INTRODUCTION TO IRRIGATED COTTON PRODUCTION

SOUTHERN NEW SOUTH WALES AND NORTHERN VICTORIA 2015/16

Developed in collaboration with Monsanto, CSD and CottonInfo
It’s an exciting time to join the Australian cotton industry with Bollgard 3 expected to be commercially available in the 2016/17 season pending key approvals.

Bollgard 3 contains a third protein, Vip3A*, to reinforce the Bt proteins found in Bollgard II – Cry1Ac and Cry2Ab. Having three proteins will increase the longevity of the technology. Each has a different mode of action which ‘kills’ larvae in a different way.

The introduction of Bollgard 3 will mark an important milestone for the cotton industry and ensure that the technology will continue to perform the way that growers need and expect for many years to come.
When will Bollgard 3 be available?

In Australia, three major regulatory approvals are required to cultivate a biotechnology crop commercially.

Bollgard 3 has now received two of these approvals from Food Standards Australia and New Zealand (FSANZ) and the Office of the Gene Technology Regulator (OGTR).

A submission has been made to the Australian Pesticides and Veterinary Medicines Authority (APVMA) to approve the Bollgard 3 product and also the proposed Resistance Management Plan.

Monsanto anticipate receiving this approval in late 2015 after planting has been completed.

Bollgard 3 Resistance Management Plan

The Resistance Management Plan (RMP) has been designed to reduce the rate of development of resistance to the two *Bacillus thuringiensis* (*Bt*) proteins expressed by Bollgard 3 cotton plants.

The cotton industry’s Transgenic and Insect Management Strategies (TIMS) Committee technology panel thoroughly reviewed and endorsed a Bollgard 3 RMP which is currently undergoing assessment by the Australian Pesticides and Veterinary Medicines Authority (APVMA).

The APVMA assessment of the Bollgard 3 product submission and the RMP is expected to be completed in late 2015.

Monsanto is seeking food and feed import approval in key importing countries. Monsanto has a global stewardship commitment to obtain regulatory approval in key importing countries to ensure growers have access to all possible trade markets without disruption.

Based on the current and projected regulatory approval status in Australia and internationally, we anticipate Bollgard 3 launch in the 2016/17 season, however this is dependent on regulatory approval status.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulatory Data Collection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OGTR Assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>APVMA Assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breeding Trials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMP Trials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed Bulk Up</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research Program</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anticipated Commercial Launch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PLANTING

Planting restrictions

All Bollgard 3 crops and refuges must be planted into moisture and or watered up between August 1 and December 31.

Time line of cotton crop development in Southern New South Wales and Northern Victoria:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Days at Whitton</th>
<th>Days at Forbes</th>
<th>Days at Tocumwal</th>
<th>Days at Swan Hill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sowing to Emergence (80 DD)</td>
<td>15</td>
<td>14</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>5th Leaf (330 DD)</td>
<td>47</td>
<td>46</td>
<td>51</td>
<td>49</td>
</tr>
<tr>
<td>1st Square (505 DD)</td>
<td>65</td>
<td>63</td>
<td>70</td>
<td>68</td>
</tr>
<tr>
<td>1st Flower (777 DD)</td>
<td>89</td>
<td>88</td>
<td>96</td>
<td>93</td>
</tr>
<tr>
<td>Peak Flowering (1302 DD)</td>
<td>129</td>
<td>128</td>
<td>139</td>
<td>137</td>
</tr>
<tr>
<td>Open Boll (1527 DD)</td>
<td>147</td>
<td>146</td>
<td>160</td>
<td>157</td>
</tr>
<tr>
<td>60% Open Bolls (2050 DD)</td>
<td>211</td>
<td>206</td>
<td>236</td>
<td>232</td>
</tr>
</tbody>
</table>

Crop growth

- Cotton does not grow below 12°C.
- Cotton does not like water logging or wet feet. Uniform beds or hills are essential for drainage and good establishment.
- In cooler season areas planting should be timed with a forecast for warm temperatures for the week after planting.
- At 10 cm depth, soil temperatures need to be 14°C at 9 am (AEST), with increasing air temperatures during the following week. If you plant cotton at soil temperatures below 14°C, the plant will take longer to emerge and thus be subject to high seedling mortality, slow plant growth and potentially delayed maturity. This could also result in the need to replant.

Nutrition

Cotton requires a good supply of both macro and micro nutrients to support high yields. Most soils require the application of Nitrogen (N) and Phosphorous (P), and some growers will need to apply Potassium, Zinc or other micronutrients as required.

The table shows the amount of nutrient removed by cotton crops yielding between 6 and 16 bales/ha.

Fertiliser applications should reflect two factors:

- The amount of certain nutrients in the soil before planting.
- The amount of nutrients removed in a previous crop.
- The yield potential of the field.
- Not all fertiliser is taken up by the plant. Average fertiliser recovery is around 50% for N fertilisers and can be lower for P and Potassium (K).

- BRF 74 is better planted shallow than deep.
- Seeding rate of 12–16 kg/ha with the aim to establish 12 uniform plants per metre. Consider soil conditions, soil temperature, pest and disease pressure in field when making your final decision.
- The majority of cotton in Southern New South Wales and Victoria is planted between the last week of September and the second week of October. To have the best chance of achieving high yields and good fibre quality aim to complete planting by 15 October.
- If Phosphorous levels are inadequate, consider spreading a phosphorus and urea blend before pulling up hills/beds as a simple alternative to fertiliser rigs.

- Apply approximately 230–300 kg Nitrogen per hectare depending on the soil test. Uptake pre-flowering is crucial to support high yields. Applications pre-planting or as a side-dressing early in the season are the best method to supply plants with nutrients when they need them.
- Conduct a soil analysis to form the base for your nutritional program. Samples are best taken from May to August, potentially from depths of 0–30, 30–60 and 60–90. Soil Nitrogen losses can occur if major flooding happens, use in crop monitoring if this happens to assess the situation.
- Discuss your fertiliser program with your agronomist to manage the crop to optimise rates and also timing.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Lint Yield (bales/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td>(kg/ha)</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>43</td>
</tr>
<tr>
<td>P</td>
<td>15</td>
</tr>
<tr>
<td>K</td>
<td>25</td>
</tr>
<tr>
<td>S</td>
<td>4</td>
</tr>
<tr>
<td>Mg</td>
<td>9</td>
</tr>
<tr>
<td>Ca</td>
<td>3</td>
</tr>
<tr>
<td>(g/ha)</td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>150</td>
</tr>
<tr>
<td>Mn</td>
<td>28</td>
</tr>
<tr>
<td>B</td>
<td>29</td>
</tr>
<tr>
<td>Zn</td>
<td>110</td>
</tr>
<tr>
<td>Cu</td>
<td>16</td>
</tr>
</tbody>
</table>
**Irrigation**

Regardless of whether the crop has been watered-up or pre-irrigated the first in crop irrigation is critical. It ensures the crop is set up to generate strong growth during the flowering period and root exploration of the soil.

A delayed first irrigation will place the plant under stress which will impact the performance of the crop. Thus it is important to measure plant available water and closely monitor the crop. Generally the first in crop irrigation occurs around 60 days after emergence (subject to weather and soil conditions). A flush may be warranted earlier.

---

**Refuge**

Refuge crops are to be planted and managed to be as attractive, if not more attractive to Helicoverpa than the Bollgard 3 crops, with the appropriate location and size, in order to be effective.

The aim of a refuge is to generate significant numbers of Helicoverpa spp. moths which have not been exposed to selection pressure from either of the Bt proteins or Vip3A\(^*\). Moths produced in the refuge crops will disperse to form part of the local mating population where they may mate with moths emerging from any Bollgard 3 crops.

Under the proposed Bollgard 3 RMP\(^*\) you can select from:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Conditions</th>
<th>% of Bollgard 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated cotton</td>
<td>Sprayed cotton refuge – an area of irrigated conventional cotton that is equal to 100% of the area of Bollgard II on the farm (refer to refuge planting dates), which can be conventionally managed for Helicoverpa spp. and other pests. No Bt products may be included at any stage.</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>OR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unsprayed cotton refuge – an area of irrigated conventional cotton which will not be treated for any reason with any products that control Helicoverpa spp. that is equal to 10% of the Bollgard 3 area on the farm (refer to refuge planting dates).</td>
<td>5</td>
</tr>
<tr>
<td>Irrigated pigeon pea</td>
<td>An area of unsprayed irrigated pigeon pea which will not be treated for any reason with any products which control Helicoverpa spp. that is equal to 5% of the Bollgard 3 area on the farm (refer to refuge planting dates) and is managed to ensure several cycles of flowering throughout the cotton season.</td>
<td>2.5</td>
</tr>
</tbody>
</table>

There is a minimum refuge size of 0.5 ha where no sprayed cotton is planted on the same farm unit.


**Note:** Pigeon Peas require soil temperatures of 17°C + for establishment and perform best if inoculated.

It is preferable that all refuge is planted within the two week period prior to planting Bollgard 3. If this is not possible, refuge planting MUST be completed within three weeks of the first sowing date of Bollgard 3.
**ESTABLISHMENT**

Emergence is expected 7–14 days after planting, dependent on soil temperature and moisture.

Aim for 10 plants per metre evenly spaced North of Dubbo and 12 plants per metre evenly spaced South of Dubbo. Less than ideal plant density can lead to poor yields and a delay in maturity. The decision to replant needs to happen before the end of October. Refer to diagram below which shows the yield penalties associated with a low even plant stand to a high even plant stand.

![Relative Yield Potential at a Range of Stand Uniformities](image-source: Greg Constable 1997)

**WEED CONTROL**

**Roundup Ready Flex® cotton**

Roundup Ready® Herbicide with PLANTSHIELD® by Monsanto

HERBICIDE APPLICATION – Growth Stage/Number of Applications and Timing

<table>
<thead>
<tr>
<th>HERBICIDE APPLICATION</th>
<th>Growth Stage/Number of Applications</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roundup Ready Flex®</td>
<td>Up to 4 x 1.5 kg/ha</td>
<td>OTT</td>
</tr>
<tr>
<td></td>
<td>OVER THE TOP (OTT) APPLICATION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 x 1.5kg/ha</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NO APPLICATION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>INF-BOLL OPEN TO HARVEST</td>
<td></td>
</tr>
</tbody>
</table>

*Image source: Monsanto Roundup Ready Flex spray recommendations*

Target the first in-crop application of Roundup Ready Herbicide with PLANTSHIELD by Monsanto on young cotton when weeds are less than 6cm in size.

Further in-crop applications of Roundup Ready Herbicide with PLANTSHIELD by Monsanto may be required to achieve good weed control. These applications should be made according to the presence of new and subsequent germination of weeds and the growth stage of the most difficult to control weed species present in each field.
CONTROLLING VOLUNTEER AND RATOON COTTON

Resistance management

Volunteer cotton increases the risk of the development of resistance in moth (*Helicoverpa* spp.) populations to the insecticidal proteins (Cry1Ac, Cry2Ab and Vip3A) in Bollgard 3 cotton. Ratoons and volunteers provide additional opportunities for *Helicoverpa* spp. that may carry the resistance genes to these proteins, to survive and pass on those genes.

Fields with ratoons and volunteers are unsuitable for planting refuge crops in as the population of *Helicoverpa* spp. moths, provided by the refuge, may have been exposed to the Cry1Ac, Cry2Ab, and Vip3A toxins and therefore may have reduced susceptibility to the proteins.

Disease prevention and risk mitigation

The ratoon and volunteer plants can act as crop hosts and/or stimulate the growth of soil bacteria, increasing the risk of Verticillium wilt, Fusarium wilt, Black root rot and Alternaria leaf spot.

Viruses such as Tobacco Streak virus and Cotton Bunchy Top (CBT) virus are unable to survive without a live plant host. Volunteer or ratoon cotton provide both a host for CBT and also an opportunity for the cotton aphid to survive over winter and then spread the virus onto nearby cotton crops, often resulting in severe yield losses.

Removing volunteers and ratoons is the simplest way of preventing aphid survival.

Control of insect populations

The presence of cotton volunteers and ratoons gives many insects an opportunity to survive over winter, increasing the risk of early season infestations and crop damage the following year. These insects include Cotton aphids, Mealybugs, Silverleaf Whitefly and Pale cotton strainers.

Infestation of the crop early in the season can result in yield losses through square damage or a reduction in leaf area. It may also require costly insecticide sprays for control that could be avoided had insect populations been controlled through good volunteer and ratoon control.
Agronomic considerations

Cotton volunteers compete for water and nutrients in the same way as weeds do.

In addition to competing for water and nutrients within your crop, cotton volunteers may also impact on water flow down the furrow. Large volunteers will also increase issues with shading when applying Roundup Ready Herbicide with PLANTSHEILD by Monsanto in-crop.

If volunteers are left uncontrolled in fallow areas, they can cause significant drying down of the soil profile reducing the available moisture being carried over for subsequent crops. In fact, ratoon cotton can dry the profile down to over 1 metre.

ROUNDUP READY FLEX COTTON WEED MANAGEMENT GUIDE

Download the Roundup Ready Flex cotton Weed Management Guide (from monsanto.com.au) for clear recommendations for weed control practices in a Roundup Ready Flex cotton crop. The guide includes a range of herbicides with different modes of action throughout the season, reducing the risk of glyphosate resistance developing on your farm and saving you time and money in the future.

ROUNDUP READY FLEX COTTON WEED RESISTANCE MANAGEMENT PLAN

Download the plan from monsanto.com.au for a simple outline of how to reduce your herbicide resistance risk and manage hard to control weeds.
FLOWERING

- Cotton has an indeterminate growth habit; it sets fruit over a period of time.
- With reproductive and vegetative phase of production, the aim is to balance plant growth between vegetative and reproductive stages, to achieve the maximum amount of fruit at harvest.
- Growth management using Mepiquat Chloride may be required dependent on how vegetative the crop is. Monitor internode spacing through this period. Any internode wider than 7cm may suggest growth management is required. Use an experienced agronomist when making growth management decisions.
- First square is at the beginning of the reproductive phase. This occurs 60–70 days after planting in Southern New South Wales and Victoria.
- Plants produce a node every three to four days depending on temperatures and soil moisture.
- Irrigation is critical during this process.
- It is recommended that you use moisture monitoring equipment.
- Flowering will occur 20–25 days after first squaring, typically around Christmas and New Years Day (85–95 days post planting).
- Cotton flowers are self-pollinating. A flower starts off as a white flower when blooming, turns pink once pollinated then withers and falls off the plant.
- Fruit retention should be monitored during the entire flowering period. It is recommended that you aim for 80% plus retention.
- Nodes above white flower (NAWF) is a measurement of the crop’s productivity during the flowering period. At first flower it is ideal to have greater than 8 NAWF to ensure the plant is growing at its optimum rate. If the NAWF rate falls to 4 or below prematurely, it has reached ‘cutout’ and yield potential will be reduced.

• ‘Cutout’ identifies the appearance of the last effective flower at the top of the plant, around 148–157 days after emergence.
• Continue to monitor the crop for insect activity in particular whitefly and aphids.
• Rainfall and humid weather during boll opening can cause ‘boll rot’.

• In Southern New South Wales and Victoria ‘cutout’ needs to be generated to help the crop mature while there is still heat (a late January Mepiquat Chloride spray – ‘Pix’). If it does not mature, the crop will have immature fibre issues and delayed defoliation and picking.
• For Southern New South Wales and Victoria, last effective flower dates range between 10 to 15 February, depending on location and season.

**Expected Flowering Date**
(days after planting, numbers in brackets are the node number)

**FINAL IRRIGATION**

- Irrigation management is critical in Southern New South Wales and Victoria as timely watering encourages fruit development and strong plant growth.
- Schedule irrigations to coincide with about 50% plant available water capacity (PAWC).
- The objective of the final irrigation is to make sure that all bolls are matured without water stress. Aim to have the soil at refill point for first pass defoliation.
- At last irrigation the bolls have set, vegetative growth is limited and majority of the plant’s carbohydrates are being used to satisfy boll demand.

**Daily water use during cotton crop production:**

- We recommend that you consult an experienced agronomist in regard to timing of final irrigation. There are a number of methods available to accurately time final irrigation.
- Budget on 10 m/L of water per hectare.
- Use soil moisture monitoring equipment to schedule final irrigation.

DEFOLIATION

- Defoliation should commence when Nodes Above Cracked Boll (NACB) is equal to four, or if cutting the last harvestable boll determines the plant is mature.
- Crops can be safely defoliated after 60–65% of bolls are open.
- Boll cutting is a useful tool for gauging boll maturity (see image).
- If boll openers/conditioners are applied prior to boll maturity they can cause bolls to shed, reduce yield and quality.
- Avoid applying defoliants when there is a risk of rainfall shortly after. Some defoliants are taken up slowly by the leaves and will wash off by rain, resulting in incomplete defoliation.
- Temperature outlook can effect defoliation – adjust rates according to the forecast. Cooler temperatures mean may mean slower results.
- To avoid regrowth issues do not defoliate an area bigger than can confidently be harvested within two weeks.
- Aim to have soil moisture at refill points at defoliation. Severely water stressed will not allow for effective defoliation.
- Ensure that defoliation practices occur before the onset of frost.
- Consult your local agronomist about the right defoliant option for your farm.
- If first defoliation occurs before March 31 pupae busting is not required for Bollgard 3.

HARVEST

Commence harvesting when:
- Seed is dry (seed should crack between your teeth).
- No free moisture remains on the lint. Avoid the following (STOP PICKING):
  - If you can feel moisture on the bolls.
  - Blocked doors, throwing cotton out the front.
  - Cotton reaches 12% on the moisture metre.
  - Cotton comes out as a dense blob and not fluffy.
  - The key to quality picking is lint cleanliness and being contaminate free.
- Picking on wet ground may also lead to compaction.
- Don’t delay picking, harvest when the crop is mature to pick. Delaying picking can result in down grading which can lead to discounts (approx $50/bale).
GINNING

There are a range of ginning organisations and contacts available for your region. For more information get in touch with the contacts below:

1. Auscott – Deniliquin Rd, Hay, NSW
   Eddie Redfern – 0418 554 498

2. Rivcott – Sturt Hwy, Carrathool, NSW
   Michelle Buster – 02 6990 5000

3. Southern Cotton Gin – Whitton, NSW
   Kate O’Callaghan – 0427 557 277

INTRODUCTION TO IRRIGATED COTTON PRODUCTION
PUPAE BUSTING

- If first defoliation occurs before March 31 pupae busting is not required.
- Pupae busting means achieving full soil disturbance 30 cm both sides of the plant line, to a depth of 10 cm.
- All reasonable efforts must be made to complete pupae busting within four weeks of harvest and all pupae busting must be completed by August 31 (includes Lachlan, Murrumbidgee and Murray Valleys).
- All Bollgard 3 fields must be slashed or mulched within 4 weeks of harvest regardless of whether they are pupae busted or not.

Why is pupae busting important?

From mid May until early September Helicoverpa spp. pupae in the soil go into diapause which means they will not emerge until the spring. The pupae can be found up to 10cm below the soil surface. Having originated from Helicoverpa spp. populations that have been exposed to the proteins in Bollgard 3 cotton, these pupae may contain individuals that potentially carry resistance genes from one season to the next.

‘Pupae busting’ by cultivation destroys the exit tunnels of the pupae and directly kills some pupae. This reduces any population that may emerge the following spring, thereby also reducing the carry-over of resistance genes.


All fields that are to be sown to cereals after a Bollgard 3 crop must be inspected by your Technology Service Provider before sowing commences.

When following Bollgard 3 with a winter crop it is important to ensure that pupae destruction has been rigorous.
CONTACTS AND RESOURCES

Monsanto

Luke Sampson
Regional Business Manager
Macquarie, Lachlan, Bourke & Southern New South Wales
0427 701 986
luke.sampson@monsanto.com

Cotton Seed Distributors

Jorian Millyard
Extension and Development Agronomist
Southern New South Wales
0428 950 009
jmillyard@csd.net.au

Bob Ford
Extension and Development Agronomist
Central NSW
0428 950 015
bford@csd.net.au

Cotton Info

Kieran O’Keeffe
Regional Development Officer
Southern New South Wales
0427 207 406
kieran.okeeffe@cottoninfo.net.au

Amanda Thomas
Regional Development Officer
Macquarie, Bourke & Upper Lachlan
0417 226 411
amanda.thomas@cottoninfo.net.au

HELPFUL LINKS

• 2015/16 Cotton Choices™ program – www.cottonchoices.com.au
• Cotton Seed Distributors – www.csd.net.au
• Cotton MyBMP (best practice guidelines) – www.mybmp.com.au
• Monsanto myBMP grants – betterfarmingbrighterfuture.com.au
• Aussie Cotton Farmers Grow Communities – aussiecottonfarmers.com.au
• CRDC publications – crdc.com.au/publications
• CottonInfo – www.cottoninfo.net.au
• CottonMap – www.cottonmap.com.au
• Cotton Assist – www.cotassist.cottoncrc.org.au
• WeedSmart – herbicide resistance management – www.weedsmart.org.au

Roundup Ready Flex, Bollgard II and Bollgard 3 are registered trademarks of Monsanto Technologies LLC, used under licence by Monsanto Australia Ltd.

*Insect control technology incorporated into these seeds is commercialised under a license from Syngenta Crop Protection AG.

*Subject to APVMA and regulatory approvals at time of printing.

Monsanto Australia Head Office: Level 12, 600 St Kilda Road, Melbourne, VIC 3004. Post: PO Box 6051, St Kilda Road Central, VIC 8008.
Phone: 03 9522 7122 Fax: 03 9522 6122

www.monsanto.com.au