

# A guide to the 2010/11 Bollgard II® Resistance Management Plan



This document should be used as a guide to the Bollgard II® Resistance Management Plan (RMP) only and must be read in conjunction with the General Terms and Conditions which accompany the Technology User Agreement (TUA).

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## Introduction

### What is the aim of the Resistance Management Plan (RMP)?

The RMP has been designed to reduce the rate of development of resistance to the two *Bacillus thuringiensis* (Bt) proteins produced by Bollgard II cotton plants. To achieve this, the components of the RMP are aimed at minimising the frequency in the pest population of individuals carrying resistance genes to either or both Bt proteins (Cry1Ac or Cry2Ab), by minimising the exposure of *Helicoverpa* spp. to the Bt proteins, providing a population of susceptible individuals that can mate with any resistant individuals and thereby dilute any potential resistance, and removing resistant individuals at the end of the cotton season.

The components of the RMP impose some limitations and requirements for management on farms where Bollgard II is grown. These have been approved and put in place by regulatory authorities to protect the technology. As with all pesticides, resistance is the greatest danger to the continued availability and efficacy of the Bollgard II technology. As such it is of the utmost importance to both the industry and to individual producers that the RMP is fully and effectively complied with.

### Why is Resistance Management important?

The Bollgard II trait is an important tool in the sustainable management of *Helicoverpa* spp. A key component of the Bollgard II registration from the Australian Pesticides & Veterinary Medicines Authority (APVMA) involves the implementation of an approved RMP.

Resistance to insecticides in *Helicoverpa* spp. has severely challenged the Australian cotton industry over the past 30 years. The fact that the Bt proteins in Bollgard II are delivered in the plant tissue does not diminish the capacity of a target pest like *Helicoverpa* spp. to develop resistance. In the 2007/08 season the combined Monsanto and CSIRO data from the Bt resistance monitoring programs detected an increase in the frequency of resistance genes conferring resistance to the Cry 2Ab protein in *Helicoverpa armigera*. CSIRO have also been monitoring *Helicoverpa punctigera* and in 2007/08 began F1 screens. In the 2008/09 season the frequency of Cry2Ab resistance genes in *H. punctigera* increased. These results highlight the **absolute** need for an effective and robust RMP.

The industry and Monsanto will be carefully monitoring the situation over the next year to determine appropriate measures with the relevant industry groups to ensure the efficacy of this valuable technology is not prematurely reduced.



### What are the key components of the RMP?

- **Refuge crops** - these are *Helicoverpa* spp. host crops planted to produce Bt susceptible moths in sufficient numbers to ensure that there is a high probability of the susceptible moths mating with any Bt resistant moths from Bollgard II crops. This has the aim of keeping resistant insects rare in the population.
- **Planting window** - defined periods within which the planting of Bollgard II crops must be completed with the aim of restricting the number of generations of *Helicoverpa* spp. exposed to Bollgard II crops each season.
- **Pupae busting/Trap crops** - in NSW and Southern Queensland, cultivation of the soil under Bollgard II crops following harvest will reduce the survival of any over-wintering *Helicoverpa* spp. pupae. In their larval form, these pupae may have been selected for resistance to the Bt proteins and therefore carry resistance genes from one season to the next. In Central Queensland, where *Helicoverpa* spp. pupae following cotton do not normally over-winter in the soil, a small area of a trap crop (ie. a suitable *Helicoverpa* spp. host crop) is planted on each farm in addition to the refuge to attract moths emerging from Bollgard II crops at the end of the season. Once these moths have laid their eggs on the trap crops, the crops and *Helicoverpa* larvae on them are destroyed.
- **Control of volunteers and stub cotton** - these are seeds or plants from the previous crop that survive cultivation and/or winter to germinate or regrow in the following season. Unless they are removed, volunteers and stub cotton could create mixtures of Bollgard II and conventional cotton which may increase survivorship of *Helicoverpa* spp. larvae in Bollgard II crops as well as increasing selection for resistance.
- **Spray limitations** - these are restrictions on the use of foliar Bt sprays on refuge crops and the use of sprays for control of *Helicoverpa* spp. on unsprayed Bollgard II refuges.

# Refuges and their management

## What is the purpose of a refuge?

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. 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 II crops. This reduces the chance that resistant moths will meet and mate. Provided susceptible moths from the refuges always predominate in the local area, they can effectively dilute resistance and slow down the rate at which it develops. It is crucial that the timing of production of moths from refuges matches that of Bollgard II crops. For this reason, refuge crops which have a shorter period of production of moths than cotton may need to have several staggered plantings to extend the period over which moths are produced.



## Refuge Location

For the refuge principle to be successful, refuge crop areas must be in close proximity to the Bollgard II crop(s) and produce sufficient quantities of *Helicoverpa* spp. moths to ensure it is highly likely that moths emerging from the Bollgard II crops will mate with susceptible moths from the refuge crop.

*Helicoverpa* spp. moths are capable of migrating long distances, but during the summer cropping season a significant part of the population may remain quite localised and move only a few kilometres within a region. The level of movement will depend on the mix of crops and their attractiveness at the time of moth emergence. For this reason the best location for a refuge crop is as close as possible to the Bollgard II crop, at least within 2km. It is critical that refuges are managed for each farm unit growing Bollgard II and it is the responsibility of each Bollgard II grower to ensure that these refuges are effective.

**Growers must take all reasonable steps to ensure that all refuges are planted:**

- i) within the farm unit growing Bollgard II
- ii) either on one side of, or next to, a Bollgard II field (special requirements exist for non-herbicide tolerant refuge crops planted near herbicide tolerant Bollgard II crops, refer to the *Refuge Mixing* section)
- iii) so that no Bollgard II field is more than 2km from the nearest Bollgard II refuge
- iv) and are managed using good agronomic practices.

## Refuge Size

The relative numbers of adult moths that emerge per hectare from Bollgard II and the associated refuge crops determines the required size of the refuge areas. Different refuge crops will produce different numbers of moths per hectare.

The likely moth productivity of different refuge options has been determined from field experiments conducted by the Cotton CRC over several seasons. This knowledge is used to determine the areas of the different refuge crop options required for a specified area of Bollgard II. Only refuges which have been assessed in this way are currently approved by the APVMA as valid options for use with Bollgard II crops. Unsprayed conventional cotton and pigeon pea generally produce more moths per hectare and over a longer period than sorghum and corn which, while effective, are most attractive only at flowering and so produce moths over a shorter period.

Where sprayed conventional cotton is grown on the farm unit, each refuge crop must be at least 48 metres wide and a minimum of 2 hectares. This is to minimise the risk of spray drift onto the refuge which will decrease the effectiveness of the refuge producing adult moths. If no sprayed conventional cotton is grown on farm, the minimum size of a refuge crop must be 24 metres wide and 24 metres long.

NB: For the purposes of the RMP conventional cotton includes any cotton varieties that do not have Bt proteins in the plant that control *Helicoverpa* spp. moths.

## Extending the Period of Refuge Efficacy

While refuges must produce moths during the cotton season when Bollgard II is grown, if feasible, refuges can also be left in place until the following spring. In this way, any pupae produced in the autumn may be carried through to spring and provide additional genetic dilution of resistant survivors.

## Refuge Mixing

It is possible to combine more than one type of refuge provided that the total requirements for area equivalence of refuges are met. Each refuge type must be managed so that it is productive and that restrictions on size, number of plantings and location are met (see *Refuge requirements*). However, a sprayed conventional cotton refuge must not be planted in the same field as any unsprayed refuge. 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 drift but be no more than 2km from the Bollgard II cotton.

## Different refuge options for dryland Bollgard II

**Dryland refuge:** For dryland Bollgard II crops the only dryland refuge options available are sprayed or unsprayed cotton. The reason for this is that the other refuge option available in irrigated Bollgard II (irrigated unsprayed pigeon pea) may need to be planted after the cotton. This limitation reflects the uncertainties of establishing crops in dryland where planting opportunities from rainfall cannot be guaranteed. In dryland situations there will always be uncertainty about whether soil moisture will be adequate to successfully establish future crops therefore a dryland refuge crop must be planted within the 2 week period prior to the first day of Bollgard II cotton. While Bollgard II may be planted into soil moisture there is no guarantee that dryland refuge crops could be established some weeks later.

**Irrigated refuge:** sprayed or unsprayed irrigated cotton and unsprayed irrigated pigeon pea are the irrigated refuge options for dryland cotton. The establishment of irrigated refuges is generally not subject to soil moisture and cotton and pigeon pea are the most effective refuges currently available. No other refuge options are approved for dryland Bollgard II.

Monsanto in conjunction with CRDC and CSIRO has begun a two year program to further evaluate dryland refuge options in the Darling Downs and the Gwydir valleys.

## Refuge Requirements

In order to ensure there are sufficient Bt susceptible *Helicoverpa* spp. moths to dominate any moths surviving from Bollgard II crops, growers must:

- plant a prescribed area of refuge crop
- manage the refuge crop appropriately to ensure healthy plants that are attractive to *Helicoverpa* spp.
- comply with specific requirements for the placement of refuges on the farm unit.
- not cultivate the refuge once the corresponding Bollgard II crop begins to flower.

The presence of Bollgard II volunteers/ratoon cotton in any refuge will diminish the value of the refuge and may impose additional selection pressure to *Helicoverpa* spp. to develop resistance to the Bt Cry 1Ac and Cry 2Ab proteins produced by Bollgard II. All refuges should preferably be planted into a fallow or rotation fields that have not been planted to cotton in the previous season so as to avoid the likelihood of ratoon or volunteer cotton in refuges.



## Irrigated Bollgard II refuge options

Refuge crops for irrigated Bollgard II must also be irrigated to ensure that they maintain attractiveness and have a high likelihood of producing sufficient moths.

CROP	CONDITIONS	% OF BOLLGARD II
Irrigated Cotton:	<i>Sprayed Cotton Refuge</i> - 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 <i>Helicoverpa</i> spp. and other pests. No Bt products may be included at any stage	100
	<b>OR</b> <i>Unsprayed Cotton Refuge</i> - an area of irrigated conventional cotton which will not be treated for any reason with any products that control <i>Helicoverpa</i> spp. that is equal to 10% of the Bollgard II area on the farm (refer to refuge planting dates).	10
Irrigated Pigeon Pea:	An area of unsprayed irrigated pigeon pea which will not be treated for any reason with any products which control <i>Helicoverpa</i> spp. that is equal to 5% of the Bollgard II on the farm, (refer to refuge planting dates) and is managed to ensure several cycles of flowering throughout the cotton season	5

## Dryland Bollgard II refuge options

Refuge options for dryland Bollgard II are currently restricted to dryland or irrigated sprayed or unsprayed cotton and unsprayed irrigated pigeon pea.

Refuges for dryland Bollgard II crops must be planted in the same row configuration as the Bollgard II crop.

CROP	CONDITIONS	% OF BOLLGARD II
Cotton:	Sprayed Cotton Refuge - an area of dryland or irrigated conventional cotton, equal to 100% of the area of dryland Bollgard II planted on the farm, planted within the 2 week period prior to the first day of planting Bollgard II, which can be conventionally managed for <i>Helicoverpa</i> spp. and other pests. No Bt products may be included at any stage	<b>100</b>
	<b>OR</b> Unsprayed Cotton Refuge - an area of dryland or irrigated conventional cotton equal to 10% of the dryland Bollgard II area planted on the farm, planted within the 2 week period prior to the first day of planting Bollgard II cotton, which will not be treated for any reason with any products that control <i>Helicoverpa</i> spp.	<b>10</b>
Irrigated Pigeon Pea:	An area of irrigated pigeon pea, equal to 5% of the Bollgard II planted on the farm, (refer to refuge planting dates) and managed to ensure several cycles of flowering throughout the cotton season, which will not be treated for any reason with any products which control <i>Helicoverpa</i> spp.	<b>5</b>

For dryland Bollgard II crops, all refuge areas should have a similar field history to the associated Bollgard II fields (i.e. the same previous cropping pattern). This is to prevent the situation where, for example, the Bollgard II field had just returned from fallow and the refuge immediately followed a cotton crop, or vice-versa, as this will affect the relative growth and development of the plants and their attractiveness to *Helicoverpa* spp.

## Planting Windows (purpose and restrictions)

### Why use planting windows and how does it help Resistance Management?

The use of planting windows is an important part of the RMP. A planting window restricts the period in which planting can occur, thereby limiting the length of time that Bollgard II will be in the ground and so limiting the number of generations of *Helicoverpa* spp. exposed to the Bt proteins.

The greater the number of generations exposed to the Bt proteins, the greater the opportunity for resistance to develop.

The default "Planting Windows" for NSW and Southern Queensland and for Central Queensland are described in the following sections. Under certain exceptional circumstances (e.g. under drought conditions where water is limited leading up to the commencement of planting) a cotton growers' association can apply to TIMS (Transgenic and Insect Management Strategy) Committee of Cotton Australia for a "Bollgard II planting window variation notice". If approved by TIMS a variation notice may allow the planting window for a region to be moved to a defined six week period between August 31 and December 31.

### Planting window for NSW and Southern Queensland

For NSW and southern Queensland the planting window requires all Bollgard II and refuges to be watered up or planted into moisture by November 15, unless otherwise advised by a "Bollgard II Planting Window Variation Notice".

### Planting windows for Central Queensland

In the Emerald and Dawson/Callide Valleys, the planting window requires all Bollgard II and refuges to be watered up or planted into moisture between September 15 and October 26. In the Belyando Valley, the planting window requires all Bollgard II and refuges to be watered up or planted into moisture between October 10 and November 20, unless otherwise advised by a "Bollgard II Planting Window Variation Notice".

### Planting dates of Refuges

As the aim of a refuge is to produce sufficient numbers of Bt susceptible moths, to mate with any potential Bt resistant moths emerging from Bollgard II crops, it is crucial that the timing of production of moths from refuges matches that of Bollgard II crops.

The optimum time to plant refuge is in the 2 week period prior to planting Bollgard II cotton varieties. 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. Should additional area of Bollgard II cotton be planted after this time that 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 the Bollgard II cotton.

## Irrigated Unsprayed Pigeon Pea Refuge

Irrigated pigeon pea refuges should not be planted until the soil temperature reaches 17°C, which is a requirement for germination. If soil temperatures are not suitable to allow pigeon pea to be planted within 3 weeks of planting the corresponding Bollgard II cotton, an alternative refuge must be planted. Failure to plant a pigeon pea refuge within 3 weeks of the Bollgard II cotton could reduce the effectiveness of the refuge, as it will flower later than the Bollgard II cotton, and therefore will not be attractive to *Helicoverpa* spp. at the same time as the Bollgard II crop.

## Harvest of refuge crops

Harvest or destruction of aerial parts of a pigeon pea refuge should only be carried out after Bollgard II lint removal has been completed.

Defoliation of cotton refuges cannot commence until defoliation of Bollgard II crops has commenced.

## Post harvest crop destruction

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

In refuge crops it is recommended that:

- (i) refuges should preferably be left uncultivated for at least two weeks after harvest to allow emergence of any pupating *Helicoverpa* spp. However, if possible, refuges should be left uncultivated until the following October.

# Pupae busting of Bollgard II crops and refuges

## What does pupae busting achieve and why is it important?

As autumn progresses in NSW and southern Queensland, an increasing proportion of the *Helicoverpa* spp. larvae that pupate under cotton crops will enter diapause. These diapausing pupae will remain dormant in soil during the winter months. The triggers for larvae to enter diapause as pupae are a combination of reducing day length and cooler temperatures. From mid May until early September, few adult moths will emerge.

Fully developed large larvae leave the plant and become pupae in the soil. The pupae can be found up to 10cm below the soil surface and mostly within 30cm from the planting row. The larvae burrow into the soil and leave a tunnel connecting the pupa to the surface to allow the moth to emerge. These pupae will have originated from *Helicoverpa* spp. populations that have been selected with the proteins in Bollgard II cotton during the second half of the cotton season and, therefore, 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. The largest benefit of this strategy comes with leaving refuges uncultivated until the following spring to contribute susceptible moths to the population while at the same time killing potentially resistant pupae from under Bollgard II. Otherwise the strategy is effectively reducing the overall population, but not increasing dilution or selectively killing resistant individuals.

Pupae can be effectively destroyed through a number of field operations listed (see Table below). More detail on the requirements for effective pupae busting can be obtained in publications available from the Cotton CRC's Technology Resource Centre. These include a research review on “Management of Overwintering Pupae”, an information sheet on “Heliothis Pupae Control – A key resistance management tactic” and in

“Machine Pak” (Chapter 3) which describes appropriate tillage equipment for different situations. Contact David Larsen (Phone 02 67991534, or email david.larsen@dpi.nsw.gov.au) at the Cotton CRC for copies.

## Pupae busting requirements for Bollgard II crops

All Bollgard II crops in NSW and southern Queensland must be cultivated after harvest at a level adequate to stop regrowth and to destroy *Helicoverpa* spp. pupae in the soil. Late season *Helicoverpa* spp. are managed by trap crops in Central Queensland (refer to the section on Central Queensland Late Summer Trap Crop below).

The incompatibility of using tillage for pupae busting with the desire to optimise soil moisture management in dryland is acknowledged. However, at present there are no alternatives.

All fields that are to be sown to cereals following a Bollgard II crop must be inspected by the Technology Service Provider before sowing commences. When following Bollgard II with a winter crop it is important to ensure that pupae destruction has been rigorous. Full soil disturbance across the entire field to a depth of at least 10 cm should be aimed for. All reasonable efforts must be made to complete pupae busting within 4 weeks of harvest and all pupae busting must be completed by July 31. NB: 1 pupa left to emerge per square metre can result in up to 10,000 moths emerging per hectare, which could seriously impact on resistance development.

## 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 before February 28 must be slashed and mulched and cultivated within 2 weeks to prevent regrowth. These crops do not require pupae busting.

## Pupae busting requirements for refuges

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.

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

### i) Unsprayed refuges (cotton or alternatives)

If possible leave these refuges uncultivated until the following spring. This will allow the emergence of moths that have not been selected by the Bt proteins. These moths can then mate with any resistant moths that have survived under Bollgard II crops, further helping to dilute resistance. Unsprayed cotton and pigeon pea refuge crops may also produce diapausing *Helicoverpa* spp. pupae in the autumn and it would be beneficial for them to be left undisturbed until the following spring. This would provide an additional supply of susceptible moths for the first generation of the next season. Moreover, pupae busting only under Bollgard II will selectively kill potentially resistant individuals.



### ii) Sprayed or unsprayed cotton refuges in Central Queensland

In Central Queensland temperatures are too high and day lengths too long to trigger larvae to enter diapause as pupae. Consequently many pupae under cotton crops at the end of the season will have completed development as adults and emerged before crops are harvested. Pupae busting after harvesting in Central Queensland is therefore not effective. Instead a summer trap crop is used to concentrate moths emerging from cotton crops late in the season (see below). It is, however, still important to destroy Bollgard II crops as soon as possible after harvest, by cultivation or herbicide, to prevent larvae developing and being selected for resistance on regrowth.



### iii) Options and effectiveness of different implements for pupae busting

#### DIFFERENT IMPLEMENTS VS EFFICIENCY (INDICATION ONLY)

GOOD	INADEQUATE ALONE	UNACCEPTABLE
Chisel, disc or blade plough	Centre busting	Stalk pulling when wet
Stalk pulling + go-devils or lillistons + alabamas	Stalk pull dry, rake and burn	Phoenix harrows Drag harrows
Cultivation with wide sweeps	Go-devils	Direct drill planters
Planters with cultivating tynes	Stubble mulchers	

# Central Queensland late summer trap crop

A late summer trap crop must be planted for all Bollgard II planted in Central Queensland.

## What is the purpose of a late summer trap crop?

In Central Queensland *Helicoverpa* spp. pupae produced late in the cotton season do not remain in the soil, but emerge within 15 days of pupating. Pupa-busting is not an effective resistance management tool in these warmer areas, and trap crops of pigeon pea are required as an alternative. Trap crops are planted after the cotton and refuge and are timed to be at their most attractive after the cotton has cut-out. Any adults emerging from Bollgard II fields at the end of the season will be attracted to the trap crops and are likely to lay their eggs in the trap crop. The egg and larval stages can last 30+ days. Once the cotton has been harvested, the trap crop should be destroyed, removing the food source from the larvae (which will then die) and the soil cultivated to destroy any pupae.

## Management recommendations for late summer pigeon pea trap crops

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 pigeon pea refuge is utilised as a trap crop the full 5% unsprayed pigeon pea refuge area must be managed to become the late summer trap crop and must adhere to all RMP requirements.

Late summer trap crops of pigeon pea should be planted at a minimum of 1% of the planted Bollgard II cotton crop. The trap crop should be planted at an approximate rate of 35kg/ha (based on 85% seed germination) 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 *Helicoverpa* spp. 2–4 weeks after final defoliation of Bollgard II.

If any sprayed conventional cotton is grown on the same farm unit, each Bollgard II trap crop must be at least 48m x 48m. If no sprayed conventional cotton is grown on the same farm unit, the Bollgard II trap crop must not be less than 1% of the combined Bollgard II area on the farm unit and at least 24m x 24m wide. Trap crop planting configuration should be the same as that of the Bollgard II and the best location for a trap crop is as close as possible to the Bollgard II crop, at least within 2km. It is critical that trap crops are managed for each farm unit growing Bollgard II and it is the responsibility of each Bollgard II grower to ensure that these trap crops are effective.

The pigeon pea trap crop must be destroyed 2 to 4 weeks after defoliation of the Bollgard II cotton and not before. This can be achieved by slashing the crop then cultivating to ensure full soil disturbance to a depth of 10cm.

## Ensuring the Pigeon Pea trap crop is effective

For a trap crop to be effective it must be attractive to *Helicoverpa* spp. moths until after the Bollgard II cotton is defoliated and therefore must be well managed and healthy. *Helicoverpa* spp. in the trap crops can be sprayed with virus sprays (Gemstar/Vivus), but the use of pyrethroids

should be avoided as this will destroy predators resulting in higher survival of *Helicoverpa* spp. eggs and larvae, and will also select for pyrethroid resistance. The trap crop must be planted in an area where it can receive the additional irrigation required. The trap crop should be irrigated when cotton is irrigated, but may need an additional irrigation after the cotton is finished to ensure the trap crop remains highly attractive to *Helicoverpa* spp. moths 2 to 4 weeks after the Bollgard II final defoliation. To ensure vigorous growth the trap crop should also be kept free of weeds and particularly volunteer or ratoon cotton.

# Control of volunteers, stub or ratoon cotton

The presence of volunteer cotton plants carrying the Bollgard II trait within a conventional cotton crop results in further selection pressure for Bt resistance. Larvae emerging from eggs laid on such volunteers will be exposed to Bt and only the more resistant or tolerant individuals will survive on the plant.

The presence of conventional cotton volunteers within a Bollgard II crop is also of concern. Larvae emerging from eggs laid on these conventional plants could survive and any larger larvae subsequently moving to adjacent Bollgard II plants will be less affected by the Bt proteins and more able to survive. This may result in damage to the Bollgard II crop. Growers must make all reasonable efforts to remove volunteer and ratoon plants as soon as possible from all fields, including fallow areas, Bollgard II crops, conventional cotton crops and all refuges and trap crops.

# Spray limitations

## Unsprayed refuge crops

- i) To ensure that adults emerging from refuge crops have not already been selected for resistance to Bt proteins, no Bt sprays are allowed on ANY unsprayed refuge crops for the whole season. Any management activity which negatively affects the population of *Helicoverpa* spp. should be regarded as an 'insecticidal' action. Once the Bollgard II crops begin flowering, and are highly attractive to *Helicoverpa* moths, cultivation of refuges (e.g. for weed control, row formation etc) must be matched by cultivation of the associated Bollgard II field(s). Inter-row cultivation destroys the pupae and should not be carried out in refuge fields unless the same action is carried out in the associated Bollgard II fields.
- ii) Food sprays cannot be used on any unsprayed refuges. The reason for this is that these crops are to be managed in a way that allows the survival of *Helicoverpa* (to breed with moths from Bollgard II fields). Food sprays aim to reduce *Helicoverpa* numbers through increased predation and parasitism and therefore compromise the effectiveness of an unsprayed Bollgard II refuge.
- iii) Trichogramma release (and other biological control agents) cannot be used on any unsprayed refuges as this aims to reduce *Helicoverpa* numbers through increased parasitism (or predation) and therefore compromises the effectiveness of an unsprayed Bollgard II refuge. cannot be used on any unsprayed refuges as this aims to reduce *Helicoverpa* numbers through increased parasitism (or predation) and therefore compromises the effectiveness of an unsprayed Bollgard II refuge.

## Sprayed refuge crops

- i) To ensure that adults emerging from refuge crops have not already been selected for resistance to Bt proteins, no Bt sprays are permitted on ANY sprayed refuge crops for the whole season.

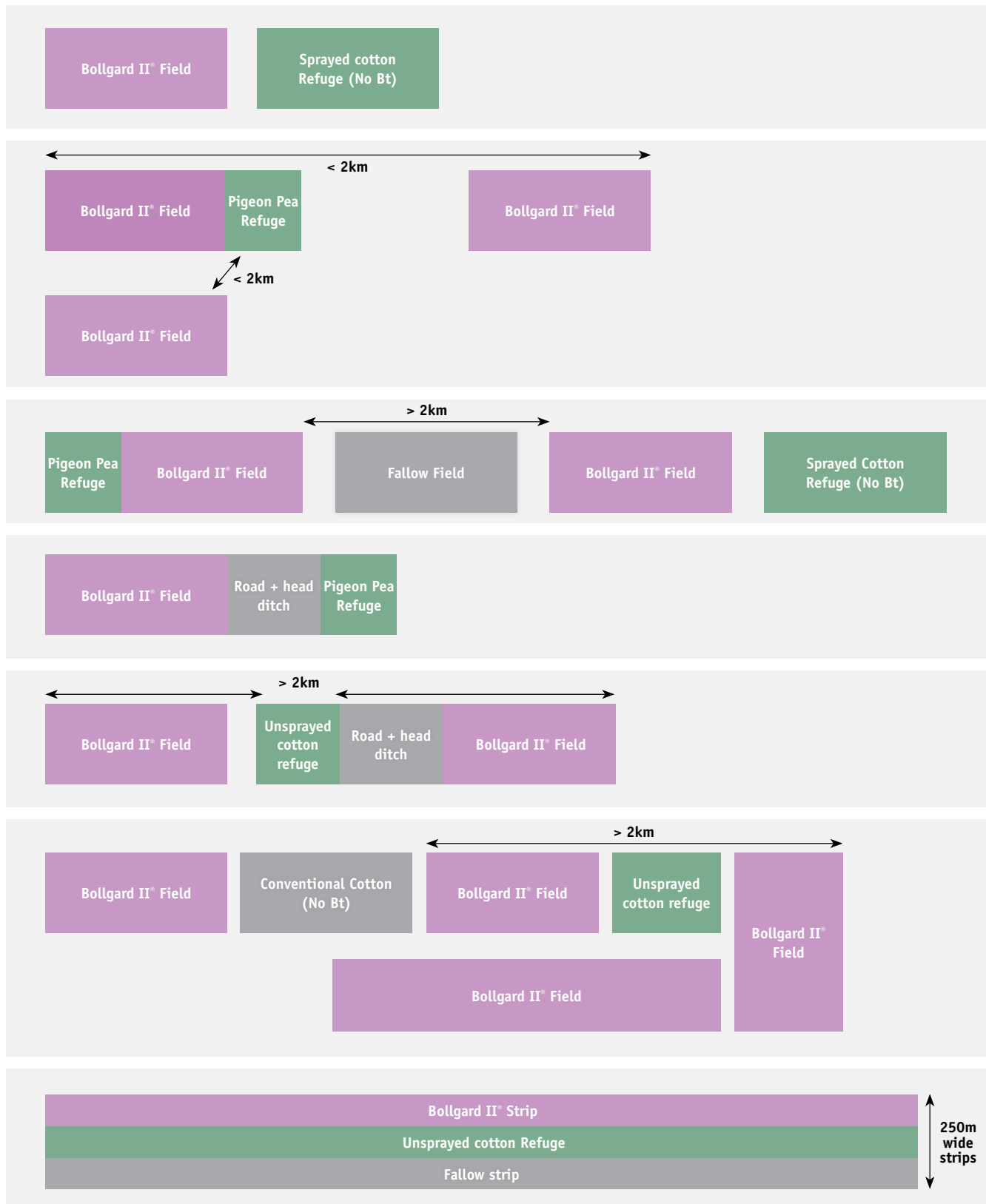
- ii) Food sprays are permitted on sprayed conventional cotton refuges but cannot be used on any unsprayed refuges.

## Bollgard II crops

- i) Bt sprays can be used to 'top-up' control of *Helicoverpa* on Bollgard II crops should the need arise.

The RMP states that: "All refuges are to be planted within the farm unit growing Bollgard II cotton, and all Bollgard II fields must be no more than 2km from the nearest associated Bollgard II refuge. All reasonable effort should be taken to plant the refuge either on one side of, or next to, a Bollgard II cotton field".

The following are acceptable refuge scenarios:



## Responses to Frequently Asked Questions

**Note:** In interpreting the Bollgard II RMP it is important to remember that it is based on the three basic principles: (1) minimising the exposure of *Helicoverpa* spp. to the 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.

**1. I have both irrigated and dryland Bollgard II cotton, can I use my irrigated pigeon pea refuge to cover both types of cotton?**

Yes, irrigated pigeon pea can be used as a refuge option for dryland Bollgard II.

**2. If I stop spraying some conventional cotton on December 15 can I use it as unsprayed refuge?**

No, refuge must remain unsprayed throughout the entire season. However, if excessive early season insect pressure threatens the establishment of an unsprayed refuge spraying may be acceptable - please speak to your Monsanto Regional Business Manager who will evaluate your situation and, if necessary, seek permission to use a non-Bt spray on the crop.

Spraying is acceptable on cotton refuge crops up until the fourth leaf stage if required to ensure establishment.

**3. Can I use 1Ha of pigeon pea alongside 30Ha of sprayed cotton refuge to make up the minimum of 2Ha for refuges?**

No – Sprayed and unsprayed refuges cannot be mixed in the same field. If you have any sprayed cotton on your farm and are using unsprayed refuges you need at least 2 Ha of unsprayed refuge – this, however, can be made of a combination of refuge types (eg 1 Ha pigeon pea, alongside v1 Ha of unsprayed cotton). The same applies for the 48m rule, the overall unsprayed refuge must be 48m wide, although this can include for example 24m of pigeon pea and 24m of unsprayed cotton.

**4. I have two properties side by side; can I plant all my refuge on one property?**

Yes – as long as all Bollgard II is within 2km of refuge and the refuge is adjacent to a Bollgard II field. However both properties need to be considered as one farm unit, therefore they must be on the same TUA and on the same farm map.

**5. If my neighbour has surplus refuge (enough to cover my Bollgard II), and all my Bollgard II fields are within 2km of this refuge, can I use this as refuge for my Bollgard II?**

No. All refuge must be under the control of the same grower who is growing the Bollgard II – i.e. on the same TUA. The only way this is permissible if you were share farming and all the cotton planted was on the same TUA & farm map, and under your control.

**6. What should I do if I am having problems complying with the RMP at any time during the season (for example if I suffer hail damage to my refuge)?**

You should immediately contact your Technical Service Provider or Monsanto, who will investigate your situation. The situation will be considered, and if appropriate, Monsanto Technical Staff and relevant industry researchers will determine if any corrective actions are required. In some instances you may be required to implement a “Resistance Risk Management Plan” that is specifically devised to minimise resistance risks associated with your situation.