

# Herbicide Resistance Management Strategy

## Explanatory Notes:

2022-23

**The HRMS is designed as a tool to manage the risk of herbicide resistance in irrigated and dryland farming systems incorporating herbicide tolerant (HT) cotton, to delay glyphosate resistance.**

The strategy has been developed in response to the escalating problem of glyphosate herbicide resistance. This version of the HRMS focuses on a glyphosate tolerant cotton system; however the future availability of multi-trait herbicide tolerant varieties has not been considered in the design of the strategy, and may require a more sophisticated strategy to follow into the future.

### The formula to manage/delay glyphosate resistance

The most effective way to delay resistance is to use:

**2** non-glyphosate tactics targeting both grasses and broadleaf weeds during the cotton crop

+

**2** non-glyphosate tactics in summer fallow targeting both grasses and broadleaf weeds

and

**NO survivors**, control survivors of glyphosate applications and do not allow them to set seed.

### Increased time to resistance:

Research indicates that typically glyphosate failure may appear in grass weeds after 13 years (dryland) and 19 years (irrigated) in a glyphosate only system. Resistance in broadleaf weeds is slower to emerge and usually takes around 18 years in both irrigated and dryland systems when cotton is grown in rotation with a summer fallow. Glyphosate resistance is delayed by 4-6 years if residual + double knock regularly implemented in summer fallow.

### Cropping system – The HRMS models two systems,

- Continuous back to back irrigated glyphosate-tolerant cotton with no summer fallow; and,
- Dryland glyphosate tolerant cotton grown every second year, alternating with long summer fallows.

With many farms now reporting glyphosate resistance, it is important to note that the strategies identified to avoid resistance are similar to those required to manage it. However, recent research has found that to eradicate populations, additional tactics such as patch management are required.

In the dryland scenario, rotation cropping should be considered similar to a fallow, with two non-glyphosate tactics recommended. Rotation crops provide an opportunity to incorporate other tactics, rotate herbicide groups, vary the time of year crop competition suppresses weeds and produce stubble loads that reduce subsequent weed germinations.

### In-crop tactics

- The control of survivors and use of two non-glyphosate tactics is critical to the HRMS.
- Aim for 100% control of glyphosate survivors after glyphosate application. Cultivation after glyphosate application is predicted to achieve 80% survivor control, whereas cultivation plus chipping is predicted to achieve 99.9% survivor control. Other tactics for survivor control could be equally effective, such as shielded or spot-spraying with an effective knockdown herbicide.
- A key principle of herbicide usage in an IWM system is to rotate herbicide groups.
- Residual herbicides need back up, such as tillage, chipping and non-glyphosate knockdowns. When using residuals, consider plant-back periods and crop safety.

### Summer fallow tactics

- Summer fallows (and rotations) may include any two non-glyphosate tactics such as residual or knockdown herbicides or tillage that are effective on the weed species present.

### Other management recommendations:

- 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 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 introduction and transport of resistant seeds.
- Monitor and follow up to ensure weeds that survive glyphosate applications are controlled using a non-glyphosate tactic before they are able to set seed. Get suspect weed survivors tested for resistance.
- Patch control – control weeds in isolated patches
- Use IWM best practice when employing tactics, including:
  - Regular scouting and correct weed identification;
  - Good record keeping;
  - Timely implementation of tactics;
  - Rotating herbicide mode of action groups;
  - Always following label recommendations; and,
  - Considering other aspects of crop agronomy.

### Assessing your own risk

Refer to page 86 of this publication for information on how to get weeds tested for resistance. For more information and tools on herbicide resistance and weed management in cotton refer to:

[www.cottoninfo.com.au](http://www.cottoninfo.com.au) or [www.weedsmart.org.au](http://www.weedsmart.org.au)

### Irrigated back to back cotton

Risk	In-crop tactics 3 x OTT glyphosate applications PLUS	Seed bank control	Comments
High - Resistance risk - Low → ↓ Decreasing - Survivor control - Increasing → ↓ Decreasing - Survivor control - Increasing → ↓ Decreasing - Survivor control - Increasing →	Very high survivor control after <b>each</b> OTT glyphosate	Very high	Control all survivors of OTT glyphosate applications. Don't use glyphosate alone to control the last in-crop flush
	2 x strategic in crop cultivations	Very high	Time the second cultivation to control last weed flush and escapes prior to row closure
	Pre-plant residual plus residual layby	Very high	Consider plant-back period restrictions
	Very high survivor control after <b>first</b> OTT glyphosate	Very high	Control survivors from first flush which has highest weed germination
	Grass selective in-crop herbicide + cultivation	High	Resistance to Group A herbicides may already be present in some populations. Controlling survivors is essential; follow with cultivation
	Moderate survivor control after <b>first</b> OTT glyphosate only	Low	Survivors allowed to set seed will increase the speed of selection for resistance. Test survivors for glyphosate resistance
	Glyphosate only	Very low	Survivors allowed to set seed will increase the speed of selection for resistance. Test survivors for glyphosate resistance

### Dryland cotton every second summer

Risk	Summer fallow tactics	In-crop tactics 3 x OTT glyphosate applications PLUS	Seed bank control in cotton phase	Comments
High - Resistance risk - Low → ↓ Decreasing - Survivor control - Increasing → ↓ Decreasing - Survivor control - Increasing → ↓ Decreasing - Survivor control - Increasing →	2 non-glyphosate tactics	Very high survivor control after <b>each</b> OTT glyphosate	Very high	The most effective scenario for delaying glyphosate resistance
	Glyphosate only fallow	Very high survivor control after <b>each</b> OTT glyphosate	Very high	Very high frequency & efficacy of survivor control is required if in-crop only tactics are used
	2 non-glyphosate tactics	Moderate survivor control after <b>each</b> OTT glyphosate	High	Lower intensity in-crop tactics can give excellent results if backed up with robust control in summer fallows. Specific, frequent, well-timed control of glyphosate survivors provides long term resistance delay/management
	Glyphosate only fallow	2 strategic cultivations	Low	Time last cultivation to control late flushes and escapes
	Glyphosate only fallow	Pre-plant residual + layby	Very low	These tactics give limited increased time to resistance and poor seed bank control
	Glyphosate only fallow	Moderate survivor control after <b>each</b> OTT	Very low	
	2 non-glyphosate tactics	Glyphosate only	Very low	
Glyphosate only fallow	Glyphosate only	Very low		

Glyphosate (Group M/9) resistance has been confirmed and is widespread in the following cotton weeds:

- Windmill grass
  - Awnless barnyard grass
  - Fleabane
  - Sowthistle
  - Feathertop Rhodes grass
  - Liverseed grass
- Annual ryegrass is a significant issue in Southern valleys and is emerging as a problem in Northern NSW. There are reports of cross resistance to glyphosate and Group A(1) herbicides.
  - Group A(1) resistance is widespread throughout broadacre farming systems and is increasing in cotton farming systems, especially in hard to control weeds such as feathertop Rhodes grass, annual ryegrass and windmill grass.
  - Emerging herbicide resistance to Group L(22) (paraquat) has been reported in other farming systems, especially in grasses. Resistance has not been reported in cotton farming systems, however the increase in double knock strategies makes it essential that **all survivors** of a double knock involving paraquat need to be controlled. Two populations of tall fleabane collected during surveys have tested as resistant to a glyphosate + paraquat double knock.
  - Increasing use of Group I(4) herbicides in summer fallows is a concern with a population of sowthistle reported as resistant to 2,4-D in winter cereals.
  - Hit weeds where it hurts: Use WeedSmart Summer BIG 6 (page 75).

**TABLE 25: Resistance risk for herbicides used in cotton**

Herbicide active ingredient	Pre plant	At plant	Post plant	Mode of Action	Years to resistance	Resistance status
MSMA	N	N	Y	Z(0)	N/A	Rare
Amitrole + paraquat	Y	N	N	Q(34) + L(22)	>15	Rare
Amitrole + ammonium thiocyanate	Y	N	N	Q(34)	N/A	Rare
Paraquat	Y	Y	Y	L(22)	>15	Occasional
Paraquat + diquat	Y	Y	N	L(22)	>15	Occasional
Glufosinate-ammonium	Y	N	N	N(10)	10-15	Rare
Glyphosate(a)	Y	Y	Y	M(9)	>12	Widespread
s-Metolachlor or Metolachlor (b)	Y	Y	Y	K(15)	>15	Rare
2,4-D (c)	Y	N	N	I(4)	10-15	Occasional
Dicamba (c)	Y	N	N	I(4)	10-15	Rare
Fluroxypyr	Y	N	N	I(4)	10-15	Rare
Fluroxypyr+ aminopyralid	Y	N	N	I(4)	10-15	Rare
Triclopyr	Y	N	N	I(4)	10+	Rare
Triclopyr + picloram	Y	N	N	I(4)	10+	Rare
Triclopyr + picloram + aminopyralid	Y	N	N	I(4)	10+	Rare
Carfentrazone-ethyl	Y	N	N	G(14)	10	Rare
Flumioxazin (d)	Y	N	Y*	G(14)	10	Rare
Oxyfluorfen	Y	N	N	G(14)	10	Rare
Saflufenacil	Y	N	N	G(14)	N/A	Rare
Norflurazon	Y	N	N	F(12)	15+	Occasional
Pendimethalin (e)	Y	Y	Y	D(3)	10-15	Occasional
Trifluralin	Y	Y	N	D(3)	10-15	Occasional
Chlorthal dimethyl	Y	Y	Y	D(3)	10-15	Occasional
Bromoxynil	Y	N	N	C(5)	10-15	Occasional
Diuron	Y	Y	Y	C(5)	10-15	Rare
Fluometuron	Y	Y	Y	C(5)	10-15	Rare
Fluometuron + prometryn	Y	Y	Y	C(5)	10-15	Rare
Prometryn	Y	Y	Y	C(5)	10-15	Rare
Isoxaflutole (c)	Y	N	N	H(27)	10	Rare
Halosulfuron-methyl	N	N	Y	B(2)	4	Widespread
Trifloxysulfuron sodium	N	N	Y	B(2)	4	Widespread
Butroxydim	N	N	Y	A(1)	6-8	Widespread
Clethodim	N	N	Y	A(1)	6-8	Widespread
Fluazifop-p	N	N	Y	A(1)	6-8	Widespread
Haloxifop	N	N	Y	A(1)	6-8	Widespread
Propaquizafop	N	N	Y	A(1)	6-8	Widespread

**Lowest resistance risk**
**Moderate resistance risk**
**Highest resistance risk**

**Group A herbicides already exhibit widespread resistance in several species. Controlling survivors is essential.**

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

- a) Roundup Ready Flex® varieties only.
- b) Bouncer® and Dual Gold formulations.
- c) See label for rainfall required before plant-back period begins.
- d) Valor® formulation only.
- e) Rifle® formulations.

**Refer to Tables 18, 19 and 21 for plant-back periods.**