

Resistance Management Plan for Bollgard II® Cotton

Developed by Monsanto Australia Limited and the Transgenic and Insect Management Strategy (TIMS) Committee of Cotton Australia Ltd.

The resistance management plan is based on three basic principles: (1) minimising the exposure of *Helicoverpa* spp. to the *Bacillus thuringiensis* (Bt) proteins Cry 1Ac and Cry 2Ab; (2) providing a population of susceptible individuals that can mate with any resistant individuals, hence diluting any potential resistance; and (3) removing resistant individuals at the end of the cotton season. The three principles are supported through the implementation of 5 elements that are the key components of the Resistance Management Plan. These elements are:

1. Refuge crops
2. Planting window
3. Pupae busting/Trap crops
4. Control of volunteers and ratoon cotton and
5. Spray limitations.

Growers of Bollgard II cotton are required to practice preventative resistance management as set out below. Compliance with the Resistance Management Plan is required under the terms of the Bollgard II Technology User Agreement and under the conditions of registration (*Agricultural and Veterinary Chemicals Act 1994*).

Section 1 is applicable to all regions in New South Wales and Queensland that grow cotton while sections 2 and 3 detail specific requirements for New South Wales and Southern Queensland, and Central Queensland respectively.

SECTION 1: NEW SOUTH WALES, SOUTHERN QUEENSLAND & CENTRAL QUEENSLAND

1. Refuges

Growers planting Bollgard II cotton will also be required to grow a refuge crop that is capable of producing large numbers of *Helicoverpa* spp. moths which have not been exposed to selection with Bt proteins Cry 1Ac and Cry 2Ab. These unselected moths are expected to dominate matings with any survivors from Bollgard II crops and thus help to maintain resistance to Bt proteins Cry 1Ac and Cry 2Ab at low levels.

All refuge options are based on the requirement of a 10% unsprayed cotton refuge or its equivalent, as determined by the relative production of *Helicoverpa* spp. from each of the refuge types as described in Tables 1 and 2, for irrigated and dryland production scenarios respectively. Irrespective of the irrigation regime for the Bollgard II cotton, all pigeon pea refuges must be fully irrigated so that they are attractive to *Helicoverpa* spp. during the growing period of the Bollgard II cotton.

For each area of irrigated Bollgard II cotton planted, a grower is required to plant a minimum of one or a combination of the following:

Table 1. Irrigated Bollgard II cotton refuge options

Crop	Conditions	% of Bollgard II
Cotton	Irrigated, sprayed conventional cotton	100
	Irrigated, unsprayed conventional cotton	10
Pigeon pea	Fully irrigated, unsprayed	5

Table 2. Dryland Bollgard II cotton refuge options

Crop	Conditions	% of Bollgard II
Cotton	Dryland or irrigated, sprayed conventional cotton	100
	Dryland or irrigated, unsprayed conventional cotton	10
Pigeon pea	Fully irrigated, unsprayed	5

No other refuge options are approved for dryland Bollgard II.

Note: Unsprayed means not sprayed with any insecticide that targets any life stage of *Helicoverpa* spp.

Bt products must not be applied to any refuge (including sprayed cotton).

If the viability of an unsprayed refuge is at risk due to early or late season pressure by *Helicoverpa* spp., or any other caterpillar species, contact Monsanto immediately. With prior approval from the Monsanto Compliance and Stewardship Manager, a non-Bt heliocide can be applied.

An unsprayed refuge should not be planted in the same field as any crop sprayed with a rate of insecticide that is registered for *Helicoverpa* spp, with the exception of Bollgard II. Sprayed crops and unsprayed refuges that are planted in adjacent fields must be separated by sufficient distance to *minimise the likelihood of insecticide drift onto the unsprayed refuge*.

For the purposes of this Resistance Management Plan, conventional cotton includes any cotton varieties that do not have Bt proteins in the plant that control *Helicoverpa* spp. larvae.

General conditions for all refuges:

- (a) Refuge crops are to be planted and managed so that they are attractive to *Helicoverpa* spp. during the growing period of the Bollgard II cotton varieties.

Irrigated: It is preferable that all refuge is planted within the 2 week period prior to planting Bollgard II. If this is not possible, refuge planting must be completed within 3 weeks of the first day of sowing of Bollgard II. At this time, sufficient refuge must have been planted to cover all of the Bollgard II cotton proposed to be planted for the season (including Bollgard II already planted and any that remains unplanted). Should additional Bollgard II planting be made after this date, which is not already covered by refuge, additional refuge must be planted as soon as possible and no more than 2 weeks after sowing of the additional Bollgard II.

Dryland: A dryland refuge must be planted within the 2 week period prior to the first day of planting Bollgard II cotton.

- (b) Pigeon pea refuges should not be planted until the soil temperature reaches 17°C, which is a requirement for germination, and should also be planted into moisture to ensure successful germination. If soil temperatures are not suitable to allow germination of pigeon peas in line with condition (a), an alternative refuge must be planted in its place within the prescribed period (under (a) above).
- (c) Once Bollgard II cotton begins to flower the corresponding refuge must not be cultivated.
- (d) Insecticide preparations containing Bt may be used on Bollgard II cotton throughout the season BUT NOT on any refuge crops.
- (e) All refuges are to be planted within the farm unit growing Bollgard II cotton. Subject to clause (f) below, all reasonable effort should be taken to plant the refuge either on one side of, or next to a Bollgard II cotton field and all Bollgard II fields must be no more than 2 km from the nearest associated Bollgard II refuge.
- (f) To minimise the possibility of refuge attractiveness being affected by herbicide drift, non-herbicide tolerant refuges should be separated from herbicide tolerant Bollgard II cotton crops by a sufficient distance to minimise such drift, but no more than 2km from the Bollgard II cotton.
- (g) To account for possible insecticide drift, the options for the width of refuge crops vary according to spray regime. If any sprayed conventional cotton is grown on the same farm unit, Bollgard II refuge crops must be at least 48 metres wide and each refuge area must be a minimum of 2 hectares. If no sprayed conventional cotton is grown on the same farm unit, Bollgard II refuge crops must be at least 24 metres wide and 24 metres long. Different unsprayed refuge options may be planted in the same field as a single unit; however a sprayed conventional cotton refuge must not be planted in a field that is also planted to an unsprayed refuge type unless a sufficient buffer is in place to prevent insecticide drift.
- (h) In all regions, destruction of refuges should only be carried out after Bollgard II cotton lint removal has been completed.
- (i) Refuges for dryland Bollgard II cotton crops must be planted in the same row configuration as the Bollgard II crop unless the refuge is irrigated. If an irrigated option is utilised for a dryland Bollgard II crop, then that refuge may be planted in a solid configuration. Dryland cotton is measured as green hectares (calculated as defined in the Technology User Agreement).

2. Control of volunteer and ratoon cotton

Volunteer and ratoon cotton may impose additional selection pressure on *Helicoverpa* spp. to develop resistance to the Bt Cry 1Ac and Cry 2Ab proteins produced by Bollgard II cotton.

Growers must ensure that volunteer and ratoon plants are removed as soon as possible from all fields, including fallow areas, Bollgard II crops, conventional cotton crops and all refuges. **The presence of Bollgard II volunteers/ratoon cotton in any refuge will diminish the value of the refuge and must be removed as soon as possible.**

Note: The refuge should preferably be planted into fallow or rotation fields that have not been planted to cotton in the previous season.

3. Post-harvest crop destruction

As soon as practical after harvest, Bollgard II cotton crops must be destroyed by cultivation or herbicide so that they do not continue to act as hosts for *Helicoverpa* spp.

SECTION 2: NEW SOUTH WALES AND SOUTHERN QUEENSLAND ONLY

1. Planting windows

All Bollgard II crops are to be planted into moisture or watered-up by 15 November, unless otherwise advised by a Bollgard II Planting Window Variation Notice.

2. Pupae destruction

In Bollgard II cotton fields, each grower will be required to undertake *Helicoverpa* spp. pupae destruction after harvest according to the following key guidelines:

- Bollgard II crops should be slashed or mulched and fields cultivated for pupae control within 4 weeks of harvesting. All pupae busting must be completed by July 31.
- Ensure disturbance of the whole soil surface to a depth of 10 cm.
- All fields that are sown to any winter crop following a Bollgard II crop must be inspected by the Technology Service Provider before sowing commences in order to ensure that pupae busting has occurred.

In Refuge crops:

In New South Wales and Southern Queensland, to ensure maximum emergence of late pupae from associated refuges, soil disturbance of refuge crops should not be undertaken until after the pupae busting in Bollgard II cotton crops on the farm unit is complete. All unsprayed refuges, should preferably be left uncultivated until the following October.

3. Failed crops

Bollgard II crops that will not be grown through to harvest for various reasons and are declared to, and verified by, Monsanto as failed must be destroyed within two weeks after verification, in such a way that prevents regrowth. Crops abandoned before February 28 do not require pupae busting. Crops abandoned on February 28 or later must be pupae busted.

NB: If any grower encounters problems in complying with the Resistance Management Plan please contact your local Monsanto Regional Business Manager.

SECTION 3: CENTRAL QUEENSLAND ONLY

1. Planting Windows

Central Highlands: All Bollgard II crops are to be planted into moisture or watered-up in the period between September 15 and October 26, unless advised otherwise by a Bollgard II Planting Window Variation Notice.

Dawson Callide Valleys: All Bollgard II crops are to be planted into moisture or watered-up in the period between September 15 and October 26, unless advised otherwise by a Bollgard II Planting Window Variation Notice.

Belyando - Clermont: All Bollgard II crops are to be planted into moisture or watered-up in the period between November 4 and December 15, unless advised otherwise by a Bollgard II Planting Window Variation Notice.

Mackenzie: All Bollgard II crops are to be planted into moisture or watered-up in the period between November 4 and December 15, unless advised otherwise by a Bollgard II Planting Window Variation Notice.

2. Refuges

Pigeon Pea refuge should preferably be planted into a fallow or rotation field that has not been planted to cotton in the previous season to avoid volunteer and ratoon cotton.

In Central Queensland soil disturbance of refuge crops can only occur 2 weeks after final defoliation of the Bollgard II cotton.

3. Late summer pigeon pea trap crop

A late summer trap crop (pigeon pea) must be planted for all Bollgard II cotton grown in Central Queensland. The planting configuration of the trap crop should be the same as that of the Bollgard II crop. Irrigated Bollgard II must have an irrigated trap crop. Table 3 shows the requirements for the late summer pigeon pea trap crop. Dryland Bollgard II growers who do not have any irrigated cotton on their farm should contact their Monsanto Regional Business Manager for alternative options.

Refuge and late summer trap crops have different purposes and, if pigeon pea is selected for both, two separate plantings may be required. However, where a pigeon pea refuge is utilised as a trap crop the full 5% pigeon pea refuge area must be managed to become the late summer trap crop and must adhere to the requirements in Table 3 below.

Table 3. Late summer pigeon pea trap crop requirements in Central Queensland

Criterion	Trap crop*
Minimum area & dimension (Requirement)	A minimum trap crop of 1% of planted Bollgard II cotton crop is required. If sprayed conventional cotton is grown on that farm unit: the trap crop must be at least 48m x 48m. If no sprayed conventional cotton is grown on that farm unit: the trap crop must be at least 24m x 24m.
Planting time	The trap crop should preferably be planted between November 1 and November 30 Note: if growers choose to plant their trap crop to coincide with the planting of pigeon pea refuges they must manage the trap crop in such a way that it remains attractive to <i>Helicoverpa</i> spp. 2-4 weeks after final defoliation.
Planting rate **	35kg/ha (recommended establishment greater than 4 plants per metre)

Criterion	Trap crop*
Insect control	The trap crop can be sprayed with virus after flowering, while avoiding insecticide spray drift, except where a pigeon pea refuge is converted to a trap crop. In this case the full 5% pigeon pea refuge area managed to become the late summer trap crop can only be sprayed with virus after the first defoliation of Bollgard II cotton.
Irrigation	The trap crop must be planted into an area where it can receive the additional irrigation required to keep the trap crop attractive to <i>Helicoverpa</i> spp. until after the cotton is defoliated.
Weed control	The trap crop should be kept free of weeds and particularly volunteer Bollgard II cotton. When using the full 5% pigeon pea trap crop option, weed control must not be carried out by cultivation once flowering of the associated Bollgard II cotton crop has commenced.
Crop destruction	The trap crop must be destroyed 2–4 weeks (but not before 2 weeks) after final defoliation of the Bollgard II cotton crop, (slash and pupae bust – full soil disturbance to a depth of 10cm across the entire trap crop area). All Bollgard II and associated trap crops must be destroyed by July 31.

* A pigeon pea trap crop is to be planted so that it is attractive (flowering) to *Helicoverpa* spp. after the cotton crop has cut out, and as any survivors from the Bollgard II crop emerge. Planting pigeon pea too early (e.g. before November) or too late (e.g. mid December) is not adequate for cotton crops planted during September through to October.

** The planting rate is a recommendation based on a minimum of 85% seed germination.

NB: If any grower encounters problems in complying with the resistance management plan, please contact your Monsanto Regional Business Manager.

For further background information on the various components of this plan see the “Preamble to the Resistance Management Plan for Bollgard II” in the current Cotton Pest Management Guide.