Preamble to the Resistance Management Plan (RMP) for Bollgard II® 2009/10

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Resistance is the greatest threat to the continued availability and efficacy of Bollgard II® cotton in Australia. Even though the Bt proteins in Bollgard II® are delivered in the plant tissues, there is still the selection for the survival of resistant individuals. The RMP for Bollgard II® was established by regulatory authorities to mitigate the risks of resistance developing to either of the proteins contained in Bollgard II® cotton. As it is difficult to be precise about the probability of resistance developing in *Helicoverpa* spp. to the proteins contained in Bollgard II® cotton the industry implemented a pre-emptive management plan that aims to prevent field level changes in resistance.

A key component of the RMP for INGARD® was a limitation on the area of INGARD® cotton that could be planted. This restriction limited selection for resistance to the Cry1Ac protein in INGARD®. The industry has so far been able to preserve the efficacy of this gene. Now that Bollgard II® has replaced INGARD®, the constraint on the area of transgenic cotton has been removed. Bollgard II® contains both Cry1Ac and Cry2Ab. Computer simulation models of resistance development indicate that it will be more difficult for a pest to develop resistance to both of the insecticidal proteins. However, it is not impossible for *Helicoverpa* spp. to adapt to this technology.

Recent work has shown that for *H. armigera* and *H. punctigera* the assumed baseline frequency of Cry2Ab resistance genes in populations is substantially higher than previously thought. The recent data for *H. punctigera* also demonstrate significant increases over seasons in the frequency of Cry2Ab resistance genes (for more details see below). The continued efficacy of Bollgard II cotton is therefore even more dependent on the effective implementation of the RMP.

The total area of cotton planted in the 2009/10 season is predicted to continue to be relatively low, but the Bollgard II® acreage will still represent around 80% of the total area planted to cotton in Australia. Given the selection pressure exerted by Bollgard II® cotton, as well as the high (and potentially increasing) baseline frequency of genes conferring resistance to Cry2Ab in *Helicoverpa* spp. it is critical to abide by the obligations under the RMP.

Future transgenic cottons may also rely on either of the two existing insecticidal genes within Bollgard II®. In particular, Monsanto's third generation Bt-cotton will build on the existing Bollgard II cotton platform. Protecting Bollgard II® cotton therefore also represents an investment in the protection of future transgenic technology for the Australian cotton industry. If field resistance to Bollgard II® cotton were to eventuate it may make it more difficult to market new transgenic products in cotton, and the perceptions of other industries, growers and the public could be unduly affected. Modelling undertaken by CSIRO also suggests that Cry2Ab resistance levels in *Helicoverpa* spp. at the time of introducing the third generation Bt-cotton will directly impact on the requirements for the RMP for that technology. Therefore, it is critical that the industry complies fully and effectively with the RMP for Bollgard II®.

The 5 Elements of the Bollgard II® RMP

The five elements of the RMP impose limitations and requirements for management on farms that grow Bollgard II®. These are: mandatory growing of refuges; control of volunteer and ratoon plants; a defined planting window; restrictions on the use of foliar Bt; and mandatory cultivation of crop residues. In theory the interaction of all of these elements should effectively slow the evolution of resistance.

YOUR QUESTIONS ANSWERED

How do we test whether the RMP is effective?

To evaluate the effectiveness of the RMP the CRDC funds a program that monitors field populations of moths for resistance to Cry1Ac and Cry2Ab. Monsanto Australia operate a separate monitoring program. These data provide an early warning to the industry of the onset of resistance to Bollgard II®. They are used to make decisions about the need to modify the RMP from one season to the next to ensure its ongoing effectiveness at managing resistance. Two sorts of tests are conducted. F2 screens involve testing the grandchildren of pairs of moths raised from eggs collected from field populations, and therefore take about 10 weeks to run. To increase the number of insects that could be processed during the season, CSIRO developed protocols for testing the frequency of the Cry2Ab resistance gene detected with F2 screens using a shorter method called an F1 test. F1 screens involve testing the offspring of single-pair matings between moths from Cry2Ab resistant strains maintained in the laboratory (SP15 for *H. armigera* and Hp4-13 for *H. punctigera*) and moths raised from eggs collected from field populations. They take around 5 weeks to conduct.

What is the current situation for Bt resistance in H. armigera in Australia?

A gene is present in field populations of *H. armigera* that has the potential to confer high-level resistance to Cry1Ac. CSIRO and Monsanto data suggests that this gene occurs at a low frequency which is probably less than 1 in 1,000,000 (<0.000001 or 0.0001%). This gene does not confer cross-resistance to Cry2Ab and in certain environments is largely recessive. It also has a high fitness cost (i.e. resistant individuals develop slowly and are more likely to die) but this disadvantage is not likely to greatly impact on the development of resistance. In addition, Dr Robin Gunning (I&I NSW) suggests that other resistance mechanisms may be present in *H. armigera*.

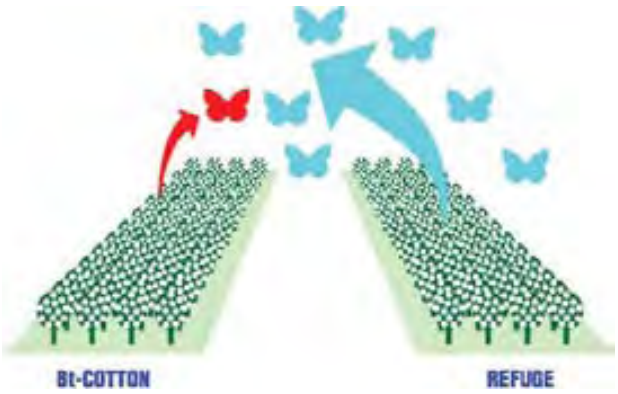
A gene that confers high level resistance to Cry2Ab is present in field populations of *H. armigera.* This gene does not confer cross-resistance to Cry1Ac. The most extensively studied colony of insects with this resistance (called SP15) appears to be as fit as susceptible insects. The resistance in such colonies is recessive. The mechanism conferring resistance to Cry2Ab in *H. armigera* has been shown to be an alteration of a binding site in the gut of the insect.

F2 tests indicated that the frequency of the gene for resistance to Cry2Ab in 2008/09 was less than 9 in 1000 (0.009, 0.9%). In 2004 CSIRO developed protocols for testing the frequency of resistance using a modified and shorter version of the F2 method called an F1 test. This method assumes that the various isolates of Cry2Ab detected so far are of the same kind. These protocols were immediately adopted by Monsanto. During the following two years CSIRO performed experiments which verified that the same mechanism appears to confer resistance in all of the isolates of Cry2Ab detected to date. In 2007/08 CSIRO began F1 tests in *H. armigera* in earnest.

Results with *H. armigera* show that the estimate of Cry2Ab resistance frequency for F1 screens is higher than for F2 tests. Of particular concern was the high frequency of Cry2Ab resistance genes at the end of the 2008/09 season – approximately 2 in 100 (0.02, 2%). Currently, we believe that the frequencies obtained from the F1 screens are likely to most accurately reflect the situation in the field. Both Monsanto and CSIRO are working together to better understand the differences between the F2 and F1 screens but to date have not determined the reason for this discrepancy.

What is the current situation for Bt resistance in* H. punctigera *in Australia

Before 2008/09 more than 4000 genes from *H. punctigera* had been screened and none had scored positive for resistance to Cry1Ac. However, in 2008/09 a gene was isolated from field populations of *H. punctigera* that confers resistance to Cry1Ac.



Moths produced from refuges dilute resistance genes in the population.

F2 tests indicate that the frequency of this gene in 2008/09 was less than 2 in 1000 (0.002, 0.2%). It is not cross-resistant to Cry2Ab. Researchers are currently attempting to establish a colony containing this gene for further characterisation.

A gene that confers high level resistance to Cry2Ab is present in field populations of *H. punctigera*. This gene does not confer cross-resistance to Cry1Ac. The most extensively studied colony of resistant insects (called Hp4-13) demonstrates the same broad characteristics as the SP15 strain of Cry2Ab resistant *H. armigera*. The resistance is recessive, occurs at a high level, and is due to an alteration of a binding site in the gut of the insect. F2 tests indicated that the frequency of this gene in 2008/09 was less than 8 in 1000 (0.008, 0.8%).

In 2007/08 CSIRO began F1 tests in *H. punctigera*. As with *H. armigera*, the Cry2Ab resistance frequency in *H. punctigera* for F1 screens is higher than that determined with the F2 tests. At the end of the 2008/09 season, the frequency of Cry2Ab genes in *H. punctigera* was approximately 5 in 100 (0.05, 5%).

Why is there a high baseline frequency of Cry2Ab genes in field populations?

The high frequency of individuals carrying the Cry2Ab resistant gene in field populations is unexpected because, until the widespread adoption of Bollgard II, there has presumably been little exposure of *Helicoverpa spp*. to this toxin and therefore little selection for resistance. Although the Cry2Ab toxin from Bt is present in some Australian soils, it is not common. In contrast, the Cry1Ac toxin is far more common in Australian soils, yet resistance to this toxin in *Helicoverpa spp*. is rare. Mutations that confer resistance to Cry2Ab may occur in field populations of *Helicoverpa spp*. at a very high rate.

Collection of *H. punctigera* moths from inland regions were made in winter 2009 to see of these populations, which would have little exposure to Bollgard II, carry resistance to Cry2Ab. F1 screens conducted by CSIRO on these populations show they carry the same Cry2Ab resistance gene present

in the cropping areas but at a much lower frequency of 5 in 1000 (0.005, 0.5%). We do not have an F1 resistance frequency for Cry2Ab in *H. punctigera* prior to the widespread adoption of Bollgard II. However, in both years that we have F2 and F1 screen data for *H. punctigera* in the cropping regions the difference in the estimated frequencies is four-fold. We can estimate an F1 screen frequency for a time close to the introduction of Bollgard II® (2004/05) by multiplying the F2 screen frequency for that season by four. This gives a frequency of 6 in 1000 (0.006, 0.6%) which is similar to the current frequency in inland regions. Hence it is likely that the background resistance in *H. punctigera* to CryAb was common even before Bollgard II® was released.

Is the frequency of Cry2Ab genes increasing in field populations of H. armigera?

F2 data for *H. armigera* do not demonstrate a significant change in frequency of Cry2Ab resistance over time. Since 2004/05 Monsanto has used the F1 protocol developed by CSIRO to screen for resistance to Cry2Ab. This data set shows no significant difference in frequencies over time. CSIRO also have F1 screen data for *H. armigera* since 2007/08. There is no statistically significant difference within a season between the CSIRO and Monsanto data for 2007/08 and 2008/09. The combined 2007/08 data set shows a significantly greater Cry2Ab frequency compared to the previous years; in 2008/09 this frequency did not continue to increase nor did it drop to below the pre-2007/08 levels. However a recent analysis showed that despite both organisations utilising identical robust protocols, and sampling from the same hosts and regions, the frequencies scored by Monsanto are consistently lower than those scored by CSIRO. This is the case for 8 of 9 sets of data collected using the same screen method, species and sampling period where positives were scored by at least one organisation. This suggests that screens are being scored differently by CSIRO and Monsanto and since the size of this difference is not consistent among data sets it is not possible to apply a simple correction. Irrespective of changes through time the frequencies of Cry2Ab in *H. armigera* are higher than expected and this finding is a concern (see above).

Is the frequency of Cry2Ab genes increasing in field populations of H. punctigera?

The F2 and F1 data sets from CSIRO demonstrate significant increases in the frequency of Cry2Ab resistance genes in field populations of *H. punctigera*. CSIRO began collecting F2 screen data for *H. punctigera* in 2002/03. Each year since 2006/07 there has been an increase in the frequencies of resistance to Cry2Ab. This gradual increase over time became statistically significant in 2007/08 and remained highly significant in 2008/09. The 2008/09 F1 data set for *H. punctigera* demonstrates at least a 5 fold increase in frequency compared to 2007/08 which is statistically significant.

Why is H. punctigera developing resistance to Cry2Ab when it has no history of resistance to insecticide sprays?

H. punctigera has the capacity to develop resistance to insecticide sprays but it has been presumed that any resistance selection in cotton regions was kept in check by dilution from susceptible immigrants from central Australia each spring. There may be some recent changes to the ecology of *H. punctigera* that could impact on their ability to develop resistance including a greater tendency to overwinter in cotton regions and less immigration of inland individuals than in the past due to low rainfall inland.

Is the current RMP adequate for controlling further increases in resistance frequencies?

There have been no reported field failures of Bollgard II® due to resistance. However the recent finding of a higher baseline frequency of Cry2Ab genes (F1 tests) than previously detected using F2 screens is a major concern. Of even more concern is the demonstrated significant increase in Cry2Ab resistance frequency in *H. punctigera*. It is imperative that all users of Bollgard II® take responsibility for the stewardship of this technology. In particular, it is critical that closer attention is paid to managing refuges and that effective pupae busting occurs in a timely fashion.

In addition, the TIMS Bt Technical Panel have developed a working document entitled 'Contingency Plan for Mitigating Resistance to the Toxins Within Bollgard II® Cotton' which provides background information and recommendations for the Cotton Australia convened TIMS Committee. This document includes possible measures to be taken in response to further increases in resistance frequencies to the Cry2Ab toxin in Bollgard II® cotton by *Helicoverpa spp*. to mitigate the risk of levels being attained that would lead to field failures. This document is undergoing a process of consultative stakeholder review prior to ratification by the Cotton Australia TIMS Committee before March 2010. The Contingency Plan will be reviewed annually in light of new information on resistance frequencies in *Helicoverpa* spp. and knowledge of and tactics for Bt resistance management. Note that the RMP will continue to be the document that informs growers of their responsibilities in managing Bollgard II® cotton while the contingency plan contains other mitigation strategies that may be introduced into the RMP.

1. Refuges

What is the purpose of refuges?

The aim of refuge crops is to generate significant numbers of susceptible moths (SS) that have

not been exposed to selection pressure from the Bt proteins. As detailed above, this production is especially critical in a drought year because there is reduced contribution from non-cropping vegetation and dryland crops. Moths produced in the refuge crops will disperse to form part of the local mating population where they may mate with any potentially resistant moths (RR) emerging from Bollgard II® crops. This reduces the chance that resistant moths will meet and mate.

The offspring from matings between one resistant and one susceptible moth will carry one gene from each parent (RS) and are referred to as heterozygotes. In the cases of Bt resistance that have so far been identified, heterozygotes are still controlled by Bollgard II® cotton. Therefore, the critical function of the refuge is to dilute the frequency of RR individuals within the population. It is crucial that the timing of the production of moths from refuges matches that of Bollgard II® crops. For this reason, refuge crop options (sorghum, corn) which have shorter periods of producing moths than cotton, need to have several staggered plantings to extend the period over which moths are produced. While the use of planting windows and use of two Bt genes in Bollgard II® cotton are aimed at reducing selection pressure for Bt resistance, the use of refuge crops is to try to **balance** or **counter** the selection that will still occur.

How were the current requirements for refuge crops determined?
The relative sizes of refuge crops required in the RMP are based on models and knowledge of *Helicoverpa* moth emergence for different crop types. The likely moth productivity of the different refuge options has been determined through large-scale field experiments conducted by the Cotton CRC over several seasons. Only refuge options that have been assessed in this way are currently approved by the APVMA. In these experiments, a refuge of 10% unsprayed cotton was considered as the reference point. On average pigeon pea produced twice as many moths as the same area of unsprayed cotton, hence a 5% refuge, half that of an unsprayed cotton refuge, is required for this crop. Sorghum and corn were effective, however were only highly attractive during flowering. Hence staggered plantings of these options are required to increase the period over which moths are produced.

Is there a minimum size to a refuge crop?
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, as this would decrease the effectiveness of the refuge in producing moths.

If no sprayed conventional cotton is grown on the farm, the minimum size of a refuge must be 24 metres wide and 24 metres long. Sprayed and unsprayed refuges must be planted separately.

Can mixtures of the refuge crop options be used to meet the refuge requirements?
It is possible to combine more than one type of refuge, provided that the total requirements for area equivalence are met. For example, 1 hectare of pigeon pea can be grown alongside 1 hectare of unsprayed cotton, rather than 2 hectares of either. Each type of refuge must be managed so that it is productive and other restrictions on minimum dimensions, number of plantings and location also need to be met. However, sprayed and unsprayed refuge options cannot be mixed in the same field. For example, it would not be acceptable to use 1 hectare of pigeon pea grown alongside 30 hectares of sprayed cotton as a substitute for 2 hectares of pigeon pea.

Why can't a conventional crop from a neighbouring property act as a refuge?
In some cases, a conventional crop grown on a neighbouring property may satisfy the requirements of a refuge for Bollgard II®. However, the crop may not be managed in a way that complies with the RMP. Since growers cannot control the management of a neighbour's crop, it is not sensible to rely on these areas as refuges for Bollgard II®.

Why do the refuge options differ for dryland Bollgard II® and irrigated Bollgard II®?
For dryland Bollgard II® crops the only available dryland refuge options are sprayed or unsprayed cotton. The reason for this is that the other refuge options available in irrigated Bollgard II® (pigeon pea, sorghum, corn) tend to be planted after the cotton and in dryland situations there is uncertainty about whether soil moisture will be adequate to successfully establish future crops. However CSIRO and Monsanto are currently conducting work on the suitability of pigeon pea as a dryland refuge option for dryland Bollgard II® cotton. CSIRO and Monsanto are also working with growers in several valleys to investigate the suitability of dryland conventional cotton treated and not treated by slashing as a potential refuge option. There are also irrigated refuge options for dryland Bollgard II® cotton. These options are sprayed or unsprayed irrigated cotton and unsprayed irrigated pigeon pea, and were chosen because to date they have been the most widely adopted refuges for irrigated Bollgard II®.

How can the 'effectiveness' of an individual refuge be evaluated?
The productivity of refuges will vary considerably across regions and seasons. It is not possible to place a value on the effectiveness of each refuge. Looking after refuges, including nutrition, weed control,

timely irrigation and all factors that make the refuge 'attractive' to female moths laying eggs, is the key to ensuring that they are effective. Managing resistance is a population level activity, and every refuge makes an important contribution to the overall RMP for the valley, and because *Helicoverpa spp*. disperse widely, on a larger scale for the whole industry. Especially during a drought season it is imperative that all refuges produce their quota of susceptible (SS) moths. Monsanto audits the quality of refuges on every farm that grows Bollgard II® to ensure that they are well maintained and effective.

Why is the location of refuge crops important?
For the refuge principle to be successful, refuge crop areas must be in close proximity to the Bollgard II® crop(s) to ensure that it is highly likely that moths emerging from the Bollgard II® will mate with susceptible moths from the refuge crop. *Helicoverpa* moths are capable of migrating long distances, but during the summer cropping season a significant part of the population may remain 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 close as possible to the Bollgard II® crop, at least within 2 km.

Is there an alternative to growing refuges for resistance management?
No, though alternatives are being investigated. It is important to recognise that the costs associated with refuge crops are an investment in the longer term value of transgenic technology for the industry. The costs associated with growing an attractive refuge should be considered as an integral part of growing Bollgard II®.

2. Volunteers

Why is it important to control conventional cotton volunteers or ratoon plants in Bollgard II®?
In terms of the RMP, it is important to prevent the establishment of conventional cotton in Bollgard II® fields because larger larvae that have grown on conventional cotton plants are moderately tolerant to Bt. If large larvae migrate to neighbouring Bt plants, those that are heterozygotes (RS) may survive and contribute to increasing the frequency of resistance genes in the *Helicoverpa spp*. population. In the cases of Bt resistance that have so far been identified, heterozygotes are controlled by Bollgard II® cotton. By removing conventional volunteers from Bollgard II® fields, heterozygotes will have no opportunity to grow large enough to be able to tolerate Bt plants and therefore contribute their resistance genes to the next generation of moths.

Why is it important to control Bollgard II® volunteers or ratoon plants in conventional cotton?
The same logic applies as in the previous question. The presence of Bollgard II® volunteer plants in a conventional crop exerts a selection pressure for Bt resistance. Heterozygous (RS) larvae that emerge from eggs laid on conventional cotton may grow and during their development move onto Bollgard II® volunteers. In this way RS larvae become exposed to Bt at later growth stages when they can survive to produce offspring. This will lead to an increase in the frequency of resistant individuals (both RS and RR) in the population. If the field happens to be designated as a refuge crop, the presence of the Bollgard II® volunteers will diminish the value of the refuge.

3. Planting Windows

Why do we need a Bollgard II® planting window?
The purpose of restricting the planting window is to limit the number of generations of *H. armigera* that will be exposed to Bollgard II® in any one season. This measure effectively restricts the selection pressure on *H. armigera* to develop resistance to Bollgard II®.

Is it possible to vary the Bollgard II® planting window?
Where exceptional circumstances exist, requests for a variation to the planting window will be considered. In the past Monsanto approached the APVMA on behalf of a grower or Cotton Grower's Association to consider requests. From 2006/07 onwards, the TIMS Committee will consider requests. Requests must satisfy a number of criteria as outlined in the 'Request for variation to the Bollgard II® planting window' document, found on page **63**. If a request is approved, the variation only affects the planting window component of the RMP for the requestee/s for the current season. All other components of the RMP remain the same.

4. No Bt sprays

Why is it important that foliar Bt sprays are not used on refuges?
By preventing the use of foliar Bt on all refuges (sprayed and unsprayed), the likelihood of producing moths that are susceptible (SS) rather than resistant (RR) to Bt is maximised. This is an important part of the RMP because susceptible refuge moths are presumed to mate with any resistant moths in the population to produce heterozygotes (RS) that are killed by Bollgard II®.

With regard to refuge crops, what does the term 'unsprayed' mean?
The term 'unsprayed' encompasses all management activities which are likely to reduce the survival of *Helicoverpa* in these crops. Insecticides with activity against *Helicoverpa* cannot be used in unsprayed refuges. Food sprays cannot be used in unsprayed

refuges as these aim to reduce *Helicoverpa* survival through increased predation and parasitism. Similarly, *Trichogramma* and other biolocial control agents cannot be released in unsprayed refuges as they too aim to reduce *Helicoverpa* survival.

5. Pupae Destruction

Given that few larvae survive in Bollgard II®, why is it important to pupae bust?

Cultivating between seasons prevents any moths that developed resistance in the previous year from contributing to the population in the following year. Although we expect few larvae to survive in Bollgard II®, those that do are most likely resistant and these are precisely the ones that must be killed so that the next generation of moths (emerging the following spring) are not enriched with resistant individuals. This is especially the case in a drought year because of the increased opportunity for 'resistance genes' to increase in frequency.

Am I required to pupae bust in my refuges?

Refuges must produce moths during the cotton season when Bollgard II® is grown but unsprayed refuges can continue to provide benefits for resistance management by being left in place until the following spring. By doing this any pupae produced in the autumn may be carried over the spring and provide additional genetic dilution of resistant survivors. Once Bollgard II® crops begin flowering and are highly attractive to *Helicoverpa* moths, cultivation of the refuge (e.g. for weed control, row formation etc) must be matched by cultivation of the associated Bollgard II® field(s).

Why are there requirements for trap cropping in central Queensland?

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. Pupae busting is not an effective resistance management tool in these warmer areas and trap crops are required as an alternative. Trap crops of pigeon peas are planted after the cotton and are timed to be at their most attractive after the cotton has cut-out. Thus moths emerging from Bollgard II® cotton 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 then cultivated to destroy any pupae. See the 2009/10 RMP for more details.

Guidelines for *Helicoverpa* management in Bollgard II® cotton

Since 2005/06 there have been occasional reports of larvae surviving for several weeks at threshold levels in Bollgard II® fields. All affected fields were at mid-flowering to late-flowering and the survivors included *H. armigera* and *H. punctigera.*

Work conducted by CSIRO and Monsanto demonstrated that these larvae did not survive on Bollgard II® due to Bt resistance or because of the absence of Bt genes in the cotton. It is possible that the survival is due to a modified or existing behaviour of larvae that enables them to target sites of the plant that do not express at high levels (e.g., pollen in flowers). It is also possible that the survival is due to a temporary decline in the expression of toxins in the whole plant. Work is underway to investigate these possibilities.

Irrespective of how survival occurs, it is recommended that if larvae reach thresholds in Bollgard II® fields they should be controlled by spraying. Work conducted by Monsanto suggests that it is unlikely that there will be a yield penalty associated with larvae survival in Bollgard II® fields. One experiment conducted by PhD student Baoqian One experiment conducted by PhD student Baoqian Lu within Bollgard II® fields at threshold involved removing larvae from plots and leaving larvae in other plots. In a field that was sprayed for *Helicoverpa* after setting up the trial there was no difference between the two types of plots. However in a field that was not sprayed for *Helicoverpa* the plots with larvae had significantly less cotton lint compared to the plots where larvae were removed. Additionally, in some instances the surviving larvae are able to pupate and emerge. This poses a threat because the larvae will presumably have been exposed to Bt toxin at a low level which may select for resistance if some dominance is present.

With the increased risk of resistance to Cry2Ab in *Helicoverpa* it is critical that we monitor the distribution and proportions of fields that are affected by surviving larvae, and the number of fields that are sprayed to control *Helicoverpa*. At the end of every season, CCA members will be asked to contribute to the ongoing 'Sprays for surviving *Helicoverpa* in Bollgard II® survey 2009' available on the Cotton CRC website (www.cottoncrc.org.au/content/Industry/IndustryHome.aspx – go to 'tools').

If you experience above threshold levels of *Helicoverpa* in your Bollgard II® fields please immediately contact;

- Sharon Downes: 02 6799 1576 / 0427 480 967,
- Baoqian Lu: 02 6799 2479 / 0407 237 404, or
- Kristen Knight 07 4634 8400 / 0429 666 086.

Collection kits are also available from your Regional Cotton Extension Officer.

Insecticide selection for Bollgard II® crops

When controlling *Helicoverpa* within Bollgard II® crops, insecticide selection should comply with the cotton industry's Insecticide Resistance Management Strategy (pages 52–55). The predator/pest ratio (described on page 2) should also be given careful consideration when the application of an insecticide is being considered. If an insecticide is required, try to choose the most effective product that is the least disruptive to the beneficial complex. Refer to page 38–39. While foliar Bt can be used on Bollgard II® crops, it is a requirement of the Bollgard II® Resistance Management Plan that foliar Bt not be used on any refuge crops.

Helicoverpa thresholds

Do not include any larvae <3 mm long in spray threshold counts. For economic management of *Helicoverpa*, larval populations should be controlled with an insecticide if a threshold of; 2 larvae /m >3 mm long are found over 2 consecutive checks; or 1 larvae /m >8 mm long is found in any check. Application of these thresholds requires careful and accurate assessment. Checks should be made over the whole plant including the terminals, squares and especially flowers and small bolls. Be sure to objectively assess larval size. A complete description of the sampling protocols for *Helicoverpa* can be found on page 1.

Guidelines for amending Bollgard II® planting windows 2009/10

Developed by the Transgenic and Insect Management Strategies Committee of Cotton Australia

Note: Requests for variation to the Bollgard II planting window only affect the planting window component of the RMP for the requestee/s for the current season.

Planting Windows in the Bollgard II® RMP are the key element in the strategy for restricting the number of generations of *Helicoverpa* spp. exposed to Bollgard II® in a region. This is necessary to limit the rate of evolution of resistance to Bt toxins. These guidelines allow a degree of flexibility to accommodate unforseen circumstances without jeopardising this objective.

The TIMS Committee will only consider requests for a variation to the planting window in situations in which exceptional circumstances exist (emergencies).

If the request is accepted and agreed to by the TIMS committee then a 'Bollgard II® Planting Window Variation Notice' will be issued by Monsanto. This variation only affects the planting window component of the Resistance Management Plan (RMP). All other components of the RMP remain the same.

Process

Monsanto is responsible for the issuing of a 'Bollgard II® Planting Window Variation Notice' under the APVMA Notice of Variation of Registration of Agricultural Product – Bollgard II® cotton (March 23, 2006).

Cotton Growers who wish to request a variation to Bollgard II® planting window dates for them or their region will need to make a formal request to the TIMS Committee who will make a written recommendation to Monsanto. The request must be in writing from their local CGA and received where possible, by the end of the first week of September.

It is essential that there has been wide consultation regarding the proposal including; CGA members, local consultants, Industry Development Officers and researchers and the local Monsanto Accounts & Stewardship Specialist. Requests that are supported by TIMS will be approved by Monsanto. The Variation Notice will be communicated to relevant organisations and individuals by TIMS and Monsanto.

Criteria for assessing the application to change a planting window:

1. The local Cotton Growers Association (CGA) must request and approve the change with a majority vote and advise all growers of the outcome of the vote. The majority decision affects TUA compliance for all licensed growers. Evidence of this process will be required from the CGA in writing together with the information requested below.
2. The region (or individual grower) requesting the variation is more than 100 kms from any other significant Bollgard II® planting.
3. Planting of Bollgard II® in the region has not exceeded 10% of the anticipated Bollgard II® cotton area.
4. No Bollgard II® cotton has been planted in excess of 21 days prior to the opening of the new window.
5. There are no known threats to the efficacy of refuges in the region (e.g., plague locust pressure).
6. The requested planting window variation must be a 42 day window that falls entirely within the period September 1 to December 15.

Essential information to be submitted with a request for a Bollgard II® planting window variation:

1. Describe the reasons for the request.
2. Proposed new window start and finish dates.
3. Map or description of the region concerned.
4. Distance of the relevant region to nearest neighbouring cotton.
5. Time of first Bollgard II® cotton planted in the region.
6. Area of Bollgard II® already planted in the region.
7. Projected total area to be planted to Bollgard II® in the region.
8. Statement confirming approval and agreement of all cotton growers in the region to abide by the requested changes to the window.
9. Statement acknowledging capacity to still meet pupae busting requirements in the RMP when a later planting window is requested.

Resistance Management Plan for Bollgard II® Cotton 2009/10

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

The resistance management plan is based on the two 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 and hence dilute any potential resistance: and (3) removing resistant individuals at the end of the cotton season.

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 NSW and QLD that grow cotton while sections 2 and 3 detail specific requirements for NSW, Southern Queensland and Central Queensland respectively.

SECTION 1: NSW/SOUTHERN QUEENSLAND SECTION & 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 Bt 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.

For each area of irrigated Bollgard II® cotton planted, a grower is required to plant a minimum of one or 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	Irrigated, unsprayed	5
Sorghum	Irrigated, unsprayed – conditions apply, see box below	15
Corn	Irrigated, unsprayed – conditions apply, see box below	20

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	Irrigated, unsprayed pigeon pea	5

No other refuge options are approved for dryland Bollgard II.

Notes: Unsprayed means unsprayed with insecticides that affect any life stage of *Helicoverpa* spp.

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

If the viability of an unsprayed conventional cotton refuge is at risk due to early season pressure by *Helicoverpa spp*., with prior approval from the Monsanto Compliance Manager, a non-Bt heliocide can be applied up to the 4th true leaf stage.

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Notes cont.: 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*. moths.

Irrigated sorghum or corn

NB: The following special conditions apply to growers who wish to grow sorghum or corn as refuges:

- A plan indicating how either of these refuges will be managed must be submitted to, and approved by, the local Accounts & Stewardship Specialist before planting either of these two options. A farm map must be included with the plan.

  Either refuge option requires three sequential plantings of the same variety. The initial planting date should be determined by the time taken to flower for the varieties chosen for use in each particular area so that the need for part of the refuge to be in flower from January 15 is satisfied. Subsequent plantings should follow at 2-weekly intervals so that some of the refuge is continuously in flower until February 28.
- A single planting of mixed maturity varieties is not acceptable.
- Each planting should be one third of the total area required for that refuge type, as described in Table 1 or Table 2. If there is no sprayed conventional cotton on the same farm unit the refuge must be a minimum of 24 metres wide. However, if there is sprayed conventional cotton on the same farm unit the refuge must be a minimum of 48 metres wide (see also clause (f) below).
- These refuge options will be closely monitored during the season to ensure refuge that they are managed appropriately and are effective and attractive from 15 January to 28 February.
- Corn refuges may be harvested after complete cob maturity.
- Sorghum refuges may be harvested after complete head maturity.

General conditions for all refuges are:

(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. 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.

(b) Pigeon pea refuges should not be planted until the soil temperature reaches 17°C, which is the requirement for 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 the Bollgard II crops begin flowering, and are highly attractive to *Helicoverpa* spp. moths, cultivation of refuges (e.g. for weed control, row formation etc) must be matched by cultivation of the associated Bollgard II field(s).

(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 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.

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(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.

(h) 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 after Bollgard II cotton plants have been removed. In all regions, destruction of refuges other than corn and sorghum should only be carried out after Bollgard II cotton lint removal has been completed.

(i) Refuges for dryland Bollgard II 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 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.

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. Unsprayed refuges should preferably be left uncultivated for 2 weeks after harvest to allow emergence of any pupating *Helicoverpa* spp.

SECTION 2: NSW 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 to ensure that pupae busting has occurred.

In Refuge crops:

- 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 local Accounts & Stewardship Specialist.

SECTION 3: CENTRAL QUEENSLAND ONLY

1. Planting Windows

Emerald: 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: All Bollgard II® crops are to be planted into moisture or watered up in the period between October 10 and November 20 unless advised otherwise by a 'Bollgard II® Planting Window Variation Notice'.

2. Late Summer 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 Accounts & Stewardship Specialist for alternative options.

Refuge and late summer trap crops have different purposes and, if pigeon pea is selected for both, two separate plantings are required.

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

Criterion	Trap Crop* *
Minimum Area and Dimension requirements	A trap crop of 1% of planted Bollgard II 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 must be planted between November 20 and December 20.
Planting rate**	35 kg/ha (recommended establishment greater than 4 plants per metre).
Insect control	The trap crop can be sprayed with virus after flowering; while avoiding insecticide spray drift.
Irrigation	Irrigation of the trap crop must be the same as for cotton, plus one additional irrigation after cotton is finished.
Weed control	Keep free of weeds.
Crop destruction	The trap crop must be destroyed 2 to 4 weeks after defoliation of Bollgard II cotton (slash and pupae bust – full soil disturbance to a depth of 10cm across the entire trap crop area).

** A pigeon pea trap crop is to be planted such 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 mid-November) or too late (e.g. January) is not adequate for cotton crops planted during September through to October.

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

NB: If any grower encounters problems in complying with the resistance management plan, please contact your Accounts and Stewardship Specialist.

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.

Toby Makim	Emerald, Dawson Callide, Darling Downs & MacIntyre	0400 691 881
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Legal responsibilities in applying pesticides

Mark Scott, Industry & Investment NSW and Lisa Dixon, ClemClear®.

Pesticides Act

The *Pesticides Act 1999* is the primary legislative instrument controlling the use of pesticides in NSW and is administered by the Department of Environment, Climate Change and Water (DECCW). The underlying principle of the Pesticides Act is that pesticides must only be used for the purpose described on the product label and all the instructions on the label must be followed. Consequently, all label directions must be read by or explained to the user prior to each use of the pesticide.

All pesticide users should take reasonable care to protect their own health and the health of others when using a pesticide. They should also make every reasonable attempt to prevent damage occurring from the use of a pesticide, such as off-target drift onto sensitive areas or harm to endangered and protected species.

A regulation was gazetted in 2009 requiring all commercial pesticide users, i.e. all farmers and spray contractors, to keep records of their pesticide application

While no set form is required for records they must include the following:

- full product name,
- description of the crop or situation,
- rate of application and quantity applied,
- description of the equipment used,
- address of the property, identification of the area treated and order of paddocks treated,
- date and time of the application (including start and finish),
- name, address, and contact details of the applicator and of the employer or owner if an employee or contractor is the applicator,
- estimated wind speed and direction (including any significant changes during application),
- other weather conditions specified on label as being relevant (e.g. temperature, rainfall, relative humidity).

An example form that captures all the information required by the Pesticides Regulation 2009 is provided on the following page. Notes on how to fill it in, can be downloaded from the I&I NSW website. A self-carbonating record book is available for purchase through the DEEDI Dalby and Toowoomba offices and through the I&I NSW SMARTtrain National Support Centre at Yanco.

Records must be made within 24 hours of application, be made in legible English, and kept for 3 years.

The Pesticides Regulation 2009 also requires all commercial pesticide users to be trained in pesticide application.

The training of aerial applicators, pest control operators and fumigators is recognised as satisfying the requirements of the regulation. Apart from these groups, all commercial users must have a prescribed qualification. Only domestic use, such as home gardens, is excluded, provided the pesticide is a specific domestic/home garden product. Covered by the regulation is pest control by/on:

- public authorities, e.g. State Rail,
- golf courses, sporting fields and bowling greens,
- agricultural, horticultural, aquacultural and forestry operations,
- businesses, educational institutions, and hospitals.

The minimum prescribed training qualification will be the AQF2 unit of competency, 'Apply chemicals under supervision', although owner-applicators are encouraged to train and be assessed in the two higher AQF3 competencies, 'Prepare and apply chemicals' and 'Transport, handle and store chemicals'.

Growers are recommended to undertake the SMARTtrain course, Chemical Application, or the standard ChemCert course, both of which cover the higher AQF3 competencies. For growers with literacy and/or numeracy problems, the lower level AQF2 competency will provide a minimum qualification that satisfies the Regulation.

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Location, Applicator, Date of Application

Property/Holding: (residential address)					Date:
Applicator's Full Name:			Owner (if not applicator):		
Address:			Address:		
		Phone:			Phone:
Mobile:	Fax:	Email:	Mobile:	Fax:	Email:
Sensitive Areas (including distances, buffers): N / W / Treated Area / E / S			Comments (including risk control measures for sensitive areas):		

Host/Pest

Paddock Number/Name:	Paddock Area:	Order of Paddocks Sprayed:
Crop/Situation:	Type of Animals:	
Crop/Pasture Variety:	Age/Growth Stage:	
Growth Stage:	Mob/Paddock/Shed:	
Pest/Disease/Weed:	Animals — Number Treated:	
	Pest Density/Incidence: ❑ Heavy ❑ Medium ❑ Light	

Application Data

Full Label Product Name:			Rate/Dose:	Water Rate L/ha:
Permit No.:	Expiry Date:		Additives/Wetters:	
Total L or kg:	WHP:	ESI*:	Date Suitable for Sale:	
Equipment Type:		Nozzle Type:	Nozzle Angle:	Pressure:
Date Last Calibrated:	Water Quality (pH or description):			

Weather

❑ Showers ❑ Overcast ❑ Light Cloud ❑ Clear Sky

Rainfall (24 hours before and after)
Before: mm During: mm After: mm

Time (show time in this column)	Temperature °C	Relative Humidity (%)	Wind Speed	Direction	Variability (e.g. gusting)
Start					
Finish					

Comments:

* When using herbicides in mixtures with fungicides and insecticides, an ESI may apply to the non-herbicide component of the mixture.

Hazardous Substances Legislation

Many registered pesticides are classified as hazardous substances and most of those that are not pose some risk to the health of those who use them or are exposed to them.

The Occupational Health and Safety Act 2000, and the Hazardous Substances section of the Occupational Health and Safety Regulation 2001, detail legal requirements of suppliers, employers and employees in the workplace for hazardous substances management. The Act and accompanying Regulation are intended to protect workers from both the short and long-term health effects of exposure to hazardous substances and to improve current health and safety practices by:

- provision of health and safety information to workers (including a list or register of all hazardous substances and an MSDS (Material Safety Data Sheet) for each hazardous substance),
- consultation with workers,
- training of workers,
- assessment of the risks arising from hazardous substances exposure,
- control of the risks, and
- recording of the risk assessment and control measures implemented, training of both those applying and exposed to hazardous substances, and health surveillance (if warranted by the risk assessment in respect of organophosphates).

Both storage and use are covered by the OH&S legislation. Records of training and risk assessments have to be kept for 5 years.

Dangerous Goods legislation has been revised to bring it into line with hazardous substances legislation. The new requirements came into force after a phase-in period ending September 1, 2006. The main requirements include;

- provision of MSDSs,
- carrying out and documenting risk assessments, and
- keeping a register of Dangerous Goods.

All these requirements already apply to hazardous substances. In practice, the only change will be to add to existing management and recording and record systems any Dangerous Goods that are not also hazardous substances.

Storage limits have changed. Premises storing large quantities require placarding of both the storage shed and the entrances to the premises. If very large quantities are stored, which would be rare on-farm, a manifest, site plan and written emergency plan are required. Consult your local WorkCover office for advice.

Farm chemicals are registered pesticides, and many are either hazardous substances or Dangerous Goods or both. As different legislation applies to each category, farmers must ensure their pesticide use complies with all relevant legislation.

WorkCover NSW's *Code of practice for the safe use and storage of chemicals (including pesticides and herbicides) in agriculture* is an approved industry code of practice and provides practical guidance for farm chemical users to comply with the legislation. This has recently been revised to reflect the new Dangerous Goods requirements. Copies can be obtained from your local WorkCover office, by download from the WorkCover website – www.workcover.nsw.gov.au – or by phoning 1300 799 003.

The cotton industry's guidelines for handling, storage and application of pesticides can be found in Part 1 and 2 of the *Australian Cotton Industry Best Management Practices Manual.*

Pesticides and the Environment

The cotton industry's guidelines for minimising risk to the environment can be found in Part 6 of the *Australian Cotton Industry Best Management Practices Manual.*

Most insecticides are toxic to aquatic organisms, bees and birds. Fungicides and herbicides are relatively safe to bees in terms of their active ingredients, but their carriers and surfactants may be toxic. The risks that a particular product poses to the environment are reflected in statements on the label under headings like 'Protecting wildlife, fish, crustacea and the environment'.

PROTECTING BEES

The cotton growing environment is a high risk environment for bees. Bees are particularly susceptible to many of the insecticides used on cotton farms, such as abamectin, fipronil, indoxacarb, pyrethroids and profenofos. The productivity of hives can be damaged if bees or the hives are contaminated. Insecticides that are particularly toxic to bees are identified as such with the following special statement on the label;

Dangerous to bees. DO NOT spray any plants in flower while bees are foraging.

The relative toxicities of cotton insecticides to honeybees are listed in Table 3 on page 40–41.

Table 3 ranks the acute toxicities of products to bees based on LD50 information. The residual toxicity of insecticides, that is, the amount of time the product remains toxic to bees after the time of application, should also be considered when information is

available. For the majority of insecticides used in cotton the residual toxicities are unknown. Table 6 summarises the currently available information.

Bees are generally active between 7:00 am and 4:00 pm and most bees forage within a 2 to 4 km radius of their hive. They may travel up to 7 km away in search of pollen and nectar, though only when nearby pollen and nectar sources are in decline or are of poor quality. Bees collect nectar from extra-floral nectaries (eg under leaves) as well as from cotton flowers so they may forage in cotton crops before, during and after flowering. As well as bees foraging in cotton crops, damage may occur to bees when pesticides drift over hives or over neighbouring vegetation that is being foraged by bees eg. coolibah.

Coolibah trees (*Eucalyptus microtheca*) are a primary soure of nectar and pollen for honey bees. These trees grow on the black soil plains along many of the river courses in the cotton growing areas. Budding and flowering occurs in response to good spring rains. In northem NSW the buds appear in November and the trees begin to flower mid-late December finishing about about the end of January, budding and flowering times vary by a few weeks in both the the southem and central Qld areas. When heavy budding occurs beekeepers often move large numbers of hives into cotton growing areas for honey production.

With good communication and good will, it is possible for apiarists and cotton growers to work together to minimise risks to bees, as both the honey industry and cotton industry are important to regional development.

The pesticide risk to bees can be reduced by:

- applying pesticides toxic to bees in the evening when bees are not foraging;
- notifying the apiarist when beehives are in the vicinity of crops to be sprayed to allow removal of the hives before spraying. Beekeepers require as much notice possible, preferably 48 hours, to move an apiary;
- where possible, using EC and granular formulations in preference to wettable powders which are particularly hazardous to bees. Micro-encapsulated formulations such as that used for lambda-cyhalothrin are particularly hazardous to bees because of their persistence in the environment and because bees transport the micro-capsules back to the hive along with the pollen;

Protect bees when using Regent® Insecticide
The Regent® Insecticide label states;
'Dangerous to bees. DO NOT apply where bees from managed hives are known to be foraging, and crops, weeds or cover crops are in flower at the time of spraying, or are expected to flower within 28 days (7 days for pastures and sorghum).
Before spraying, notify beekeepers to move hives to a safe location with an untreated source of nectar, if there is any potential for managed bees to be affected by the spray or spray drift. If an area has been sprayed inadvertently, in which the crop, weeds or cover crop were in flower or subsequently came into flower, notify beekeepers in order to keep managed bees out of the area for at least 28 days (7 days for pastures and sorghum) from the time of spraying. Where the owner of managed hives in the vacinity of a crop to be sprayed is not known, contact your State Department of Primary Industries/Agriculture, citing the registration number, for assistance in contacting the owner.'

Table 6. Cotton insecticides with known residual toxicities to honey bees

Active Ingredient	Chemical Group	Residual Toxicity to Bees[1]	Comment
fipronil	phenyl pyrazole	7 to 28 days	Long residual. See label extract above.
clorfenapyr	pyrrole	2 days	Foraging beaviour could be affected for longer than 2 days[2].
spinosad	spinosyn	1 day	Not hazardous once the spray has dried. Avoid drift onto hives.
betacyfluthrin	synthetic pyrethroid	>1 day	Longer residual expected in Australian conditions.
esfenvalerate	synthetic pyrethroid	1 day	
lambda–cyhalothrin	synthetic pyrethroid	>7 days	Micro-encapsulated formulation has longer residual.
carbaryl	carbamate	up to 7 days	
chlorpyrifos	organophosphate	up to 1 day	
dimethoate	organophosphate	up to 3 days	
parathion	organophosphate	1 day	Depending on weather conditions, residual may be 4–6 days[3].

Source: Primefact 149, *Pesticides – a guide to their effect on honey bees.*

[1] Residual toxicity is the amount of time the pesticide remains toxic after application. Data is derived from United States field trials conducted by the University of California (Atkins et al. 1981, *Reducing pesticide hazards to honey bees*) and Washington State University (Mayer et al. 1999, *How to reduce bee poisoning from pesticides*) unless otherwise indicated.

[2] APVMA, when formerly the National Registration Authority.

[3] United States Environment Protection Agency.

- inform contract pesticide applicators operating on the property of the locations of apiaries;
- paying particular attention to windspeed and direction, air temperature and time of day before applying pesticides;
- using buffer zones as a mechanism to reduce the impact of spray drift or overspray; and
- avoiding drift and contamination of surface waters where bees may drink (see advice on risk management for aquatic organisms).

Bee Alert

The Cotton CRC website hosts a voluntary service called **'Bee Alert'** that aims to improve communication between hive owners and cotton growers. Bee Alert is a free service which allows beekeepers to regularly update information about their hives on the web page for use by cotton growers. The Cotton CRC oversees the placement of data, allowing the Regional Cotton Extenion Officer to be notified when new listings are made in a region. Communication with growers and aerial operators can then be co-ordinated locally. Each Bee Alert provides;

- a description of where the hives are located,
- the likely duration of their stay, and
- contact details for the apiarist to be used in the event that hives may need to be moved.

When communicating with beekeepers, encourage them to use this service, particularly when aparies are being placed within bee flight range of flowering crops.

Further information about protecting bees or to contact the owner of bee hives

NSW Apiarist Association
Ms Julie Lockhart, Secretary
PO Box 3018, Toongabbie East, NSW 2146
Phone (02) 9631 3934. Fax (02) 9631 0585

QLD Beekeepers Association Inc.
Mr Bob Johnson, State Secretary
PO Box 49, Mapleton QLD 4560
Phone: (07) 5445 7512
Email: qba@hypermax.net.au

I&I NSW
Dr Doug Somerville,
Technical Specialist – Honeybees
PO Box 389, Goulburn NSW 2580
Phone: (02) 4828 6619. Mobile: 0427 311 410
Email: doug.somerville@dpi.nsw.gov.au

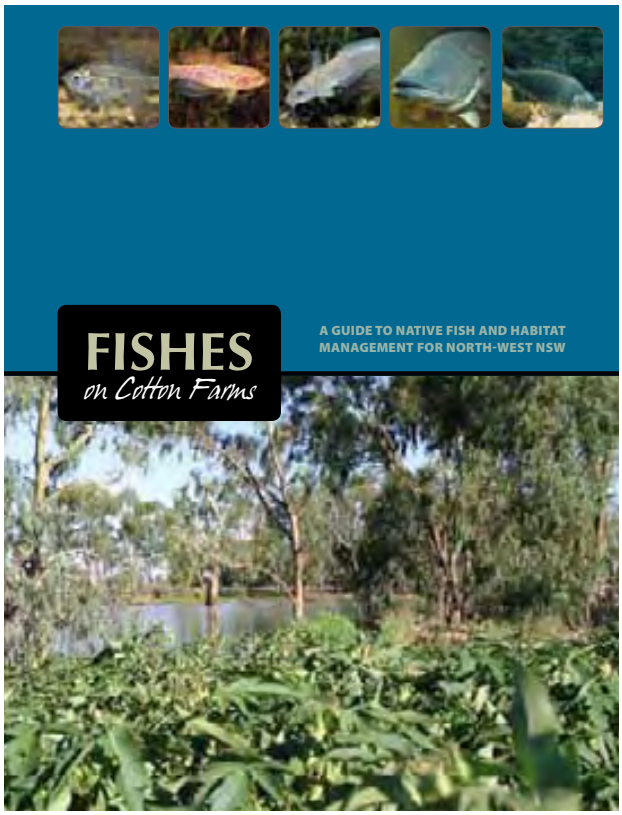
DEEDI
Peter Warhurst, Apiary Officer
Locked Bag 17, Warwick QLD 4370
Phone: (07) 4661 6623. Mobile: 0428 616 623
Email: peter.warhurst@dpi.qld.gov.au

Cotton CRC weblink;
www.cottoncrc.org.au/content/Industry/Tools/BeeAlert/Bee_Sites_All_Regions.aspx

PROTECTING THE AQUATIC ENVIRONMENT

The risk to aquatic organisms can be managed by:

- preventing drift into surface waters during application;
- locating mixing/loading and decontaminating facilities away from surface waters and providing such facilities with bunding and sumps to prevent movement of either concentrate or rinsate into surface waters;
- installing valves which prevent back-flow when filling spray tanks from surface waters and in suction lines for chemigation systems which draw directly from surface waters;
- avoiding aerial application of spray on fields during irrigation;
- building sufficient on-farm storage capacity (including provision for storm run-off) to contain pesticide contaminated tail water from irrigation;
- spraying in an upstream direction, when it is necessary to spray near surface waters, to reduce the maximum concentration at any one point in the watercourse;



NEW Fishes on Cotton Farms Guide available through the Cotton Catchment Communities CRC; www.cottoncrc.org.au or (02) 6799 1534

- using only registered products to control aquatic weeds, e.g. Roundup Bioactive® rather than Roundup®; and
- avoiding disposal of used containers in surface waters and on flood plains and river catchments.

PROTECTING BIRDS

The organophosphate and carbamate insecticides can be particularly toxic to birds, especially in granular formulations. Bird kills from diazinon, monocrotophos and carbofuran have been well documented in Australia and overseas. Insecticidal seed dressings can pose similar risks. Just a few seeds and granules can be lethal. Spillages can be very hazardous as birds can easily ingest a toxic dose from a small area.

Risks to birds from granular products can be managed by:

- ensuring complete incorporation beneath the soil, particularly at row ends where spillage may occur; and
- immediate clean up of spillage, however small.

Bait materials for control of rodents or soil insect pests can also be hazardous to birds, either through direct consumption of the bait or from feeding on bait-affected animals or pests. The risks to birds from baits can be managed by:

- ensuring even bait distribution, with no locally high concentrations;
- not baiting over bare ground or in more open situations, such as near crop perimeters, where birds may see the baits;
- not baiting near bird habitat such as remnant native vegetation;
- use of bait stations which prevent access by birds, particularly near bird habitat;
- only baiting where pest pressure is high;
- baiting late in the evening when birds have finished feeding;
- prompt collection and burial of rodent carcasses where these occur in open situations; and
- immediate clean up of spillage, however small.

Foliar applied insecticide sprays can also be hazardous to birds, either because of direct contact with the sprayed chemical, or by feeding on sprayed insect pests or crops. Even where birds are not killed, they may be sufficiently affected to make them more vulnerable to predation. Contaminated seed and insects collected from sprayed fields by parent birds can also be lethal to young chicks still in the nest. Risks to feeding and nesting birds can be managed by:

- minimising drift into remnant vegetation, wildlife corridors, nesting sites, or other bird habitats;
- actively discouraging birds from feeding in crops which are to be sprayed;
- spraying late in the day when birds have finished feeding; and
- using only low toxicity chemicals when large concentrations of birds are nesting nearby.

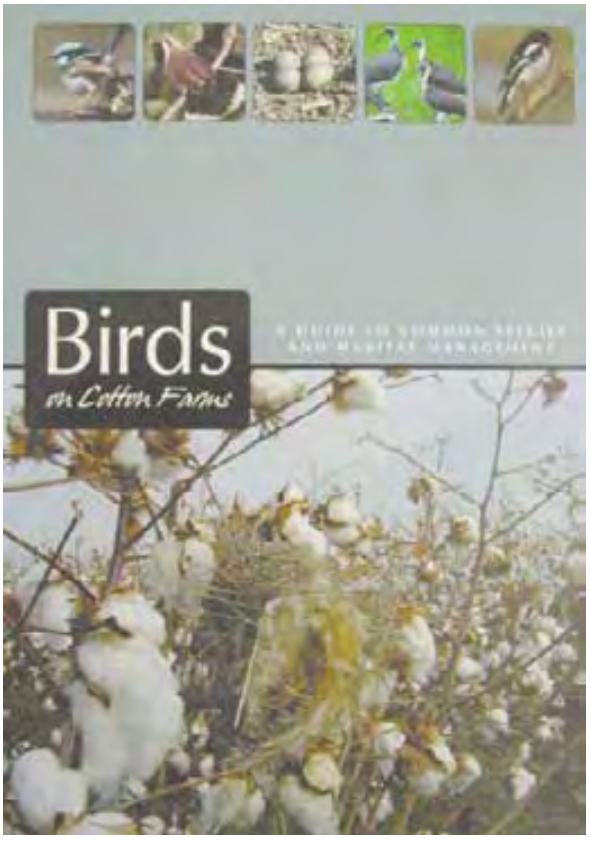
The best way to manage any long term adverse environmental risks is to follow the protection

Birds on Cotton Farms

'Birds on Cotton Farms' has been re-printed by the Cotton Catchment Communities CRC. The guide provides cotton growers of Northern New South Wales and Southern Queensland with an easy to use field guide of common bird species and their habitat requirements in the farming landscape. Some simple management practices that cotton growers can employ to maintain and improve local bird population densities and diversity are outlined.

This guide complements the management guidelines outlined in the Australian Cotton Best Management Practice (BMP) Manual.

Within the Guide there is a checklist of more than 300 bird species known to occur on farms, grasslands, wetlands and woodlands across these cotton production regions. This list represents more than one-third of all Australian birds. Also included are photographs of 118 common and significant bird species plus a brief description of their appearance, behaviour, habitat and preferred diet. The guides are available through the Cotton Catchment Communities CRC;
Locked Bag 1001 Narrabri NSW, 2390
Phone (02) 6799 1534 www.cottoncrc.org.au



statements on labels, minimise spray drift, and to dispose of chemical containers and waste in accordance with label directions and codes of practice.

RECYCLE CHEMICAL CONTAINERS

Recycling is now possible for properly rinsed metal and plastic containers used for farm chemicals. *drumMUSTER* is the national program for the collection and recycling of non-returnable crop production and animal health product chemical containers.

The containers when presented at a *drumMUSTER* receival site MUST BE: Free of chemical residue with the lids removed. Some stains are acceptable but physical chemical residue is **not**. Dirt, dust and mould are not reasons for rejection.

Inspection of containers at *drumMUSTER* collection points is necessary to ensure that containers can be safely recycled. There must be no product residue on the inside or the outside of the container, including the thread and cap. Visible residues could be powder, flake, coloured /dark fluid or clear fluid.

Preparing chemical drums for recycling

Always follow these procedures to ensure your drums are suitable for delivery to a collection centre;

1. Triple or pressure rinse your containers immediately after use (residues are more difficult to remove when dry). Pour the rinse water back into the spray tank.
2. Thoroughly clean the container thread and outside surfaces with a hose into the spray tank. Rinse all caps separately in a bucket of clean water, and pour the rinsate into the spray tank.
3. Inspect the container, particularly the thread and screw neck to ensure all chemical residue has been removed.
4. Metal containers should be punctured using a steel rod or crowbar, this should be done by passing it through the neck/pouring opening and out the base of the container. This also allows the containers to vent and remove any residual odour.
5. Allow the containers to drain completely and air dry them (this may take a number of days) to ensure they do not retain any rinse water.
6. Store cleaned containers in a sheltered place with caps removed, where they will remain clean and dry until they can be delivered to a *drumMUSTE*R collection centre.

If containers are rejected the user is responsible for ensuring that the container is taken back to the property and cleaned using all rinsate to make up an application of the same chemical according to the label recommendations.

For information on the *drumMUSTER* program phone 1800 008 707 or contact your local representative;

Northern NSW	Southern QLD	Northern QLD
Phil Tucker	Colin Hoey	Bill Davis
0427 925 274	0428 964 576	0427 691 760

SAFELY DISPOSE OF UNWANTED CHEMICALS

ChemClear® is an industry stewardship program which is funded to collect currently registered agricultural and veterinary chemicals at the end of their life cycle, or, when they become surplus. The program is targeted to meet disposal requirements of ag and vet chemical users, and, whilst doing so diverts potential hazardous chemicals from being dumped in landfills, creeks or being inappropriately disposed of in the community.

Unwanted rural chemicals may result from; discontinued use of a chemicals because of changes in cropping or animal practices, development of newer, more effective or safe chemicals, changes in a chemicals registration through the APVMA and/ or banning from use, unknown product, sale of property, inherited product and deceased estates. Any unwanted or unknown chemicals held on farm are potential hazards to people, the environment and the community. The ChemClear® program aranges for the collection of unwanted chemicals for their appropriate environmental disposal.

Registering to use the ChemClear® program

There are six simple steps in using the program;

1. Take an inventory of any unwanted rural chemicals. The inventory should include all identifiable features of the container including label, manufacturer, expiry date, size of container and the remaining quantity of chemical left in the container.
2. Register the inventory for the next collection in your area. Book on; free-call 1800 008 182 or at; www.chemclear.com.au
3. Continue to store your registered chemicals safely and securely.
4. ChemClear® will contact you direct to advise the location for retrieval.
5. Prepare chemicals for delivery to collection site.
6. Deliver chemicals.

The cost to use the ChemClear® service depends on the chemical to be collected. Group 1 chemicals are collected free of charge under the program. These chemicals are currently registered ag and vet chemicals manufactured by companies supporting the Industry Waste Reduction Stewardship initiative. Group 2 chemicals are those chemicals that are no longer registered, unknown, unlabelled, out of date, or mixed ag and vet chemicals. A fee applies for disposal.

Re-entry periods after spraying

Mark Scott, Industry & Investment NSW

The re-entry period is the period in which a treated field must not be re-entered by unprotected persons after the application of a chemical on a crop. This should be considered as part of the risk assessment. Workers including chippers must be advised on the correct time lapse. It is important to observe the re-entry period when contact between foliage and skin is unavoidable. Herbicides are not included in the tables below as they are generally not as toxic.

Always check the label for the re-entry period.

Where no re-entry period is stated, a minimum of 24 hours should be observed or until the chemical has dried upon the crop, whichever is the later (subject to risk assessment), unless appropriate Personal Protective Equipment (PPE) is provided and worn as intended. Caution should be exercised when entering wet crops where chemicals have previously been applied, irrespective of the time lapse between application and re-entry.

Even after the re-entry period has been observed, some PPE may be necessary. Appropriate PPE should be indicated by the risk assessment.

Re-entry periods and the PPE to be worn are found in the General Instructions section of the label, which follows the Directions for Use table. All information will be found under the heading 'Re-entry Period'.

Re-entry periods may vary with formulation and product. The examples given in the table below may not be the same for all products with the active ingredient. Older labels for the same product may have different or no re-entry restrictions. Check the label of the product you are using and follow the directions.

If entry is necessary before the time stated, limit duration of entry and wear cotton overalls buttoned to the neck and wrist (or equivalent clothing), a washable hat, and elbow-length chemical resistant PVC gloves. Clothing must be laundered after each day's use.

Re-entry periods may change or be added to labels as chemicals are re-evaluated. Always read the label.

Refer to Table 16, page 86 for the trade names of active ingredients.

Insecticides without label re-entry periods

Active ingredient	Hazard Classification (WHO 2000–2002)
Spinosad, Bt	Unlikely to present acute hazard in normal use
Dicofol, Propargite	Slight
Alpha-cypermethrin, Pirimicarb	Moderate

Common insecticides with label re-entry periods

Active Ingredient	Re-entry Period
Abamectin	Under field conditions the spray should be allowed to dry on the foliage before re-entry into treated areas.
Acetamiprid	Do not allow entry into treated areas until the spray deposits have dried.
Amitraz	Do not allow entry into treated areas until the spray deposits have dried.
Amorphous silica	Do not allow entry into the treated area until the spray has dried.
Bifenthrin	Do not re-enter treated field/crop until spray deposits have dried.
Beta-cyfluthrin	Do not allow entry into treated areas until spray has dried.
Chlorfenapyr	Do not allow entry into treated areas for 12 hours after treatment.
Chlorpyrifos	Do not allow entry into treated areas until spray deposits have dried.*
Deltamethrin	Do not allow entry into treated areas until the spray deposits have dried.
Diafenthiuron	Do not allow entry into treated areas for 24 hours after treatment.*
Emamectin benzoate	Do not allow entry into treated areas for 12 hours after treatment.
Endosulfan	Re-entry to treated areas is permitted once the spray has dried.
Etoxazole	Do not allow entry into treated areas until the spray has dried.
Gamma cyhalothrin	Do not allow entry into treated areas until spray has dried
Indoxacarb	Do not allow entry into treated areas until spray has dried.
Lambda-cyhalothrin	Do not allow entry into treated areas until the spray has dried.
Methomyl	Do not allow entry into treated areas until at least 24 hours after treatment.
Methoxyfenozide	Do not allow entry into treated areas until spray has dried.
NPV	Do not allow entry into treated areas until spray has dried.
Profenofos	Do not enter treated areas without protective clothing until 24 hours after spraying.
Pymetrozine	Do not allow entry into treated areas until spray has dried.
Pyriproxyfen	Do not allow re-entry into treated area until the spray has dried.
Spinosad	Do not allow entry into treated areas until spray has dried.
Thiametoxam	Do not allow entry into the treated areas until spray has dried.
Thiodicarb	Do not allow entry into treated areas for 1 day after treatment.

* Check label instructions for cotton chippers.

Withholding period (WHP) after pesticide application

Mark Scott, Industry & Investment NSW

WHP is the minimum time period from when a pesticide is applied to when the treated area is allowed to be grazed, cut for fodder or harvested.

Some pesticide labels prohabit grazing by livestock or cutting fodder for livestock. Where a product has a no grazing WHP, crops treated with the product should not be grazed prior to harvest. Stock that graze the stubble or are fed by-products of the treated crop may develop detectable residues of the chemical. Growers should read the label and contact the chemical manufacturer for advice on managing chemical residues in stock.

Pesticides users must comply with these instructions or they may be prosecuted under offence provisions of the *Pesticides Act 1999* for use of a pesticide in disregard of a label.

Withholding period after application for common chemicals

Active ingredient	Crops not to be harvested for:	No grazing or cutting as stock fodder for:
Insecticides/miticides		
Abamectin	20 days	20 days
Acetamiprid	10 days	Do not graze or cut for stock fodder.
Aldicarb	0	Do not graze or cut for fodder. Do not cotton trash to animals feed
Alphamethrin	14 days	not stated
Alpha-cypermethrin	14 days	not stated
Amitraz	21 days	not stated
Amorphous silica	0	0
Bacillus thuringiensis	0	0
Bifenthrin	14 days	not stated
Beta-cyfluthrin	28 days	not stated
Carbaryl	3 days	1 day
Chlorantraniprole	28 days	Do not allow livestock to graze crops, stubble or gin trash
Chlorfenapyr	28 days	Do not graze or cut for fodder
Chlorpyrifos	28 days	28 days
Chlorpyrifos-methyl	28 days	Do not graze crop or stubble
Clothianidin	5 days	Do not graze or cut for stockfeed. Do not feed gin trash to livestock
Cypermethrin	14 days	not stated
Deltamethrin	7 days	not stated
Diafenthiuron	14 days	Do not graze or cut for fodder
Dicofol	7 days	Do not graze or cut for fodder
Dimethoate	14 days	not stated
Disulfoton	70 days	70 days
Emamectin benzoate	28 days	Do not feed cotton trash from treated areas to animals
Endosulfan	56 days	Do not feed cotton fodder, stubble or trash to livestock.
Esfenvalerate	7 days	not stated
Etoxazole	21 days	Do not graze treated area or cut treated area for stock feed
Fipronil	28 days	Do not graze or cut for fodder
Gamma-cyhaldthrin	21 days	not stated
Imidacloprid	91 days	Do not graze or cut for fodder
Indoxacarb	28 days	Do not graze or cut for fodder
Lambda-cyhalothrin	21 days	not stated
Methidathion	3 days	not stated
Methomyl	0	Do not graze or cut for fodder
Methoxyfenoziole	28 days	Do not graze or cut for fodder
NPV	0	0
Omethoate	21 days	not stated
Paraffinic oil	1 day	not stated
Parathion	14 days	Do not graze or cut for fodder
Pirimicarb	21 days	21 days
Profenofos	28 days	not stated
Propargite	28 days	Do not graze or cut for fodder
Pymetrozine	28 days	Do not graze crop stubble or gin trash
Pyriproxyfen	28 days	Do not graze on or cut for stock feed. Do not feed treated cotton trash to livestock
Spinosad	28 days	Do not graze or cut for fodder
Thiamethoxam	28 days	Do not graze or feed cotton trash to stock
Thiodicarb	21 days	21 days
Growth regulator and defoliant chemicals		
Dimethipin	7 days	7 days
Endothal	1 day	Do not graze
Ethephon	7 days	Do not graze
Ethephon + cyclanilide	7 days	Do not graze
Mepiquat	28 days	Do not graze
Paraquat + diquat	7 days	1 day
Sodium chlorate	0	0
Thidiazuron	0	Do not graze or cut for fodder

The WHP given may not be the same for all products with that active ingredient. Always check the label.

Refer to Table 13 for the trade names of active ingredients.

Cotton Insect Control Guide – Registered chemicals as at 15 October 2009

Tracey Farrell, formerly Industry & Investment NSW.

Registration of a pesticide is not a recommendation from I&I NSW for the use of a specific pesticide in a particular situation. Growers must satisfy themselves that the pesticide they choose is the best one for the crop and pest. Growers and users must also carefully study the container label before using any pesticide, so that specific instructions relating to the rate, timing, application and safety are noted. This publication is presented as a guide to assist growers in planning their pesticide programs.

Growers must also ensure that their insecticide program fits in with the Insecticide Resistance Management Strategy for *Helicoverpa*, aphids, mites and whitefly (see pages 52–55). Insecticides can be the most costly part of cotton production. Ensure that industry thresholds (pages 20 to 21) are followed to prevent unnecessary spraying.

IMPORTANT— AVOID SPRAY DRIFT

Take every precaution to minimise the risk of causing or suffering spray drift damage by:

- Planning your crop layout to avoid sensitive areas, including homes, school bus stops, waterways, grazing land and non-target crops.
- Ensuring that all spray contractors have details of any sensitive areas near spray targets.
- Consulting with neighbours to minimise risks from spraying near property boundaries. Keep neighbours informed of your spraying intentions near property boundaries. Make it clear that you expect the same courtesy from them.
- Carefully following all label directions.
- Paying particular attention to wind speed and direction, air temperature and time of day before applying pesticides using buffer zones as a mechanism to reduce the impact of spray drift or overspray.
- Keeping records of chemical use and weather conditions at the time of spraying.

SPRAY LOG BOOKS

To assist in record keeping for pesticide applications, Spray Log Books can be purchased from the state departments of primary industries.

Contacting DEEDI to place an order;

Toowoomba – Natalie Fletcher 07 4688 1460 or Rebecca Simmons 07 4688 1360.
Dalby Office – 07 4669 0800.

The cost $6.60 each plus postage.

Contacting I&I NSW to place an order;

Yanco – SMARTtrain National Resource Centre 1800 138 351.

The cost is $12.00 plus postage.

ABBREVIATIONS USED IN THE TABLES 7–18

AC	=	Aqueous concentrate	L	=	Liquid	SL	=	Soluble liquid
CS	=	Capsule suspension	LC	=	Liquid concentrate	ULV	=	Ultra low volume
EC	=	Emulsifiable concentrate	ME	=	Microencapsulated	WDG	=	Water dispersible granule
EC/ULV	=	Dual formulation	OL	=	Oil miscible liquid	WP	=	Wettable powder
G	=	Granule	SC	=	Suspension concentrate			

Table 7. Control of armyworm, cutworm and tipworm

Active ingredient	Concentration and formulation	Application rate of product	Comments
Armyworm (Lesser) *Spodoptera exigua*			
Chlorpyrifos	500 g/L EC	0.7 or 0.9 L/ha	When 'army' is moving treat broad strip over and in advance of the infestation. Use higher rate for larvae > 3 cm.
Cutworm *Agrotis* spp.			
Chlorpyrifos	500 g/L EC	0.9 L/ha	Apply immediately infestation is oberved. Apply in a minimum of 100 L of water.
Endosulfan	350 g/L EC	2.1 L/ha	Apply at first sign of infestation. Ensure pesticide application management plan (PAMP) is completed.
Tipworm *Crocidosema plebejana*			
Endosulfan	350 g/L EC	2.1 L/ha	Apply at first sign of infestation. Ensure pesticide application management plan (PAMP) is completed.

Table 8. Control of wireworm

Active ingredient	Concentration and formulation	Application rate of product	Comments
Wireworm *Apryprius variabilis* and False wireworm *Pterohelaeus* spp.			
Aldicarb	150 g/kg G	3.0–7.0 kg/ha	Apply into the seed furrow at sowing.
Bifenthrin	100 g/L EC	0.375 L/ha	Apply as spray into the furrow at planting. Use a spray nozzle which will deliver a coarse spray in a total volume of 60–100 L/ha.
Chlorpyrifos	300 g/L EC, EC/ULV 500 g/L EC	0.8–2.5 L/ha 0.5–1.5 L/ha	Use higher rate with extreme population numbers. Use rates for row spacing of 1 m. Apply as band spray at least 10 cm wide into open furrow at sowing. Use minimum spray volume of 20 L per sown ha.
Phorate	200 g/kg G	3.0 kg/ha	Apply into the seed furrow at sowing.

Table 9. Control of aphids

Active ingredient	Concentration and formulation	Application rate of product	*A. gossipii* resistance detected	Comments
Cotton aphid *Aphis gossypii* and Green peach aphid *Myzus persicae*				
Acetamiprid	225 g/L SL	0.05–0.1 L/ha	Yes	Ensure good coverage. Use high rate under sustained heavy pressure.
Aldicarb	150 g/kg G	3.0–7.0 kg/ha	No	Apply into the seed furrow at sowing. Refer to the label for the method of distribution.
Amitraz	200 g/L EC	2.0 L/ha	No	Suppression when used for controlling *Helicoverpa*.
Chlorpyrifos	300 g/L EC, EC/ULV 500 g/L EC	0 5–0.7 L/ha 0.3–0.4 L/ha	No	Use higher rates on heavy infestations.
Clothianidin	200g/L SC	0.125-0.25L/ha	Yes	Apply when aphid numbers are low and beginning to build.
Diafenthiuron	500 g/L SC	0.6 or 0.8 L/ha	Yes low level	Apply before damage occurs. Only use lower rate when spraying by ground rig.
Dimethoate	400 g/L EC	0.5 L/ha	No	Do not use where resistant strains are present.
Disulfoton	50 g/kg G	14.0 kg/ha	No	Apply in band near seed at planting.
Endosulfan	350 g/L EC	2.1 L/ha	No	Apply at first sign of infestation. Ensure pesticide application management plan (PAMP) is completed.
Imidacloprid	200 g/L SC	0.25 L/ha	Yes	Add Pulse penetrant at 0.2% v/v (2 mL/L water)
Omethoate	800 g/L SL	0.25 L/ha	No	Apply by ground or air.
Paraffinic oil	792 g/L	2% or 2L/100 L of water	No	Apply by ground rig using a minimum of 80L/ha of water. If populations exceed 20 per terminal use in a mixture with another aphicide.
Parathion-methyl	500 g/L EC	0.7–1.4 L/ha	No	Use low rate on light infestations and open crops. Ground application only. Higher rate in NSW only.
Phorate	100 g/kg G	6.0 kg/ha	No	For short residual control.
		11.0–17.0 kg/ha	No	For extended period of control. Only use the highest rate on heavy soils when conditions favour good emergence.
	200 g/kg G	3.0 kg/ha	No	For short residual control.
		5.5–8.5 kg/ha	No	NSW registration only.
Pirimicarb	500 g/kg WDG, WP	0.5 or 0.75 kg/ha	No	Thorough spray coverage essential for best results.
Profenofos	250 g/L EC 500 g/L EC	2.0 L/ha 1.0 L/ha	No	Spray timing is important. For best results apply when pest levels have reached commercial thresholds.
Pymetrozine	500 g/kg WDG	0.4 kg/ha	No	Apply to an actively growing crop prior to cut out. Add 0.2% v/v organo-silicone surfactant.
Thiamethoxam	250 g/kg WDG	0.2 kg/ha	Yes	Add 0.2% w/v organo-silicone surfactant. Apply to aphid population in early stages of development. DO NOT apply more than twice per season or as consecutive sprays.

Table 10. Control of cotton leafhopper and silverleaf whitefly

Active ingredient	Concentration and formulation	Application rate of product	Comments
Cotton leafhopper (jassids) *Amrasca terraereginae* and Vegetable leafhopper *Austroasca viridigrisea*			
Aldicarb	150 g/kg G	3.0–7.0 kg/ha	Planting into moist soil will allow greater and faster uptake. Use higher rate for longer residual control.
Dimethoate	400 g/L EC	0.35–0.375 L/ha	Use the higher rate for heavy infestations. Lower rate in NSW
Endosulfan (jassids only)	350 g/L EC	2.1 L./ha	Apply at first sign of infestation. Ensure pesticide application management plan (PAMP) is completed.
Gamma-cyhalothrin	150 g/L CS	0.05 L/ha	Apply at recommended threshold levels as indicated by field checks.
Omethoate	800 g/L SL	0.28 L/ha	Apply by ground or air.
Phorate	100 g/kg G	6.0 kg/ha	For short residual control.
		11.0–17.0 kg/ha	For extended period of control. Only use the highest rate on heavy soils when conditions favour good emergence.
	200 g/kg G	3.0 kg/ha	For short residual control
		5.5–8.5 kg/ha	NSW registration only.
Silverleaf whitefly *Bemesia tabaci* B-biotype			
Bifenthrin	100 g/L EC 250 g/L EC	0.8 L/ha 0.32 L/ha	The adult stage should be targeted. Do not spray crops with a high population of the juvenile stages. Thorough coverage of the crop canopy is essential. Do not apply more than 2 applications per crop.
Diafenthiuron	500 g/L SC	0.6 or 0.8 L/ha	Apply when population densities are 10–20% leaves infested. Suppression may not be satisfactory once population densities exceed 25% infestation, or when high numbers of adults are invading from nearby fields.
Pyriproxyfen	100 g/L EC	0.5 L/ha	Ensure thorough coverage. Apply when industry recommended thresholds are exceeded. If a second spray is required observe a two week retreatment interval. DO NOT apply more than twice in one season.

Table 11. Control of green vegetable bug, mirids and thrips

Active ingredient	Concentration and formulation	Application rate of product	Comments
Green vegetable bug *Nezara viridula*			
Dimethoate	400 g/L EC	0.34–0.5 L/ha	Apply when pests appear.
Endosulfan	350 g/L EC	2.1 L/ha	Apply at first sign of infestation. Ensure pesticide application management plan (PAMP) is completed.
Mirids (Green mirid *Creontiades dilutus* and Yellow mirid or Apple dimpling bug *Campylomma liebknechti)*			
Acetamiprid	225 g/L SC	0.1 L/ha	Apply with 0.2% Incide penetrant. Target nymphs and/or adults. On above threshold or increasing populations, suppression only may be observed.
Aldicarb	150 g/kg G	5.0 kg/ha	Apply into the seed furrow at planting.
Alpha-cypermethrin	16 g/L ULV 100 g/L EC	2.0–2.5 L/ha 0.3–0.4 L/ha	Apply at recommended threshold levels as indicated by field checks. Use the higher rate when pest pressure is high and increased residual protection is required.
Beta-cyfluthrin	25 g/L EC	0.6 L/ha	When *Helicoverpa spp.* are present follow *Helicoverpa spp.* instructions. Otherwise apply at threshold levles as determined by field checks.
Bifenthrin	100 g/L EC	0.6–0.8 L/ha	Apply at recommended threshold levels as indicated by field checks. Use the higher rate for increased pest pressure and longer residual control.
Chlorpyrifos-methyl	500 g/L EC	1.0–2.0 L/ha	Apply when pest numbers approach threshold levels.
Deltamethrin	27.5 g/L EC	0.18 L/ha	Suppression only.
Dimethoate	400 g/L EC	0.34–0.5 L/ha	Apply when pests appear.
Emamectin benzoate	17 g/L EC	0.55–0.7 L/ha	For suppression only. Apply to developing populations that are predominantly nymphs.
Fipronil	200 g/L SC	0.0625–0.125 L/ha	Apply spray to achieve thorough coverage. Use higher rate under sustained heavy pressure.

Table 11. Control of green vegetable bug, mirids and thrips (continued)

Active ingredient	Concentration and formulation	Application rate of product	Comments
Fipronil	200 g/L SC	0.0625–0.125 L/ha	Apply spray to achieve thorough coverage. Use higher rate under sustained heavy pressure.
Gamma-cyhalothrin	150 g/L CS	0.05 L/ha	Apply at recommended threshold levels as indicated by field check.
Imidacloprid	200 g/L SC	0.25 L/ha	Add Pulse penetrant at 0.2% v/v (2 mL/L water). See withholding period.
Indoxacarb	150 g/L EC	0.65 L/ha or 0.85 L/ha	Under high populations suppression only may be observed.
Lambda-cyhalothrin	250 g/L ME	0.06 L/ha	Apply at recommended threshold levels as indicated by field checks.
Omethoate	800 g/L SL	0.14–0.28 L/ha	Use high rate where population exceeds 1/m row.
Paraffinic Oil	792 g/L SL	2–5% v/v or 2–5 L/100 L of water	Apply low rate for suppression of fewer than 0.5 mirids/m. Apply high rate if population reaches threshold of 0.5 mirids/m or apply 2 successive low rate sprays not more than 7 days apart.
		1–2% or 1–2 L/100 L of water	Suppression only. Include Canopy® in tank-mix when applying any other insecticide by ground rig.
Phorate	200 g/kg G	50 g/100 m row	QLD only. Suppression only. Apply into seed furrow at planting.
Thrips (Tobacco thrip *Thrips tabaci* and Tomato thrip *Frankliniella schultzei*)			
Aldicarb	150 g/kg G	3.0–7.0 kg/ha	Apply into the seed furrow at planting.
Dimethoate	400 g/L EC	0.35–0.375 L/ha	Apply by ground rig or air. Aircraft may use double track spacing with a reliable cross wind.
Disulfoton	50 g/kg G	14.0 kg/ha	Apply in band near seed at planting.
Endosulfan	350 g/L EC	2.1 L/ha	Apply at first sign of infestation. Ensure pesticide application management plan (PAMP) is completed.
Fipronil	200 g/L SC	0.0625–0.125 L/ha	Regent will take 3–4 days to reach full effectiveness. Use higher rates under high pressure
Omethoate	800 g/L SL	0.14–0.28 L/ha	Use higher rate for longer residual control
Phorate	100 g/kg G	6.0 kg/ha	For short residual control.
		11.0–17.0 kg/ha	For extended period of control. Only use the highest rate on heavy soils when conditions favour good emergence.
	200 g/kg G	3.0 kg/ha	For short residual control
		5.5–8.5 kg/ha	NSW registration only.

Table 12. Control of *Helicoverpa* spp.

Active ingredient	Concentration and formulation	Application rate of product	*H. armigera* resistance present	Comments
Cotton bollworm, *Helicoverpa armigera*, and native budworm, *Helicoverpa punctigera*				
Abamectin	18 g/L EC	0.3 or 0.6 L/ha	No	For the control of *Helicoverpa punctigera* only. Use the higher rate alone or the lower rate with a suitable mixing partner. Do not use more than twice in one season for *H. punctigera* control.
Alpha-cypermethrin	16 g/L ULV 100 g/L EC	2.0, 2.5 or 3.0 L/ha 0.3, 0.4 or 0.5 L/ha	Yes	Use low rate for eggs or newly hatched larvae. Use higher rates for higher egg pressure or larger larvae.
Amitraz	200 g/L EC	2.0 L/ha	No	Apply as an ovicide with larvicide when eggs or very small larvae are detected. May suppress mites.
Amorphous silica	450 g/L SC	2.5–5.0 L/ha	No	Apply during egg lay to egg hatch. Best results are obtained from two sequential applications 6–7 days apart.
Bacillus thuringiensis	Btk SC	1.0–4.0 L/ha	No	Use alone or with mixtures. Refer to relevant label for details.
Beta-cyfluthrin	25 g/L EC	0.46–0.8 L/ha	Yes	Can be mixed with mineral spraying oil for ULV applications or with water for EC applications.
Bifenthrin	100 g/L EC	0.6–0.8 L/ha	No	Time spray to coincide with egg hatch. DO NOT apply to larvae > 5 cm.
Chlorpyrifos	300 g/L EC	4.0–5.0 L/ha	No	Target sprays against brown eggs and newly hatched, very small and small larvae.

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Table 12. Control of *Helicoverpa* spp. (continued)

Active ingredient	Concentration and formulation	Application rate of product	*H. armigera* resistance present	Comments
Cotton bollworm, *Helicoverpa armigera*, and native budworm, *Helicoverpa punctigera*				
Chlorpyrifos-methyl	500 g/L EC	1.0–2.0 L/ha	No	Use the lower rate at or when just exceeding threshold levels. Increase rate as numbers increase.
Cyfluthrin	50 g/L EC	0.6 L./ha or 0.8 L/ha	Yes	Application should be timed to coincide with egg hatch.
Cypermethrin	40 g/L ULV 200 g/L EC 250 g/L EC 260 g/L EC	2.0–3.25 L/ha 0.3–0.7 L/ha 0.3–0.5 L/ha 0.385–0.48 L/ha	Yes	Use high rate if *H. punctigera* larvae > 1 cm are present or *H. armigera* larvae < 5 cm are present.
Deltamethrin	5.5 g/L ULV 27.5 g/L EC	2.5–3.5 L/ha 0.5–0.7 L/ha	Yes	Use low rate as ovicide and high rates for small to medium larvae.
Emamectin benzoate	17 g/L EC	0.55–0.7 L/ha	No	Apply at or just prior to hatching. DO NOT target larvae > 5mm.
Endosulfan	350 g/L EC	2.1 L/ha	Yes	Apply at or just prior to egg hatching. Larvae larger than 7–10 mm are not readily controlled. Ensure pesticide application management plan (PAMP) is completed.
Esfenvalerate	50 g/L EC	0.5–0.7 L/ha	Yes	Use low rate when larvae are small and pressure is low.
Ethion + zeta-cypermethrin	360 g + 20 g/L EC	2.0–2.5 L/ha	Yes	Application of low rate should be timed to coincide with egg hatch and small larvae.
Gamma-cyhalothrin	150 g/L CS	0.05 L/ha 0.06 or 0.07 L/ha	Yes	Ovidicidal rate. Use low rate for newly hatched larvae.
Indoxacarb	150 g/L EC	0.65 or 0.85 L/ha	No	Use low rate for eggs and small larvae.
Lambda-cyhalothrin	250 g/L ME	0.06 L/ha, 0.07 or 0.085 L/ha	Yes	Ovicidal rate. Use low rate for newly hatched larvae.
Helicoverpa NPV	2000 M-Obs/ mL LC	0.5 L/ha	No	Alone or with compatible larvicide. See label for details. Target application to coincide with egg hatching.
Magnet		0.5L/100 m row (10–50 cm bands) in 72 m or 36 m		Use including insecticides as per label instructions
Methomyl	225 g/L SL	0.5–1.0 L/ha 1.8–2.4 L/ha	Yes	Ovicidal rate. Larvicidal rate. Higher rate of larvicidal rate may cause reddening of foliage, if excessive use an alternative. Do not apply during periods of plant stress.
Methoxyfenozide	240 g/L SC	1.7 L/ha or 2.5 L/ha	No	Apply with recommended adjuvant. Use high rate on rapidly growing crops.
Paraffinic oil	792 g/L	2% or 2L/100L of water	No	See page 22 for thresholds. Use a minimum of 80L/ haof water. Apply only by ground rig before crop closure.
Parathion methyl	500 g/L EC		Yes	Apply to larvae < 10 mm in length.
Piperonyl butoxide	800 g/L EC			Use as a synergist when applying synthetic pyrethroids. See label.
Profenofos	250 g/L EC		Yes	Ovicidal rate Larvicidal rate
			Yes	Ovicidal rate Larvicidal rate. Higher rates may injure older leaves.
Rynaxypyr (chlorantraniliprole)	350 g/kg WDG	0.090 or 0.150 g/ha + non ionic surfactant @ 125 gai/100 L	No	Target brown eggs or hatchling to 2nd instar larvae before they become entrenched in squares, flowers and bolls. Use high rate where the potential is for >3.5 larvae/m to achieve longer residual control.
Spinosad	125 g/L ULV 480 g/L SC 800 g/kg	0.6–0.8 L/ha 0.15–0.2 L/ha 90-100 g/ha	No	Maximum three sprays per season. Use low rate against light infestations. target sprays against brown eggs and newly hatched very small larvae
Thiodicarb	375 g/L SC	2.0–2.5 L/ha 0.5–1.0 L/ha	Yes	Larvicidal rate. Ovicidal rate.

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Table 13. Control of rough bollworm

Active ingredient	Concentration and formulation	Application rate of product	Comments
Rough bollworm (*Earias huegeli*) (This pest is not normally a problem where a *Helicoverpa* species control program is adopted.)			
Alpha-cypermethrin	16 g/L ULV 100 g/L EC	2.0–2.5 L/ha 0.3–0.4 L/ha	It is essential to detect and treat infestations before larvae are established or concealed in bolls deep in the canopy. Use high rate for large larvae.
Beta-cyfluthrin	25 g/L EC	0.6 or 0.8 L/ha	Application should be timed to coincide with egg hatching.
Carbaryl	500 g/L SC	2.2 L/ha	NSW only. Apply when pest appears. DO NOT use on cotton after 25% of bolls have opened.
Cypermethrin	40 g/L ULV 200 g/L EC 250 g/L EC 260 g/L EC	1.9–2.5 L/ha 0.375–0.5 L/ha 0.3–0.4 L/ha 0.29–0.385 L/ha	Rates vary. See product label for specific rates. Use highest rate when canopy is dense. Effectiveness is lower for established and concealed infestations.
Endosulfan	350 g/L EC	2.1 L/ha	Apply at or just prior to egg hatching. Ensure pesticide application management plan (PAMP) is completed.
Methoxyfenozide	240 g/L SC	1.7 L/ha or 2.5 L/ha	Apply with recommended adjuvant. Use high rate on rapidly growing crops.
Rynaxypyr (chlorantraniliprole)	350 g/kg	150 g/ha + non ionic surfactant @ 125 gai/100 L	Target brown eggs or hatchling to 2nd instar larvae before they become entrenched in terminals or bolls.

Table 14. Control of pink spotted bollworm

Active ingredient	Concentration and formulation	Application rate of products	Comments
Pink spotted bollworm (*Pectinophora scutigera*)			
Chlorpyrifos	300 g/L EC 500 g/L EC	1.75 L/ha 1.0 L/ha	QLD only. Apply when 10–15 moths are trapped on two consecutive nights to prevent infestation of bolls by larvae.
Deltamethrin	5.5 g/L ULV 27.5 g/L EC	2.5–3.0 L/ha 0.5–0.6 L/ha	QLD only. Apply at first sign of activity before larvae enter boll.
Esfenvalerate	50 g/L EC	0.4 L/ha	Central QLD only. Apply at this rate when pink spotted bollworm is only pest present.
Gamma-cyhalothrin	150 g/L CS	0.06 L/ha	QLD only. If *Helicoverpa* spp. are not present apply when more than 10 adults moths are caught in pheromone traps on 2 consecutive nights.
Lambda-cyhalothrin	250 g/L ME	0.07 L/ha	As above

Table 15. Control of mites

Active ingredient	Concentration and formulation	Application rate of product	Comments
Mite (*Tetranychus*) species			
Abamectin	18 g/L EC	0.3 L/ha	Best results will be obtained when applied to low mite populations. Do not use more than twice in one season.
Aldicarb	150 g/kg G	3.0–7.0 kg/ha	Apply into the seed furrow at sowing.
Amitraz	200 g/L EC	2.0 L/ha	Suppression when used for controlling *Helicoverpa*
Bifenthrin	100 g/L EC	0.6–0.8 L/ha	Applications against *Helicoverpa* spp. will give good control of low mite populations.
Chlorpyrifos	300 g/L EC	1.0–1.5 L/ha	Mix with pyrethroids as a preventative spray to minimise buildup of mite populations.
		2.5 L/ha	For established mite populations.
Diafenthiuron	500 g/L SC	0.6 or 0.8 L/ha	Treatment at higher infestation levels may lead to unsatisfactory results.
Dicofol	240 g/L EC	4.0 L/ha	NSW registration only. Apply by ground rig at first appearance of mites before row closure.
Dimethoate	400 g/L EC	0.34–0.5 L/ha	Will not control organophosphate-resistant mites.
Disulfoton	50 g/kg G	14.0 kg/ha	Apply in a band near seed at planting.
Emamectin benzoate	17 g/L EC	0.55–0.7 L/ha	When applied for *Helicoverpa* control will reduce the rate of mite population development. Suppression only.
Etoxazole	110 g/L SC	0.35 L/ha	Apply by ground rig only. Best results when used on low to increasing populations.
Methidathion	400 g/L EC	1.4 L/ha	Knockdown and short residual control.
Phorate	100 g/kg G	6.0 kg/ha	For short residual control.
		11.0–17.0 kg/ha	For extended period of control. Only use the highest rate on heavy soils when conditions favour good emergence.
	200 g/kg G	3.0 kg/ha	For short residual control.
		5.5–8.5 kg/ha	NSW registration only.
Profenofos	250 g/L EC	1.0–2.0 L/ha	Use low rate to suppress build up. Use high rate if aphids present.
	500 g/L EC	0.5–1.0 L/ha	
Propargite	600 g/L EC	2.5 L/ha	Apply as spray before mite infestations reach damaging levels.

Table 16. Insecticide trade names and marketers – Registered chemicals as at 15 Oct 2009

Active ingredient	Chemical group	Insecticide group	Concentration and formulation	Trade name	Marketed by
Abamectin	avermectin	6A	18 g/L EC	ABA 18	Genfarm
			18 g/L EC	Abachem	ChemAg
			18 g/L EC	Abamect	Nufarm
			18 g/L EC	Abamectin	eChem
			18 g/L EC	Abamectin	Accensi
			18 g/L EC	Abamectin	4Farmers
			18 g/L EC	Abamectin	Chemtura
			18 g/L EC	Agrimec	Syngenta
			18 g/L EC	Biomectin	Jurox
			18 g/L EC	Gremlin	Sipcam
			18 g/L EC	Kill-a-mite	Sevroc
			18 g/L EC	Romectin	Rotam Australasia
			18 g/L EC	Romite	Rotam Limited
			18 g/L EC	Stealth	PCT Holdings
			18 g/L EC	Vantal 18 EW	Ospray
			18 g/L EC	Wizard 18	Farmoz
Acetamiprid	chloronicotinyl	4A	225 g/L SL	Intruder	Du Pont
Aldicarb	carbamate	1A	150 g/kg G	Temik 150G	Bayer CropScience
Alpha-cypermethrin	pyrethroid	3A	16 g/L ULV	Alpha-Scud ULV	Farmoz
			16 g/L ULV	Dictate ULV	ChemAg
			16 g/L ULV/EC	Fastac Duo ULV	Nufarm
			16 g/L ULV	Dominex 16 ULV	FMC Australasia
			16 g/L ULV	Alpha-cyp ULV	eChem
			100 g/L EC	Alpha 100	Conquest
			100 g/L EC	Alpha 100	Innova
			100 g/L EC	Alpha-Cyp 100 DUO	eChem
			100 g/L EC	Alpha-cyper	Tradelands
			100 g/L EC	Alpha-Cypermethrin 100	4Farmers
			100 g/L EC	Alpha-Cypermethrin 100	Accensi
			100 g/L EC	Alpha-Cypermethrin 100	Chemforce
			100 g/L EC	Alpha-Cypermethrin 100	Halley
			100 g/L EC	Alpha-Cypermethrin 100	Ospray
			100 g/L EC	Alpha-Cypermethrin 100	Titan
			100 g/L EC	Alpha DuoAlpha Duo	Genfarm
			100 g/L EC	Alpha Duop 100	Grow Choice
			100 g/L EC	Alpha-Scud Elite	Farmoz
			100 g/L EC	Alphasip Duo	Sipcam
			100 g/L EC	Astound Duo	Nufarm
			100 g/L EC	Biotis Alpha 100	Biotis Life Science
			100 g/L EC	Buzzard	PCT International
			100 g/L EC	Centaur 100	Genfarm
			100 g/L EC	Dictate 100	ChemAg
			100 g/L EC	Dictate Duo 100	ChemAg
			100 g/L EC	Dominex Duo	Crop Care
			100 g/L EC	Dominex Duo	FMC
			100 g/L EC	G. valley Alpha-Cypermethrin 100	Grassvalley
			100 g/L EC	Fastac Duo	forrmulations
			100 g/L EC	Ken-Tac 100	Nufarm
			100 g/L EC	Unialphacyper	Kenso AgCare
					United Farmers Co-op
Amitraz	triazapentadiene	19A	200 g/L EC	Amitraz 200 EC/ULV	ChemAg
			200 g/L EC	Amitraz 200 EC/ULV	Jurox
			200 g/L EC	Amitraz EC/ULV	eChem
			200 g/L EC	Amitraz Elite EC/ULV	Farmoz
			200 g/L EC	Amitraz Duo	Genfarm Crop Protection
			200 g/L EC	Hitraz 200 EC/ULV	Rotam
			200 g/L EC	Mitra 200 EC/ULV	United Phosphorus
			200 g/L EC	Opal Duo	Nufarm
			200 g/L EC	Ovasyn Options	Arysta Lifescience
			200 g/L EC	Rotaz 200 EC/ULV	Rotam Australasia
Amorphous silica	not a member of any chemical group		450 g/L SC	Abrade Abrasive Barrier	Grow Choice
Bacillus thuringiensis	Bt microbials	11C	Btk* HD1** SC	Dipel SC	Valent BioSciences, Sumitomo Chemicals
Betacyfluthrin	pyrethroid	3A	25 g/L EC	Bulldock Duo	Bayer CropScience

* *Bacillus thuringiensis* subspecies KURSTAKI. ** Strain type.

Table 16. Insecticide trade names and marketers (continued)

Active ingredient	Chemical group	Insecticide group	Concentration and formulation	Trade name	Marketed by
Bifenthrin	pyrethroid	3A	100 g/L EC	Agfen 100 EC	Agriwest
			100 g/L EC	Arrow 100 EC	Conquest
			100 g/L EC	Bifen 100	ChemAg
			100 g/L EC	BiFendoff 100	Grow Choice
			100 g/L EC	Bifenthrin	4 Farmers
			100 g/L EC	Bifenthrin 100	Genfarm
			100 g/L EC	Bifenthrin 100	United Farmers Co-op
			100 g/L EC	Bifenthrin 100 EC	Accensi
			100 g/L EC	Bifenthrin 100 EC	Ospray
			100 g/L EC	Disect 100 EC	UPL
			100 g/L EC	Sarritor	Nuchem
			100 g/L EC	Tal-Ken 100	Kenso Agcare
			100 g/L EC	Talstar 100 EC	Crop Care
			100 g/L EC	Venom 100	Farmoz
			100 g/L EC	Webzone	Webcot
			250 g/L EC	Talstar 250 EC	Crop Care
Carbaryl	carbamate	1A	500 g/L SC	Bugmaster Flowable	Bayer CropScience
Chlorpyrifos	organophosphate	1B	300 g/L EC	Instinct 300	Farmoz
			300 g/L EC	Kensban 300 Duo	Kenso AgCare
			300 g/L EC	Prowler 300	ChemAg
			500 g/L EC	Chlorpyrifos 500	4Farmers
			500 g/L EC	Chlorpyrifos 500	Accensi
			500 g/L EC	Chlorpyrifos 500	Agspray
			500 g/L EC	Chlorpyrifos 500	ChemAg
			500 g/L EC	Chlorpyrifos 500	Chemforce
			500 g/L EC	Chlorpyrifos 500	Conquest
			500 g/L EC	Chlorpyrifos 500	David Grays
			500 g/L EC	Chlorpyrifos 500	Genfarm
			500 g/L EC	Chlorpyrifos 500	Halley
			500 g/L EC	Chlorpyrifos 500	Titan
			500 g/L EC	Chlorpyrifos 500	United Farmers Co-op
			500 g/L EC	Chlorpyrifos 500 EC	Nufarm
			500 g/L EC	Chlorpyrifos 500 EC	WSD
			500 g/L EC	Cyren 500	Ospray
			500 g/L EC	Fortune 500	PCT International
			500 g/L EC	Generifos	Grow Choice
			500 g/L EC	Kensban 500	Kenso Corporation
			500 g/L EC	Lorsban 500	Dow AgroSciences
			500 g/L EC	Strike-out 500 EC	Farmoz
Chlorpyrifos-methyl	organophosphate	1B	500 g/L EC	Diplomat	ChemAg
Cypermethrin	pyrethroid	3A	40 g/L ULV	Cypershield ULV 40	ChemAg
			40 g/L ULV	Scud 40 ULV	Farmoz
			200g/L ULV	Boom 200	Genfarm
			200 g/L EC	Cypermethrin 200	Halley
			200 g/L EC	Cypermethrin 200	Titan
			200 g/L EC	Cypermethrin 200 EC	WSD
			200 g/L EC	Cypermethrin 200 EC	United Farmers Co-op
			200 g/L EC	Cypershield 200	ChemAg
			200 g/L EC	Ken-Cyper 200	Kenso AgCare
			200 g/L EC	Scud Elite	Farmoz
			200 g/L EC	Sonic 200 EC	Nufarm
			250 g/L EC	Cyper 250 Plus	Genfarm
			250 g/L EC	Cypermethrin 250	Conquest
			250 g/L EC	Cyrux 250 EC	United Phosphorus
			260 g/L EC	Cypermethrin 260 EC	4Farmers
Deltamethrin	pyrethroid	3A	5.5 g/L ULV	Ballistic ULV	Farmoz
			5.5 g/L ULV	Deltaguard ULV	PCT International
			27.5 g/L EC	Ballistic Elite	Farmoz
			27.5 g/L EC	D-Sect	PCT International
			27.5 g/L EC	Decis Options	Bayer CropScience
			27.5 g/L EC	Delta Duo	ChemAg
			27.5 g/L EC	Deltamethrin Duo	Halley
			27.5 g/L EC	Deltashield 27.5	ChemAg
Diafenthiuron	thiourea	12B	500 g/L SC	Pegasus	Syngenta
Dicofol	organochlorine	2B	240 g/L EC	Miti-Fol EC	Farmoz

Table 16. Insecticide trade names and marketers (continued)

Active ingredient	Chemical group	Insecticide group	Concentration and formulation	Trade name	Marketed by
Dimethoate	organophosphate	1B	400 g/L EC	Danadim	Ospray
			400 g/L EC	Dimethoate	ChemAg
			400 g/L EC	Dimethoate	Nufarm
			400 g/L EC	Dimethoate 400	4Farmers
			400 g/L EC	Dimethoate 400	Conquest
			400 g/L EC	Dimethoate 400	Farmoz
			400 g/L EC	Dimethoate 400	Halley
			400 g/L EC	Dimethoate 400	Gemax
			400 g/L EC	Dimethoate 400	Superway
			400 g/L EC	Dimethoate 400	Titan
			400 g/L EC	Rogor	Sipcam
			400 g/L EC	Saboteur	Crop Care
			400 g/L EC	Stalk	PCT Holdings
			400 g/L EC	Unidime 400	United Farmers Co-op
Disulfoton	organophosphate	1B	50 g/kg G	Disulfoton 50	David Grays
Emamectin benzoate	avermectin	6A	17 g/L EC	Affirm	Syngenta
Endosulfan	organochlorine	2A	350 g/L EC	Endosan	Crop Care
			350 g/L EC	Endosulfan 350 EC	Farmoz
			350 g/L EC	Endosulfan 350 EC	Nufarm
			350 g/L EC	Thiodan EC	Bayer CropScience
Esfenvalerate	pyrethroid	3A	50 g/L EC	Sumi-Alpha Flex	Sumitomo Chemicals
Ethion + zeta-cypermethrin	organophosphate + pyrethroid	1B + 3A	360 g/L + 20 g/L EC	Mustang	Crop Care, FMC
Etoxazole		10A	110 g/L SC	ParaMite	Sumitomo Chemicals
Fipronil	phenyl pyrazole	2C	200 g/L SC	Regent	Nufarm
Gamma-cyhalothrin	pyrethroid	3A	150 g/L CS	Trojan	Dow AgroSciences
				Trojan	Ospray
Helicoverpa NPV	nuclear polyhedrosis virus		2 x 10^9 PIB/mL* LC	Vivus	Ag Biotech
			5 x 10^9 PIB/mL** LC	Vivus Max	Ag Biotech
			2 x 10^9 PIB/mL*** LC	Vivus Gold	Ag Biotech
Imidacloprid	chloronicotinyl	4A	200 g/L AC	Annihilate	ChemAg
			200 g/L SC	Confidor 200 SC	Bayer CropScience
			200 g/L SC	Couraze 200 SC	Ospray
			200 g/L SC	Imidacloprid 200 SC	Genfarm
			200 g/L SC	Kohinor 200	Farmoz
			200 g/L SC	Nuprid 200SC	Nufarm
			200 g/L SC	Savage 200	Kenso
			200 g/L SC	Senator 200 SC	Agcare Crop Care
			200 g/L SC	Surefire Spectrum 200SC	PCT Holdings
Indoxacarb	oxadiazine	22A	150 g/L EC	Steward	Dupont
Lambda-cyhalothrin	pyrethroid	3A	250 g/L ME	Karate Zeon	Syngenta
			250 g/L ME	Kung Fu 250	ChemAg
			250 g/L ME	Matador Zeon	Crop Care
Methidathion	organophosphate	1B	400 g/L EC	Supracide 400	Syngenta
			400 g/L EC	Suprathion 400 EC	Farmoz
Methomyl	carbamate	1A	225 g/L EC	Electra 225	Farmoz
			225 g/L AC	Marlin	Dupont
			225 g/L AC	Methomyl 225	Ospray
			225 g/L AC	Sinmas	Sinon Australia
			225 g/L LC	Lannate L	Pinhead
			225 g/L LC	metholmyl 225	Crop Care
			225 g/L SC	Seneca	Ronic International
			225 g/L SL	Nudrin 225	Crop Care
Methoxyfenozide	benzoic acid, hydrazide	16A	240 g/L SC	Prodigy	Dow AgroSciences

Table 16. Insecticide trade names and marketers (continued)

Active ingredient	Chemical group	Insecticide group	Concentration and formulation	Trade name	Marketed by
Omethoate	organophosphate	1B	800 g/L SL	Folimat 800	Ayrsta Lifescience
			800 g/L SL	Sentinel 800	ChemAg
Paraffinic oil	petroleum spray oil (PSO)		792 g/L EC	Canopy	Caltex
Parathion-methyl	organophosphate	1B	500 g/L EC	Methyl Parathion 500	Crop Care
			500 g/L EC	Parathion-Methyl 500	Farmoz
			500 g/L EC	Parashoot 500 EC	Ospray
			450 g/L ME	Parashoot CS	Ospray
Phorate	organophosphate	1B	100 g/kg G	Thiamet 100	Nufarm
			100 g/kg G	Thiamet 100	BASF
			100 g/kg G	Umet 100G	UPL
			200 g/kg G	Thiamet 200G	Nufarm
			200 g/kg G	Thiamet 200G	Barmac
			200 g/kg G	Zeemet 200G	UPL
Piperonyl butoxide	synergist	synergist	800 g/L EC	Enervate	Nufarm
			800 g/L EC	PBO 800 EC	Farmoz
			800 g/L EC	Puppet	Imtrade
			800 g/L EC	Synergy	Crop Care
Pirimicarb	carbamate	1A	500 g/kg WDG	Aphidex WG	Farmoz
			500 g/kg WDG	Atlas WDG	Titan
			500 g/kg WDG	Pirimor WG	Syngenta
			500 g/kg WDG	Pirimicarb 500	Ospray
			500 g/kk WDG	Pirimicarb 500 WG	ChemAg
			500 g/kg WP	Pirimicard 500 WP	4Farmers
Pirimicarb	carbamate	1A	500 g/kg WDG	Aphidex WG	Farmoz
			500 g/kg WDG	Atlas WDG	Titan
			500 g/kg WDG	Pirimor WG	Syngenta
			500 g/kg WDG	Pirimicarb 500	Ospray
			500 g/kk WDG	Pirimicarb 500 WG	ChemAg
			500 g/kg WP	Pirimicard 500 WP	4Farmers
Profenofos	organophosphate	1B	250 g/L EC/ULV	Prochem Duo 250	ChemAg
			500 g/L EC/ULV	Prochem Elite 500	Imtrade
Propargite	sulfite ester	14A	600 g/L EC	Bullet	Crop Care
			600 g/L EC	Comite	Chemtura Australia
			600 g/L EC	Dyna-Mite 600	Farmoz
			600 g/L EC	Mitigate	United Phosphorous
			600 g/L EC	Treble	Nufarm
Pymetrozine	pymetrozine	9A	500 g/kg WDG	Fulfill	Syngenta
Pyriproxyfen	juvenile hormone mimic	7C	100 g/L EC	Admiral	Sumitomo
Rynaxypyr (chlorantraniliprole)	oxadiazine	22A	350 g/kg	Altacor	Dupont
Spinosad	spinosyn	5A	125 g/L ULV	Tracer II	Dow AgroSciences
			480 g/L SC	Tracer	Dow AgroSciences
			800 g/L WP	Entrust	Dow AgroSciences
Thiodicarb	carbamate	1A	375 g/L SC	Larvin 375	Bayer CropScience
			375 g/L SC	Showdown 375	Farmoz
			800 g/kg WDG	Confront 800 WG	Imtrade
			800 g/kg WDG	Larvin 800 WG	Bayer CropScience

* contains 2 x 10^9 polyhedral occlusion bodies of the NPV of *Helicoverpa armigera*.
** contains 5 x 10^9 polyhedral occlusion bodies of the NPV of *Helicoverpa armigera*.
*** contains 2 x 10^9 polyhedral occlusion bodies of the NPV of *Helicoverpa armigera* with a minimum of 50% native isolate and 50% vivus isolate.

Use of beneficial insect attractants (food sprays) and spray additives

The application of food sprays in cotton crops enables beneficial insects (particularly predators) to be attracted retained and conserved in the crop. Food sprays cannot manage cotton pests alone but combined with other IPM compatible tools they can help manage cotton pests and minimise synthetic insecticide use without sacrificing yield.

There are two type of food spray. The yeast based food spray attract beneficial insects while the sugar based food spray help retain beneficials that are already present. For more information on the use of food sprays see page 37.

Table 17. Food sprays and spray additives

Active ingredient	Concentration and formulation	Application rate of product	Comments
Food concentrate (yeast based) sucrose, lactose, alkyl aryl sulfonate, sodium ligno sulfate	WP	2.5 kg/ha	Beneficial insect attractant. Apply prior to increase of pests. See labels of each product for notes on spray coverage.
Food flavouring (sugar based)	265 g/L WP	0.25 L/ha 0.5 L/ha	Ground application Aerial application Spray additive to improve acceptance of insecticides by pests. Encourages feeding of stomach ingested insecticides.

Table 18. Food sprays and spray additives trade names and marketers

Active ingredient	Concentration and formulation	Trade names	Marketed by
Food concentrate		Predfeed	Growth Agriculture
Food flavouring	265 g/L	Mobait	Nufarm (Agnova Technologies)