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
- **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 on farm, 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 2 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 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 (eg 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
  - Rotate herbicide mode of action groups
  - Always follow label recommendations
  - Consider other aspects of crop agronomy

### Assessing your own risk

Information on how to get weeds tested for resistance, refer to page 87 CPMG.

For more information and tools on herbicide resistance and weed management in cotton refer to;

The strategy has been developed in response to the escalating problem of glyphosate herbicide resistance. This has been identified as a significant issue in cotton growing regions, particularly in those areas where glyphosate is used extensively in summer fallow systems. The HRMS models two systems, cotton every second summer and irrigated back to back cotton. The decision between these two systems should consider whether the herbicide stress from glyphosate is required if in-crop only tactics are used, or whether it is necessary to control weeds in isolated patches of non-crop areas.

In Crop Tactics

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

Dryland cotton every second summer

<table>
<thead>
<tr>
<th>Risk</th>
<th>Summer fallow tactics</th>
<th>In Crop Tactics 3 x OTT glyphosate applications PLUS</th>
<th>Seed Bank Control in cotton phase</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high survivor control after each OTT glyphosate</td>
<td>Very high</td>
<td>Very high</td>
<td>The most effective scenario for delaying glyphosate resistance</td>
<td></td>
</tr>
<tr>
<td>2 x strategic in crop cultivations</td>
<td>Very high</td>
<td>Very high</td>
<td>Very high frequency &amp; efficacy of survivor control is required if in-crop only tactics are used</td>
<td></td>
</tr>
<tr>
<td>Pre-plant residual + residual layby</td>
<td>Very low</td>
<td>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 provide long term resistance delay/management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very low brush control after each OTT glyphosate</td>
<td>Very low</td>
<td>Time last cultivation to control late flushes and escapes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate survivor control after first OTT glyphosate</td>
<td>Very low</td>
<td>These tactics give limited increased time to resistance and poor seedbank control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate survivor control after first OTT glyphosate</td>
<td>Very low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glyphosate only</td>
<td>Very low</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Glyphosate resistance has been confirmed and is widespread in the following cotton weeds:
- Windmill grass
- Fleabane
- Feathertop Rhodes grass
- Awnless barnyard grass
- Sorghum
- Liverseed grass
- Annual ryegrass
- Feather 
- Group A resistance is widespread throughout broadacre farming systems and is increasing in cotton farming systems, especially in hard to control weeds such as Feather 
- Emerging herbicide resistance to Group L (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 Flaxleaf fleabane collected during surveys have tested as resistant to glyphosate + paraquat double knock. 
- Increasing use of Group I herbicides in summer fallows is a concern with a population of sowthistle reported as resistant to 2,4-D in winter cereals.