

Excellent spray coverage of contact herbicides is essential. Use sufficient volumes and appropriate speeds and note that shadowing from nearby stubble, lint or other weeds can adversely affect spray outcomes.

Crop rotation enables the use of alternate modes of action and residual herbicides. Ensure good control is achieved as cotton plants hidden within subsequent crops can continue to host pests and diseases.

Occasionally, cotton plants become well established before there is opportunity to control them due to unforeseen circumstances (often weather-related). Fluroxypyr (Comet®) can be used on larger (15-30 nodes) plants (see Table 31). Where isolated plants establish in fallows or non-field areas such as along roadsides and fences, physical removal by chipping can be very effective.



Ratoon cotton

Ratoon cotton (also called regrowth or stub cotton) usually results from ineffective crop destruction – either the stems have not been fully severed or have not been cut below the cotyledons. Ratoons are more likely to occur from volunteer plants or if planted seed grew outside the row line targeted by root cutting.

In theory, ratoons should not occur after Bt crops as harvested plants are required to be controlled as soon as practical after picking (usually by mulching and/or root cutting followed by cultivation to destroy the root system) in the Technology User Agreement.

In minimum-till situations, thorough crop destruction can be particularly challenging and care must be taken to ensure regrowth is prevented.



Effective end of season crop destruction

youtu.be/rO-JAX7s7jg

Crop destruction also provides an opportunity to destroy overwintering helicoverpa pupae (a mandatory strategy for Bollgard 3 crops where the first defoliation occurs after March 31) to manage insecticide resistance.

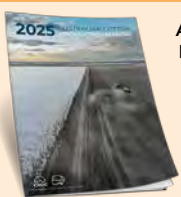
Ratoon cotton plants that have survived crop destruction can be difficult to control, having developed a large root system and small leaf surface area. Three herbicide options, registered for both optical booms and broadcast application, are available for the control of large volunteer cotton or ratoon cotton amongst stubble or in fallow (see Table 31). **ALWAYS FOLLOW LABEL DIRECTIONS.**

USEFUL RESOURCES:



WEEDpak

cottoninfo.com.au/publications/weedpak



Australian Cotton Production Manual: Chapter 23, Post-harvest pest and stubble management

cottoninfo.com.au/publications/australian-cotton-production-manual



TABLE 30: Herbicides for control of volunteer cotton

Active ingredient	MoA group	Comments (always refer to product labels)
Amitrole + paraquat*	34(Q) + 22(L)	Can be applied after glyphosate (as a double knock). See label for spot spray rates.
Bromoxynil	5(C)	Apply in minimum of 80 L/ha water for Roundup Ready cotton. See label for rain-fastness and restrictions on spray quality & condition.
Carfentrazone-ethyl	14(G)	Apply minimum spray volume of 80 L/ha to ensure effective coverage. To broaden weed spectrum may be tank mixed with the recommended rate of a knockdown herbicide. See label for adjuvant recommendation.
Paraquat + diquat*	22(L)	Apply in 50-100 L water/ha. Avoid spraying under hot dry conditions. For best results, spray in the evenings or in humid conditions.
Flumetsulam	2(B)	May be banded (>40%) over the row or broadcast. Minimum spray volume 150 L/ha for optimum results.
Flumioxazin	14(G)	Do not apply post-sowing pre-emergent. Do not sow crops for at least one hour after application. Can be tank mixed with glyphosate to control other weeds that may be present. See label for adjuvant details.
Glufosinate-ammonium**	10(N)	Good coverage is essential. Do not apply more than three applications per season. Best results are achieved when applied under warm humid conditions.
Metribuzin	5(C)	Registered for control of volunteer cotton in pigeon pea. See label for critical comments.
Fluroxypyr	4(I)	Summer fallow.
Saflufenacil	14(G)	Do not apply post-sowing pre-emergent. Always apply with adjuvant or high quality methylated seed oil. See label for mandatory no-spray zone and spraying rates.
Pyraflufen-ethyl	14(G)	Prior to sowing summer crop or starting a summer fallow. Apply by ground rig only. Good spray coverage is essential. Do not sow crops for at least 1 hour after application.

*paraquat and diquat are currently under APVMA review, with a final decision expected late in 2025. If reduced rates are recommended, this control option may be less effective.

**Note that volunteers with XtendFlex® traits will be tolerant to glufosinate-ammonium; adjust your IWM plan accordingly.

For the latest registration details, refer to portal.apvma.gov.au/pubcris

TABLE 31: Herbicides for control of large (15 to 30 node) volunteer cotton and ratoon cotton in fallow

Active ingredient	Rates	Comments
Fluroxypyr 4(I)	1 L/ha followed by 1 L/ha	OR
	1 L/ha followed by Shirquat® (22/L) 2 L/ha	OR
	1 L/ha + 1 L/ha Amicide Advance® (4/I) 700/ha	
		For control of large cotton plants or ratoon cotton a sequential application of Comet followed by Comet is required for maximum control. Ensure sufficient leaf regrowth has occurred on the ratoon cotton to maximise chemical uptake.
		For control of large cotton plants or ratoon cotton a sequential application of Comet followed by Shirquat is required for maximum control. The sequential application interval should be 7-14 days. Ensure sufficient leaf regrowth has occurred on the ratoon cotton to maximise chemical uptake.
		For a single pass operation apply Comet + Amicide Advance 700. Ensure sufficient leaf regrowth has occurred on the ratoon cotton to maximise chemical uptake.

Refer to the Comet® 400 registration label for further details on control rates for optical spot spray technologies. Note that paraquat is currently under review by the APVMA, and if reduced rates are recommended, a double knock with this product may not be as effective. Note that control rates are based on L/ha for broadcast application and L/100L (spot spraying rate) for optical sprayers.

For the latest registration details, refer to portal.apvma.gov.au/pubcris