Key insects and mite pests of Australian cotton

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This chapter is presented as a guide to assist growers in planning their Integrated Pest Management (IPM) programs. This section provides specific management information for each of the key insect and mite pests of Australian cotton. For each pest, information is provided under the sub-headings of:

- Damage symptoms
- Sampling
- Thresholds
- Key beneficial insects
- Selecting an insecticide/miticide
- Resistance status
- Overwintering habits
- Alternative hosts

Damage symptoms indicate that a pest could be influencing crop development and possibly yield potential. In some instances, damage symptoms will be observed without the pest. This may mean that the pest is there but cannot be observed or that the pest has caused the damage but since left the crop. In other instances, the pest will be observed but there will be no symptoms of damage to the crop. Knowledge of the pests and beneficials present and crop damage should be used in combination to make pest management decisions.

Sampling is the process of collecting the day-to-day information on pest and beneficial abundance and crop damage that is used to make pest management decisions.

Thresholds provide a rational basis for making decisions and are a means of keeping decisions consistent. Knowing the key beneficial predators and parasitoids for each pest is important for developing confidence in IPM approaches to pest management.

Selecting an insecticide (or miticide) can be a complex decision based on trade offs between preventing pest damage and conserving beneficials, or reducing one pest but risking the outbreak of another.

All pests have survival strategies that allow them to live and breed in cotton farming systems. Understanding how pests can survive, including knowing their **resistance status** and risks, **overwintering habit** and **alternative hosts** can help with good decision making for the long term.

Information in this section links to a number of tables in the Guide.

Registration of a pesticide is not a recommendation 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.

Growers must also ensure that their insecticide program fits in with the Insecticide Resistance Management Strategy (see pages 59–67). Insecticides can be a costly part of cotton production. Ensure that industry thresholds (pages 39–40) are followed to prevent unnecessary spraying.

Important – avoid spray drift

For legal requirements and best practice information on reducing spray drift, refer to the Spray Application chapter pages 142–158. Carefully follow all label directions.

ABBREVIATIONS USED IN TABLES 1–18

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

INSECT PEST	MANAGEMENT AND REGISTERED CHEMICALS
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IMPORTANT – Use an integrated approach to pest management. For more information on Integrated Pest Management Guidelines for Australian cotton refer to Page 47.

TABLE 1: Seasonal activity plan for IPM

	Overwinter/Planning	Planting – first flower	Flower – first open boll	Open cotton – Harvest
Develop an IPM strategy	Set and communicate IPM Goals Develop and Communicate CHAMP	Good record keeping support CHAMP, regulatory requirements and allows end of season assessment of IPM strategy.		
Know your enemy	Do you have your IPM resources? (ID guides, CPMG, CPM).	Participate in IPM training, field days, or workshops; Contact RDO to join mailing list.		
Take a year around approach	Review the success of last year's approach. Plan ahead to ensure necessary resources and insecticides are available. Monitor winter crops for pests and beneficials – manage carefully to avoid disrupting beneficial populations that may later move to cotton.	Build Beneficials. Check other crops for pests and beneficials. Maintain native vegetation in good condition. Consider planting Lucerne strips. Consider the summer cropping plan and risks of pests moving between crops. Check fallow areas for weeds and pests.	Sample pest and beneficial populations in all crops on the farm. Maintain native vegetation. Begin planning for rotation crops. Check fallow areas for weeds and pests.	Reduce pests / resistance risks for next season by considering which rotation crops will be planted and where. Ensure that native vegetation is maintained. Check fallow areas for weeds and pests.
Think of the farm and surrounding vegetation as a whole system.	Enhance vegetation by: Managing for groundcover and diversity; Prioritise connectivity; Enhance habitat with water ways; and, Weed out pest hosts, especially volunteer cotton. Consider rotation crops (type, location, and potential to host pests and disease). Apply IPM to all crops.	Participate in Area wide Management (AWM). Establish and maintain communication with any apiarist in the region. Use best practice spray application to avoid spray drift. Apply IPM to all crops.	Participate in Area wide Management (AWM). Maintain communication with any apiarist in the region. Use best practice spray application to avoid spray drift. Apply IPM to all crops	Participate in Area wide Management (AWM). Maintain communication with any apiarist in the region. Carefully consider Winter rotation crops (type, location, and potential to host pests and disease). Apply IPM to all crops.
Have good on-farm hygiene.	Zero tolerance to volunteer cotton in rotation crops, fallows and non-field areas. Keep farm weed free over winter. Ensure host free period for pests and diseases. Where practical remove weeds from native vegetation areas.	Keep farm weed free. Zero tolerance to volunteer cotton. Consider pre-irrigation, to allow control of cotton volunteers and other weeds with non-glyphosate control prior to planting. Consider in-crop cultivation where necessary.	Continue to monitor and manage volunteer cotton including adjacent to fields, as well as non-field areas such as fencelines, channels, perennial vegetation and pastures. Consider chipping where necessary.	Conduct effective crop removal to prevent ratoons.
Consider options to escape, avoid or reduce pests.	When planning cotton, consider proximity to sensitive areas, and other host crops relative to prevailing winds, as well as how beneficials move through the landscape. Select a variety that suits the region's season length. Consider okra leaf shape. Plant spring chickpea trap crop. Consider growing a diverse habitat and manage areas of vegetation to encourage beneficials. Plant lucerne (strips or block) in autumn. If planning to release Trichogramma, plan to sow other crops (eg sorghum) that will host Helicoverpa for the wasps to sting and hence maintain populations	Monitor stubble load and assess risk of soil and other pest activity prior to planting, and decide on control options. Good seed bed preparation, optimum soil temps and variety with seedling vigour promote rapid and healthy seedlings that can outgrow damage. Avoid planting to reduce SLW influx risk. Consider summer trap crop. Cultivate chickpea trap crops by 30 September. Build beneficials through use of pest and damage threshold and careful insecticide choice. Consider food sprays or release of beneficial insects.	Optimise crop inputs to avoid particularly rank or stressed crops. Sample for beneficials and parasitism rates. Build beneficials through use of pest and damage threshold relevant to sampling technique, and careful insecticide choice. Food sprays or release of beneficial insects may be considered.	Slash and pupae bust last generation summer trap crop 2-4 weeks after last defoliation. Pupae busting is required following harvest of Bollgard II cotton and is recommended by the industry's IRMS for all cotton. Come Clean Go Clean to prevent spread of pests on, off and around farm.
Sample crops effectively and regularly.	Ensure you can identify key pests, beneficials and types of plant damage.	Sample for pests, beneficials and parasitism rates in cotton. Monitor early season damage. Track pest trends. Use pest thresholds and the predator to pest ratio.	Sample for pests, beneficials and parasitism rates. Track pest trends and incorporate parasitism into spray decisions. Monitor fruit load. Use pest thresholds and the predator to pest ratio.	Sample for pests, beneficials and parasitism rates in cotton as well as last generation trap crop. Monitor fruit load. Use pest thresholds and the predator to pest ratio.

TABLE 1: Seasonal activity plan for IPM (continued)

	Overwinter/Planning	Planting – first flower	Flower – first open boll	Open cotton – Harvest
Grow a healthy crop	Consider the best rotation crop for your situation. Test soil nutrient status to determine fertiliser requirements for cotton crop. Consider potential disease risks.	Good seed bed preparation, optimum soil temps and variety with seedling vigour promote rapid and healthy seedlings that can outgrow damage. Monitor for leaf loss or discoloration; tip damage; development of first squaring position.	Monitor first position retention, fruit retention, nodes above white flower and vegetative growth.	Monitor for leaf damage/ discolouration, fruit retention, nodes above whiteflower, vegetative growth and for honeydew. Manage nutrition and irragtion to avoid or reduce regrowth that may harbor pests.
Evaluate pest abundance against established thresholds	Monitor weeds. Use thresholds and careful spray selection for all crops.	Use pest and damage threshold, relevant to region, timing and sampling method, and consider parasitism and beneficial activity	Use pest and damage threshold, relevant to region, timing and sampling method, and consider parasitism and beneficial activity	Use pest and damage threshold, relevant to region, timing and sampling method, and consider parasitism and beneficial activity. Monitor for honeydew.
Choose insecticides wisely to conserve beneficials	Monitor weeds Use thresholds and careful spray selection for all crops.	Consider insecticide selectivity and impact on beneficials and bees. Avoid early season use of broad-spectrum (eg.OPs) sprays. Consider edge or patch spraying for aphids and mites. Avoid prophylactic sprays.	Consider insecticide selectivity and impact on beneficials and bees.	Defoliation may be a late season alternative to an insecticide.
Apply good resistance management principles.	Complete pupae busting. Zero tolerance of ratoon and volunteer cotton including in rotation crops, fallows and non-field areas.	For Bollgard II, adhere to refuge requirements and planting window. For all cotton crops follow IRMS for every spray. Consider choice of at-planting / seed dressings and implications for later sprays. If a phorate is used at planting instead of a neonicotinoid seed dressing then do not use pirimicarb or dimethoate/ omethoate.	Use thresholds and follow IRMS for every spray. Manage Bollgard refuge for attractiveness.	Pupae busting is required following harvest of Bollgard II cotton and is recommended by the industry's IRMS for all cotton. In CQ slash and pupae bust summer trap crop 2–4 weeks after last defoliation.

TABLE 2: Impact of insecticides at planting or as seed treatments on key beneficial groups in cotton

		Main target pest(s)							Beneficial group				
Insecticides	**Rate (g ai/ha)**	**WW**	**Mite**	**Mir.**	**Aph.**	**Th[5]**	**Persistence[6]**	**Overall[7]**	**Predatory beetles[1]**	**Predatory bugs[2]**	**Spiders**	**Wasps and Ants**	**Thrips**
At Planting													
Aldicarb	450		✓	✓	✓	✓	medium-long	very low[3]	v. low	v. low	v. low	v. low	v. high
Phorate	600	✓	✓	✓	✓	✓	medium-long	very low[3,4]	No data	No data	No data	No data	v. high
Carbosulfan	750–1000	✓		✓		✓	medium-long	very low[3,4]	No data	No data	No data	No data	v. high
Chlorpyrifos	250–750	✓					medium	very low[4]	No data	No data	No data	No data	No data
Seed Treatments													
Thiodicarb	500 g ai/100 kg seed					✓	short	very low[3]	v. low	v. low	v. low	v. low	high
Thiodicarb + Fipronil	259 + 12 g ai/ 100 kg seed	✓				✓	short-medium	very low[3,4]	No data	No data	No data	No data	high
Imidacloprid	525 g ai/100 kg seed	✓			✓	✓	medium	very low[3]	v. low	v. low	v. low	v. low	v. high
Imidacloprid	700 g ai/100 kg seed	✓			✓	✓	medium	very low[3,4]	v. low	v. low	v. low	v. low	v. high
Thiomethoxam	280 g ai/100 kg seed	✓			✓	✓	medium	very low[3,4]	No data	No data	No data	No data	v. high

1. Predatory beetles – ladybeetles, red and blue beetles, other predatory beetles.
2. Predatory bugs – big-eyed bugs, minute pirate bugs, brown smudge bugs, glossy shield bug, predatory shield bug, damsel bug, assassin bug, apple dimpling bug.
3. Except for effects on thrips which are predators of mites. Note that aldicarb and phorate will also control mites.
4. Based on observations with other soil or seed applied insecticides.
5. WW, wireworm; Mir., mirids; Aph., aphids; Th, thrips.
6. Persistance; short, 2–3 weeks; medium, 3–4 weeks; long, 4–6 weeks.
7. Impact rating (% reduction in beneficials following application); very low, less than 10%; low, 10–20%; moderate, 20–40%; high, 40–60%; very high, > 60%

TABLE 3: Impact of insecticides and miticides on predators, parasitoids and bees in cotton

Insecticides (in increasing rank order of impact on beneficials)	Rate (g ai/ha)	Target pest(s)							Beneficials																	Pest resurgence [12]			
										Predatory beetles				Predatory bugs							Hymenoptera								
		Helicoverpa	Mites	Mirids	Aphids	Thrips	Silverleaf whitefly	Persistence[8]	Overall Ranking[10]	Total[1]	Red & Blue beetle	Minute 2-spotted lady beetle	Other lady beetles	Total[2]	Damsel bugs	Big-eyed Bugs	Other Predatory bugs	Apple Dimpling	Lacewing adults	Spiders	Total (wasps)	Eretmocerus[19]	Trichogramma	Ants	Thrips	Mite	Aphid	Helicoverpa	Toxicity to bees[14]
Bt[11]		√						very short	very low	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	—	—	—	VL
NP Virus		√						very short	very low	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	—	—	—	VL
Pirimicarb	250				√			short	very low	VL	VL	VL	VL	L	L	M	VL	VL	VL	VL	VL	M	M	VL	L	—	—	—	VL
PSO (Canopy)[16]	2%	√			√			short	very low	VL	L	L	VL	VL	VL	VL	VL	VL	VL	L	VL	—	VL	H	VL	—	—	—	VL
Methoxyfenozide	400	√						medium-long	very low	L	VL	VL	L	L	L	L	VL	VL	VL	VL	VL	—	VL	VL	VL	—	—	—	VL
Pyriproxyfen	50						√	long	very low	M	—	M	M	VL	—	—	—	—	L	VL	VL	L	VL	VL	VL	—	—	—	L
Etoxazole	38.5		√					short	low	VL	VL	—	L	VL	VL	VL	VL	VL	VL	M	L	—	VL	VL	L	—	—	—	VL
Indoxacarb (low)	60			√				medium	low	L	L	H	M	VL	L	—	L	H	M	VL	VL	—	VL	H	VL	—	+ve	—	—
Indoxacarb (low+salt)	60			√				medium	low	L	L	H	M	VL	L	—	L	H	M	VL	L	—	VL	H	VL	—	—	—	—
Indoxacarb (low+Canopy)	60			√				medium	low	L	L	H	M	VL	L	—	L	H	M	VL	L	—	VL	H	VL	—	+ve	—	—
Rynaxypyr	52.5	√						long	low	L	M	M	L	VL	VL	VL	L	VL	VH	VL	L	—	L	L	VL	—	+ve	—	—
Dicofol[3]	960		√					long	low	L	—	—	—	L	—	—	—	L	—	L	—	M	—	—	VL	—	—	—	VL
Amorphous silica[17]	2500	√						short	low	L	L	—	M	M	—	VL	—	L	L	L	L	—	—	M	VL	—	—	—	—
Spinosad	96	√						medium	low	VL	M	L	VL	M	L	H	VL	L	VL	VL	M	H	H	H	H	+ve	—	—	H[15]
Diafenthiuron	350		√		√		√	medium	low	M	H	VL	M	L	M	VL	L	H	VL	L	L	H	VL	H	L	—	—	+ve	M
Pymetrozine	150				√			short	low	M	M	M	M	L	L	L	VL	H	M	L	L	L	L	M	VL	—	—	—	VL
Fipronil (v. low)	8			√				medium	low	L	L	L	VL	L	M	—	L	M	L	M	L	—	—	VH	L	+ve	—	—	VH
Fipronil (v. low + salt)	8			√				medium	low	L	L	L	VL	L	M	—	L	M	L	M	L	—	—	VH	L	+ve	+ve	+ve	VH
Indoxacarb[13]	127.5	√		√				medium	low	H[14]	L	VH	VH	L	M	L	L	VH	M	VL	L	—	VL	VH	VL	—	+ve	—	H[15]
Spirotetramat	96				√		√	medium	moderate	M	L	H	H	VL	VL	VL	VL	M	VH	M	M	—	M	M	M	—	—	—	—
Abamectin	5.4	√[6]	√					medium	moderate	L	M	H	VL	M	L	M	M	H	VL	M	M	H	M	H	M	—	—	—	H
Emamectin	8.4	√						medium	moderate	L	VL	M	VL	H	H	H	H	H	L	M	M	—	M	VL	M	—	—	—	H
Dimethoate (low)	80		√[18]	√	√[18]	√		short	moderate	M	L	H	H	M	L	—	H	M	M	L	M	—	M	H	M	+ve	+ve	+ve	H
Dimethoate (low + salt)	80		√[18]	√	√[18]	√		short	moderate	M	L	H	H	M	L	—	H	M	M	L	M	—	M	H	M	+ve	+ve	+ve	H
Propargite	1500		√					medium	moderate	M	H	H	M	M	H	VL	VL	L	VL	M	M	L	H	H	M	—	+ve	+ve	L

Acetamiprid	22.5				√			medium	moderate	M	M	VH	H	M	M	H	M	VH	L	VL	L	VH	H	VH	VH	—	—	—	M[15]
Clothianidin (low)	25			√				medium	moderate	M	VL	—	H	L	M	VL	VL	H	H	M	M	H	M	VH	VL	—	—	+ve	—
Amitraz	400	√	√[9]		√[9]			medium	moderate	H	M	VH	H	L	—	—	—	H	VL	M	M	H	L	H	M	—	—	—	L
Fipronil (low)	12.5			√		√		medium	moderate	L	L	H	L	L	H	L	L	VH	L	M	M	—	M	VH	VH	+ve	+ve	+ve	VH
Chlorfenapyr (low)	200	√	√					medium	moderate	M	L	VH	VL	M	VL	H	H	VH	L	L	M	—	VH	H	M	—	—	—	H
Thiamethoxam	100				√			medium	moderate	H	H	H	H	M	M	M	H	H	M	VL	M	—	H	VH	H	+ve	—	+ve	H
Fipronil (high)	25			√		√		medium	moderate	L	VL	H	L	M	H	H	L	VH	L	M	M	—	M	VH	VH	+ve	—	+ve	VH
Imidacloprid	49			√	√			medium	moderate	H	L	VH	H	H	M	H	L	VH	L	L	L	VH	M	H	H	+ve	—	+ve	M
Clothianidin (high)	50			√				medium	moderate	H	VL	—	VH	M	M	L	VL	H	H	M	M	VH	H	VH	VL	+ve	—	+ve	—
Methomyl	169	√						very short	high	H	L	VH	VH	M	L	VH	L	VH	M	M	M	VH	H	H	H	+ve	—	—	H[15]
Thiodicarb	750	√						long	high	VH	M	VH	VH	M	M	L	L	VH	VL	M	M	—	M	M	H	+ve	+ve	—	M[15]
Dimethoate (high)	200		√[18]	√	√[18]	√		short	high	M	M	H	H	M	H	—	H	H	VH	M	H	H	H	VH	M	+ve		+ve	H
Chlorfenapyr (high)	400	√	√					medium	high	H	M	VH	L	H	H	H	H	VH	L	M	M	—	VH	VH	M	—	+ve	—	H
OP's[5]		√	√	√	√	√		short-medium	high	H	M	H	H	H	M	H	H	VH	L	M	H	VH	H	VH	H	+ve	—	—	H
Carbaryl[3]								short	high	H	—	—	—	H	—	—	—	—	—	—	—		—	—	H	—	—	—	H
Pyrethroids[4]		√	√[7]	√[7]			√[7]	long	very high	VH	—	—	—	VH	—	—	—	VH	VH	VH	VH	VH	VH	VH	VH	+ve	+ve	+ve	H

1. Total predatory beetles – ladybeetles, red and blue beetles, other predatory beetles
2. Total predatory bugs – big-eyed bugs, minute pirate bugs, brown smudge bugs, glossy shield bug, predatory shield bug, damsel bug, assassin bug, apple dimpling bug
3. Information; Citrus pests and their natural enemies, edited by Dan Smith; University of California Statewide IPM project, Cotton, Selectivity and persistence of key cotton insecticides and miticides.
4. Pyrethroids; alpha-cypermethrin, cypermethrin,beta-cyfluthrin, cyfluthrin, bifenthrin, fenvalerate, esfenvalerate, deltamethrin, lambda-cyhalothrin,
5. Organophosphates; omethoate, monocrotophos, profenofos, chlorpyrifos, chlorpyrifos-methyl, azinophos ethyl, methidathion, parathion-methyl, thiometon
6. *Helicoverpa punctigera* only.
7. Bifenthrin is registered for mite and silverleaf whitefly control; alpha-cypermethrin, beta-cyfluthrin, bifenthrin, deltamethrin and lambda-cyhalothrin are registered for control of mirids
8. Persistence of pest control; short, less than 3 days; medium, 3-7 days, long, greater than 10 days.
9. Suppression of mites and aphids only.
10. Impact rating (% reduction in beneficials following application, based on scores for the major beneficial groups); VL (very low), less than 10%; L (low), 10-20%; M (moderate), 20-40%; H (high), 40-60%; VH (very high), > 60%. A '—' indicates no data available for specific local species.
11. *Bacillus thuringiensis*
12. Pest resurgence is +ve if repeated applications of a particular product are likely to increase the risk of pest outbreaks or resurgence. Similarly sequential applications of products with a high pest resurgence rating will increase the risk of outbreaks or resurgence of the particular pest species.
13. Very high impact on minute two-spotted ladybeetle and other ladybeetles for wet spray, moderate impact for dried spray.
14. Data Source: British Crop Protection Council. 2003. The Pesticide Manual: A World Compendium (Thirteenth Edition),. Where LD50 data is not available impacts are based on comments and descriptions. Where LD50 data is available impacts are based on the following scale: very low = LD50 (48h) > 100 ug/bee, low = LD50 (48h) < 100 ug/bee, moderate = LD50 (48h) < 10 ug/bee, high = LD50 (48h) < 1 ug/bee, very high = LD50 (48h) < 0.1 ug/bee. Refer to the Protecting Bees section in this booklet.
15. Wet residue of these products is toxic to bees, however, applying the products in the early evening when bees are not foraging will allow spray to dry, reducing risk to bees the following day.
16. May reduce survival of ladybeetle larvae – rating of moderate for this group.
17. May be detrimental to eggs and early stages of many insects, generally low toxicity to adults and later stages.
18. Will not control organophosphate resistant pests (e.g. mites, some cotton aphid (*Aphis gossypii*) populations
19. Rankings for *Eretmocerus* based on data for *E. mundus* (P. De Barro, CSIRO, unpublished) and for *E. eremicus* (Koppert B.V., The Netherlands (http://side-effects.koppert.nl/#))

DISCLAIMER Information provided is based on the current best information available from research data. Users of these products should check the label for further details of rate, pest spectrum, safe handling and application. Further information on the products can be obtained from the manufacturer.

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Cotton bollworm

Helicoverpa armigera

Damage symptoms

Larvae attack all stages of plant growth. In conventional cotton (non-Bt varieties), larval feeding can result in; seedlings being tipped out, chewing damage to squares and small bolls causing them to shed, and chewed holes in maturing bolls, preventing normal development and encouraging boll rot. In any year an average of 15% of Bollgard II area may carry *Helicoverpa* larvae at or above the recommended threshold levels for a short period during peak to late flower. In Bollgard II cotton, chewing damage is mostly confined to fruit and may lead to yield loss.

Sampling

Sample the **egg and larval growth stages** of the pest. The growth stages of the cotton bollworm are defined as:

White egg	WE	pearly white
Brown egg	BE	off-white to brown
Very small larvae	VS	0 mm–3 mm
Small larvae	S	3 mm–7 mm
Medium larvae	M	7 mm–20 mm
Large larvae	L	> 20 mm

Eggs are laid on plant terminals, leaves, stems and the bracts of fruit. Larvae may be found on terminals, the upper or lower surface of leaves, inside squares, flowers and bolls and along stems. Sample the whole plant.

Sample **fruit retention** or fruiting factors once squaring begins, to gauge what level of damage is being caused to the crop.

Sample **key beneficials**. This information will allow thresholds based on the predator to pest ratio to be applied. Collect eggs to check for parasitism by *Trichogramma*.

Frequency

Check at least 2 times/week in both conventional and Bollgard II crops.

Begin cotton bollworm sampling at seedling emergence. Cease sampling when the crop has 30–40% open bolls.

H. armigera **larvae (left) have pale hairs compared to darker hairs.on *H.punctigera* larvae (right).** (Hugh Brier, DAFF Qld)

Methods

Through the entire season, cotton bollworms are most accurately sampled using visual methods. Check at least 30 plants or 3 separate metres of row for every 50 ha of crop. Larger samples will give more accurate estimates. Fields are rarely uniform, lush areas often occur in head ditches and these are more attractive to insects. The crop variability within the field may determine the minimum number of sampling points required.

Thresholds

Using eggs as the basis of a threshold can be very misleading as not all eggs hatch. Successful egg hatch has been measured to be 20% early season, 25% mid season and 40% late season. Early in the season eggs are particularly prone to desiccation and being washed or blown from the small plants. Parasitism and predation also reduce survival. *Trichogramma* parasitoids have the potential to reduce egg survival by over 90%. Larval thresholds are also impacted on by beneficial insects. Therefore it is important to assess beneficial insect numbers when making pest control decisions. Fruit retention can also be used to determine whether pests have caused or are at risk of causing economic damage.

Conventional cotton

Helicoverpa spp.

SEEDLING TO FLOWERING	FLOWERING TO CUT-OUT
2 larvae /m or 1 larvae > 8 mm /m	2 larvae /m or 1 larvae > 8 mm /m or 5 brown eggs /m

CUT-OUT TO 15% OPEN BOLLS	15% TO 40% OPEN BOLLS
3 larvae /m or 1 larvae > 8 mm /m or 5 brown eggs /m	5 larvae /m or 2 larvae > 8 mm /m or 5 brown eggs /m

Bollgard II cotton

Calculation of spray thresholds in Bollgard II cotton should exclude larvae that are smaller than 3 mm and all eggs. Be sure to objectively assess larval size.

Helicoverpa spp.

SEEDLING TO 40% OPEN BOLLS
2 larvae > 3 mm /m in 2 consecutive checks or 1 larvae > 8 mm /m

Where larvae between 3 mm and 8 mm are observed on Bollgard II cotton, consecutive checks are essential for decision making. *Helicoverpa* spp. must feed in order to ingest the Bt toxin. If the number of 3–8 mm larvae are above threshold on a given check, chances are that a large portion of these will ingest sufficient dose of the toxin and die before the next check.

Using the predator/pest ratio

The predator/pest ratio can be applied in conventional and Bollgard II cotton. The ratio is calculated as:

$$\frac{\text{Total predators*}}{\textit{Helicoverpa}\text{ spp. (eggs + VS + S larvae)}}$$

At least 30 plants or 3 separate metres of row by visual sampling or 20 metres of row by suction sampling is needed in order to use the ratio. The total number of predators must only include the key predator insects (marked with an asterisk in the list below). At least 3 of the key predator species need to be present.

When the predator/pest ratio is 0.5 or higher, the Helicoverpa population should remain below the threshold of 2 larvae/m.

The predator to pest ratio calculated above does not incorporate parasitoids, particularly Trichogramma, in the calculation. To use both predators and parasitoids, the level of egg parasitism should be deducted from the number of Helicoverpa eggs before the predator to pest ratio is calculated. Levels of egg parasitism can vary greatly from farm to farm, region to region and from season to season. Generally levels decline as the season progresses. Notes on how to monitor egg parasitism levels and how to use the predator/pest ratio refer to page 51.

Key beneficial insects

Predators of eggs – red and blue beetle*, damsel bug*, green lacewing larvae*, brown lacewing*, ants, nightstalking spiders.

Predators of larvae – glossy, brown* and predatory shield bugs, big-eyed bug*, damsel bug*, assassin bug*, red and blue beetle*, brown lacewing*, common brown earwig, lynx, tangleweb and jumping spiders.

Predators of pupae – common brown earwig

Predators of moths – orb-weaver spiders and bats

Parasitoids of eggs – *Trichogramma* spp., *Telenomus* spp.

Parasitoids of larvae – *Microplitis demolitor*, orange caterpillar parasite, two-toned caterpillar parasite

Parasitoids of pupae – banded caterpillar parasite

Selecting an insecticide

The insecticide products registered for the control of *Helicoverpa* spp. in cotton are presented in Table 4 on page 13. The use of more selective insecticide options will help to conserve beneficial insects. Refer to Table 3 on pages 8–9.

Be aware of resistance status and follow IRMS (pages 64–65).

***The total number of predators must only include the key beneficial insects marked by a similar.**

Resistance profile

Conventional cotton

Widespread use of Bollgard II cotton has reduced reliance on chemical insecticides. However large plantings of Bollgard II does not change the overall frequencies of resistance genes in the Helicoverpa population and will not influence the rate at which H. armigera will develop resistance to conventional insecticides if significant selection pressure is imposed. While resistance to indoxacarb (Steward), avermectins (Affirm), rynaxypyr (Altacor) and organophosphates (chlorpyrifos) are low, recent testing has identified that frequencies of resistance to Bifenthrin (SP) have increased to 40%. This means that field failures are now likely for this product. Resistance to general pyrethroids has increased to 90%. Therefore the use of conventional chemistries for control of H. armigera in conventional and Bollgard II crops should be used according to the relevant thresholds and the principles of the IRMS applied to all spray decisions (pages 59–67).

Pupae busting is another key tactic for mitigating resistance risk to all insecticides targeting H. armigera, including Bollgard II. Individuals that have survived seasonal selection by insecticides can be controlled before they have a chance to mate, thereby reducing carryover of resistant insects from one season to the next. Pupae busting should be a priority post-harvest operation on all cotton farms. The IRMS recommends pupae busting as soon as possible after harvest. For Bollgard II crops, follow the pupae busting directions in the products Resistance Management Plan.

OCCASIONAL DETECTION OF RESISTANCE	WIDESPREAD RESISTANCE
Indoxacarb emamectin benzoate chlorpyrifos (OP)	methomyl/thiodicarb (carbamate) (moderate frequency) general pyrethroids (high frequency) bifenthrin (SP) (moderate frequency)
CROSS RESISTANCE	
H.armigera resistance to Bifenthrin has increased. Field failures are likely.	

Bollgard II cotton

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 5 in 10,000. It is not cross-resistant to Cry2Ab and in certain environments is largely recessive.

A gene that confers high level resistance to Cry2Ab is also present in field populations of *H. armigera*. This gene does not confer cross-resistance to Cry1Ac. In 2012–13 around 1–2% of the *H. armigera* population carried the Cry2Ab resistance gene. The continued efficacy of Bollgard II has become even more dependent on how the industry manages its refuges and implements the other elements of the resistance management plan (RMP). For further details, including information about recent changes in the frequency of Cry2Ab resistance genes in *H. armigera*, refer to the Preamble to the RMP for Bollgard II on page 68.

Over-wintering habit

The cotton bollworm over-winters in cotton fields as diapausing pupae. These pupae are the major carriers of resistance from one season to the next. The initiation of diapause in the pupae is caused by falling temperatures and shortening day lengths. The proportion of pupae entering diapause increases from 0% in late February to +90% in late April – early May, depending on the region. Across all regions (Central Queensland, Macintyre, Namoi and Macquarie Valleys) diapause is initiated in at least 50% of pupae by the first week in April. Diapause termination is based on rising soil temperatures beginning in mid to late September in most regions. Emergence from diapause usually occurs over a 6 to 8 week period in each valley.

Alternative hosts

Spring host crops include; faba beans, chickpeas, safflower, linseed and canola. Pastures and weed flushes also sustain emerging spring populations. Summer host crops include; soybeans, mungbeans, pigeon pea, sunflower, sorghum and maize. The cotton bollworm will attack flowering crops of sorghum and maize preferentially over most other crop hosts.

Further Information:

CSIRO Narrabri
Sharon Downes: (02) 6799 1576 or 0427 480 967.
Colin Tann: (02) 6799 1557 or 0429 991 501.

Qld DAFF, Toowoomba
Melina Miles: (07) 4688 1369.

NSW DPI, Narrabri
Lisa Bird: (02) 6799 2428.

Native budworm

Helicoverpa punctigera

Damage symptoms

Larvae cause early to mid season damage to terminals, buds, flowers and bolls of conventional cotton (non-Bt varieties) in a similar manner to *H. armigera*.

Sampling

Refer to the section on sampling cotton bollworm on the previous page. It is not possible to visually differentiate the eggs or early larval stages of the native budworm from the cotton bollworm, hence it is appropriate that these pests be sampled as one.

Thresholds

Refer to the section on thresholds for cotton bollworm on the previous page. The thresholds for *Helicoverpa* spp. are based on the assumption of potentially mixed populations of cotton bollworm and native budworm.

Key beneficial insects

Refer to the section on Key Beneficial Insects for the cotton bollworm. These predators and parasitoids also attack the native budworm.

Selecting an insecticide

The insecticide products registered for the control of native budworm in cotton in Australia are presented in Table 4 on page 13. The use of more selective insecticide options will help to conserve beneficial insects. Refer to Table 3 on pages 8–9.

Survival strategies

Resistance profile

Conventional cotton

Resistance to insecticides has only rarely been detected in Australia. In conventional cotton, the tendency for the native budworm to occur in mixed populations with the cotton bollworm often limits insecticide control options to those that are also efficacious on the cotton bollworm.

Bollgard II cotton

A gene is present in field populations of *H. punctigera* that has the potential to confer resistance to Cry1Ac. Research suggests that this gene occurs at a low frequency which is probably less than 1 in 1,000. It is not cross-resistant to Cry2Ab and in certain environments is largely recessive.

A gene that confers high level resistance to Cry2Ab is present in field populations of *H. punctigera*. In 2012–13 around 1–1.5% of the *H. punctigera* population carried a Cry2Ab resistance gene.

The continued efficacy of Bollgard II has become even more dependent on how the industry manages its refuges and implements the other elements of the resistance management plan (RMP). For further details, including information about recent changes in the frequency of Cry2Ab resistance genes in *H. punctigera* refer to the Preamble to the RMP for Bollgard II on page 68.

Over-wintering habit

The native budworm has the capacity to over-winter as pupae, but extensive research conducted in the early 1990s found that it is rarely observed to do so in cotton growing areas. However between 20–50% of overwintering pupae collected from numerous crops and fields in cotton regions during 2007 and 2008 were *H. punctigera* suggesting that this strategy may now be more common. If conditions are favourable during winter, sparse but large populations survive and breed on native host plants in inland (central) Australia. As these winter annuals hay-off in spring, large migrations of moths may fly to cotton growing areas in eastern Australia.

***Helicoverpa armigera* & *punctigera* moths.** (Hugh Brier DAFF Qld)

Alternative hosts

The native budworm is not as closely associated with crop hosts as the cotton bollworm. The host range of the native budworm appears to be restricted to dicotyledonous (broad-leaved) hosts. Spring crop hosts include; faba beans, chickpeas, safflower, linseed and canola. Uncultivated hosts, particularly naturalised medics, are important in the initial buildup of the first spring generation. Summer crop hosts include; soybeans, mungbeans, pigeon pea and sunflower.

Further Information:

CSIRO Entomology, Narrabri
Sharon Downes: (02) 6799 1576 or 0427 480 967
Colin Tann: (02) 6799 1557 or 0429 991 501

Qld DAFF, Toowoomba
Melina Miles: (07) 4688 1369

NSW DPI, Narrabri
Lisa Bird: (02) 6799 2428.

TABLE 4: 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 – see IRMS.#
Alpha-cypermethrin	100 g/L EC 250 g/L SC	0.3, 0.4 or 0.5 L/ha 0.12, 0.16, or 0.2 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		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		Apply during egg lay to egg hatch. Best results are obtained from two sequential applications 6–7 days apart.
Bacillus thuringiensis	Btk SC	0.5–4.0 L/ha	No*	Use alone or with mixtures. Refer to relevant label for details. *See RMP preamble page 74
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 250g/L EC	0.6–0.8 L/ha 0.24–0.32L/ha	Yes	Time spray to coincide with egg hatch. DO NOT apply to larvae >5 cm.#
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	200 g/L EC 250 g/L EC 260 g/L EC	.3–0.70 L/ha 0.3–0.5 L/ha 0.29–0.48 L/ha	Yes	See label for higher rate situations.
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. Use non-ionic surfactant as per label.#
Esfenvalerate	50 g/L EC	0.5–0.7 L/ha	Yes	Use low rate when larvae are small and pressure is low.#
Gamma -cyhalothrin	150 g/L CS	0.05 or 0.06, 0.07 L/ha	Yes	Ovicidal rate. Apply higher rate when egg lay is heavy and/or *H.punctigera* >10mm and/or *H.armigera* <5mm.#
Indoxacarb	150 g/L EC	0.65 or 0.85 L/ha	No	Refer to label for rate selection criteria. Compatible with amitraz.#
Lambda-cyhalothrin	250 g/L ME	0.06, 0.07 or 0.085 L/ha	Yes	Ovicidal rate. Use low rate for newly hatched larvae.#
Helicoverpa NPV	2000 M-Obs/mL LC 5x109 M-Obs/mL LC	0.5 L/ha 0.5 L/ha		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.#
Paraffinic oil	792 g/L	2% or 2L/100L of water		Use a minimum of 80L/ha of water. Apply only by ground rig before crop closure.
Piperonyl butoxide	800 g/L EC	0.3–0.4 L/ha		Use as a synergist when applying synthetic pyrethroids. See label.
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 and to achieve longer residual control.
Thiodicarb	375 g/L SC 800 g/L WG	0.5–1.0L/ha + Larvacide 2.0-2.5L/ha 0.235–0.470 kg/ha + Larvacide 0.940–1.2kg/ha	Yes	This product has ovicidal and larvicidal activity. See label for details.#

#See label for instructions to minimise impact on bees.

Aphids

Cotton aphid – *Aphis gossypii*
Green peach aphid – *Myzus persicae*
Cowpea aphid – *Aphis craccivora*

Cotton aphid is the most common aphid pest in cotton. Green peach aphid and cowpea aphid are occasionally a pest of young cotton but both species decline as temperatures increase (generally early December).

Damage symptoms

Nymphs and wingless adults of cotton aphid cause early to late season damage to terminals, leaves, buds and stems which can result in yield loss. Cotton aphids have also been shown to transmit the disease Cotton Bunchy Top (CBT). CBT is described on page 124. Once bolls begin to open, the sugary 'honeydew' excreted by aphids can contaminate the lint. Green peach aphid can cause more severe damage to plant growth than cotton aphid at lower densities.

Sampling

Sampling should focus on non-winged adults together with their nymphs. Winged adults may be transitory, while the presence of non-winged adults together with their nymphs indicates a population has settled in the crop.

Sample for Species and Population

Species: Verify which aphid species is present before implementing any management strategies. Aphid species can be distinguished by close examination with a hand lens. The distinguishing features for green peach are the presence of tubercles (on the head between the antenna), and the long siphunculi (tubes between the back legs). Cotton aphid and cowpea aphid don't have tubercles (the head is smooth between the antenna) and the siphunculi are very short. Adults of cowpea aphid are shiny black and nymphs are always dusky grey, while adults and nymphs of cotton aphid are matt and vary widely from yellow, green, brown to dull black. If you are unable to make a determination, or suspect both could be present, contact Lewis Wilson, CSIRO Plant Industry at Narrabri, to arrange for a sample to be sent for identification. Contact details are provided at the end of this section.

Population: Sample for non-winged adults and nymphs on the underside of mainstem leaves 3–4 nodes below the plant terminal. If a high proportion of plants have only the winged form, recheck within a few days to see if they have settled and young are being produced.

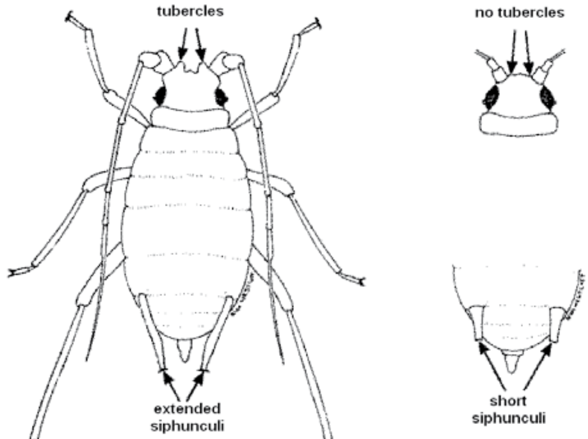
Frequency

Check the **population** at least weekly. Begin aphid sampling at seedling emergence and continue until defoliation. The species composition may change during the season. Particularly when aphid infestation occurs early in the season, the species should be verified on more than one occasion during the season.

Methods

Seedling to first open boll: Use a 0–5 scoring system based on the number of aphids /leaf. The protocols for scoring aphids are presented in full on pages 17–18. The presence/absence sampling method is no longer recommended during this part of the season as recent research has found that this technique has poor precision in the range from 80–100% plants infested.

If hot spots of cotton aphid are found early season, monitor cotton for symptoms of CBT.



Green peach aphid *Myzus persicae* — Cotton aphid *Aphis gossypii*

First open boll to harvest: Use a presence/absence scoring system. Check one leaf /plant. Choose a recently expanded leaf, close to the plant terminal. Only score a plant as infested if there are 4 or more non-winged aphids within 2 cm^2. Aphids are most abundant on the edges of fields so ensure perimeter sampling occurs. Assess plants for the presence of honeydew.

Thresholds and Cotton Bunchy Top

Cotton Aphid

From the seedling stage through until first open boll, thresholds are based on the potential for feeding change of the aphid population to reduce yield. These thresholds are dynamic, allowing the grower/consultant to consider the value of the crop and the cost of control as part of the decision. After first open boll the thresholds aim to protect the quality of the lint by avoiding contamination from honeydew. As penalties for honeydew contamination are severe, thresholds aim to limit honeydew contamination to trace amounts.

There is also a risk that yield loss can occur through crop infection with CBT. These thresholds do not take into account the risk of yield loss due to CBT. Recent research has shown that risks of CBT spreading through crops and affecting yield are low unless significant populations of ratoon cotton or alternative weed hosts are neighbouring or within the field. If there are many hosts of CBT near the field and a large influx of aphids occurs, control may be required to prevent spread of CBT. In these situations the development and spread of aphids should be monitored intensively (at least twice weekly), and any hotspots checked for the presence of plants showing CBT symptoms. Mark aphid hotspot areas and return to them to check aphid survival. If it is low, then no action may be needed; but if populations are healthy, increasing and spreading, control may be required to prevent transmission of CBT within the crop. If control is needed choose a selective option to conserve beneficials. Removing cotton ratoons/volunteers and weeds in and around fields well before cotton planting will reduce winter survival of aphids and carryover of CBT in these hosts. Refer to page 125 for hosts of CBT.

Cotton aphid

SEEDLING TO FIRST OPEN BOLL	FIRST OPEN BOLL TO HARVEST
Calculate the Cumulative Season Aphid Score (page 18)	50% plants infested or 10% if trace amounts of honeydew present

Aphids

Aphids and mummies. (Lewis Wilson, CSIRO)

Green peach aphid

This species can severely stunt young cotton plants and can occasionally be found late season. As it is more damaging than cotton aphid the threshold for control is lower. However as populations usually decline naturally when temperatures increase, it is unusual for control to be necessary.

SEEDLING TO FLOWERING	FLOWERING TO HARVEST
25% plants infested	Populations decline in hot weather. Highly unlikely to be present post-flowering.

Cowpea aphid

This species usually declines as temperatures increase. Control would only be needed if plants were showing signs of damage and stunting.

Key beneficial insects

Predators – lady beetle larvae and adults, red and blue beetles, damsel bugs, big-eyed bugs, lacewing larvae, hoverfly larvae.

Parasitoids – *Aphidius colemani, Lysiphlebus testaceipes* (these cause mummification).

Selecting an insecticide

The insecticide products registered for the control of cotton aphid and green peach aphid in cotton in Australia are presented in Table 5 on page 16. If aphid control is required early season, use a selective option to help conserve beneficial populations, in accordance with the IRMS. These beneficials can assist in controlling any survivors from the insecticide.

Resistance profile

Aphids reproduce asexually. All the progeny of a resistant individual will be resistant. Once resistance is selected in a population it can quickly dominate and give rise to new, entirely resistant populations.

Resistance profile – Cotton aphid

WIDESPREAD, HIGH LEVELS OF RESISTANCE	WIDESPREAD, LOW/MOD LEVELS OF RESISTANCE
OCCASIONAL DETECTION OF HIGH LEVELS OF RESISTANCE	**OCCASIONAL DETECTION OF LOW LEVELS OF RESISTANCE**
pyrethroids (SP) dimethoate (OP) omethoate (OP) profenofos (OP) pirimicarb (carbamate) acetamiprid, clothianidin thiamethoxam, and imidacloprid (chloronicotinyl)	chlorpyrifos-methyl (OP)
CROSS RESISTANCE	
Strong cross-resistance between omethoate or dimethoate and pirimicarb. Strong cross-resistance between phorate and pirimicarb. Strong cross-resistance between all the chloronicotinyls. *If a phorate side dressing is used instead of a neonicotinoid seed dressing then do not use pirimicarb or dimethoate/omethoate as first foliar spray as there is cross resistance between them all. Dimethoate/omethoate use will select catastrophic pirimicarb resistance in aphids so do not use pirimicarb and dimethoate/omethoate in the same field.*	

Neonicotinoid resistance was once widespread but is now trending down and is sporadic but there remains cross resistance between acetamiprid, thiamethoxam, imidacloprid and clothianidin. While there has been very low use of neonicotinoid insecticides against aphids during recent cotton seasons, resistance in cotton aphids to this insecticide group still persists. Resistance is being inadvertently selected in two ways. The first has been through the widespread use of neonicotinoid seed treatments and the second is through the use of foliar applied products targeting mirids. Even when aphids are present at very low levels, resistance is being selected.

It remains critical to follow the recommendations of the industry's IRMS and rotate insecticide chemistries taking into account the insecticide group of any seed treatment (currently all commercially treated seed includes a neonicotinoid, refer to table 2) or at-planting insecticide.

There is cross resistance in cotton aphid between pirimicarb and dimethoate/omethoate, and in the early 2000s this resistance rendered these compound ineffective. Fortunately in recent years resistance to these compounds has declined dramatically and they again will provide effective control of aphids. However, re-selection of resistance is a risk, and the IRMS stipulated that omethoate/dimethoate should not be used in rotation with pirimicarb, or vice versa. Neonicotinoid resistance places strong pressure on pirimicarb and dimethoate/omethoate and attention should be paid to the effective management of these valuable products.

When choosing an aphicide, consider previous insecticide choices for mirids as well as for aphids and rotate chemical groups. It should be noted that if a phorate side dressing is used instead of a neonicotinoid seed dressing then do not use pirimicarb or dimethoate/omethoate as first foliar spray as there is cross resistance between them all. Dimethoate/omethoate use will select catastrophic pirimicarb resistance in aphids so do not use pirimicarb and dimethoate/omethoate in the same field.

Resistance profile – Green peach aphid

HIGH LEVELS OF RESISTANCE	LOW / MOD LEVELS OF RESISTANCE
dimethoate (OP) omethoate (OP) chlorpyrifos (OP)	pirimicarb (carbamate) profenofos (OP)
CROSS RESISTANCE (DIFFERENT TO COTTON APHID)	
No cross-resistance between omethoate, dimethoate or pirimicarb	

Over-wintering habit

Aphids don't have an overwintering form, but cool temperatures slow the growth rate of aphids dramatically. In cotton growing areas aphids persist through winter on whatever suitable host plants are available, including cotton volunteers and ratoons.

Aphids on cotton. (Lewis Wilson, CSIRO)

Alternative hosts

Cotton aphid has a broad host range, including many common weeds. Winter weed hosts include; marshmallow, capeweed and thistles. Ratoon or volunteer cotton is a host and may also carryover the CBT disease. Some legume crops such as faba beans are also potential winter hosts. Spring and summer weed hosts include; thornapples, nightshades, paddymelon, bladder ketmia and Bathurst burr. Sunflower crops and volunteers also accommodate the cotton aphid.

Winter weeds that support green peach aphids include; turnip weed and marshmallow. Spring germinations of peach vine and thornapples also host green peach aphid. Canola is an attractive host crop through late winter and early spring.

Further Information:

CSIRO Plant Industries, Narrabri
Lewis Wilson: (02) 6799 1550 or 0427 991 550.

NSW DPI, Camden
Grant Herron: (02) 4640 6471.

TABLE 5: Cotton aphid *Aphis gossypii* and Green peach aphid *Myzus persicae*

Active ingredient	Concentration and formulation	Application rate of product	*A. gossipii* resistance detected	Comments
Acetamiprid	225 g/L SL	0.05–0.1 L/ha	Yes	Ensure good coverage. Use high rate under sustained heavy pressure.
Amitraz	200 g/L EC	2.0 L/ha		Suppression when used for controlling Helicoverpa.
Chlorpyrifos	300 g/L EC 500 g/L EC	0 5–0.7 L/ha 0.3–0.4 L/ha	Yes	Use higher rates on heavy infestations
Clothianidin	200g/L SC	0.125–0.25L/ha + Maxx Organsilicone Surfactant 0.02 L/L of water	Yes	Apply when aphid numbers are low and beginning to build.
Diafenthiuron	500 g/L SC	0.6 or 0.8 L/ha	No	Apply before damage occurs. Only use lower rate when spraying by ground rig.#
Dimethoate	400 g/L EC	0.5 L/ha	Yes	Do not use where resistant strains are present. Do not harvest for 14 days after application. Do not graze or cut for stockfood for 14 days after application.#
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	Yes	Apply by ground or air.#
Paraffinic oil	792 g/L 815 g/L	2% or 2L/100 L of water, 2.5 L/ha		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.
Phorate	100 g/kg G	6.0 kg/ha	Yes	For short residual control at time of planting.
		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		
		5.5–8.5 kg/ha (NSW only)		For short residual control.
Pirimicarb	500 g/kg WDG, WP	0.5 or 0.75 kg/ha	Yes	Thorough spray coverage essential for best results.
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 organosilicone surfactant.
Spirotetramat	240g/L SC	0.3–0.4L/ha	No	Add Hasten Spray Adjuvant 1.0L/ha. Use the higher rate when periods of high pest pressure or rapid crop growth are evident, when longer residual control is desired or when crops are well advanced. Do not re-apply within 14 days of a previous spray. Do not apply more than 2 applications per crop.
Sulfoxaflor	240g/L SC	0.2–0.3L/ha	No	Use higher rate for heavy infestations or when water volume is reduced, such as with aeerial application.#
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.#

#See label for instructions to minimise impact on bees.

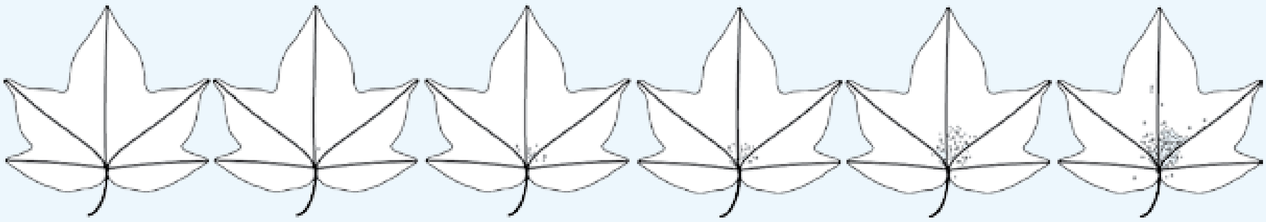
SAMPLING PROTOCOLS FOR COTTON APHID FOR USE UNTIL FIRST OPEN BOLL

STEP 1. COLLECT LEAVES.

Fields should be sampled in several locations as aphids tend to be patchy in distribution. At each location collect at least 20 leaves, taking only one leaf per plant. Choose mainstem leaves from 3–4 nodes below the terminal. The same leaves can also be used for mite and whitefly scoring. It is important to sample for aphids regularly, even if it is suspected that none are present. The estimate of yield loss will be most accurate when sampling detects the time aphids first arrive in the crop.

STEP 2. SCORE LEAVES.

Allocate each leaf a score of 0, 1, 2, 3, 4 or 5 based on the number of aphids on the leaf. After counting aphids a few times, you will quickly gain confidence in estimating abundance. As a guide, the diagrams below represent the minimum population for each score. Discount pale brown bloated aphids as these are parasitised. Sum the scores and divide by the number of leaves to calculate the Average Aphid Score.



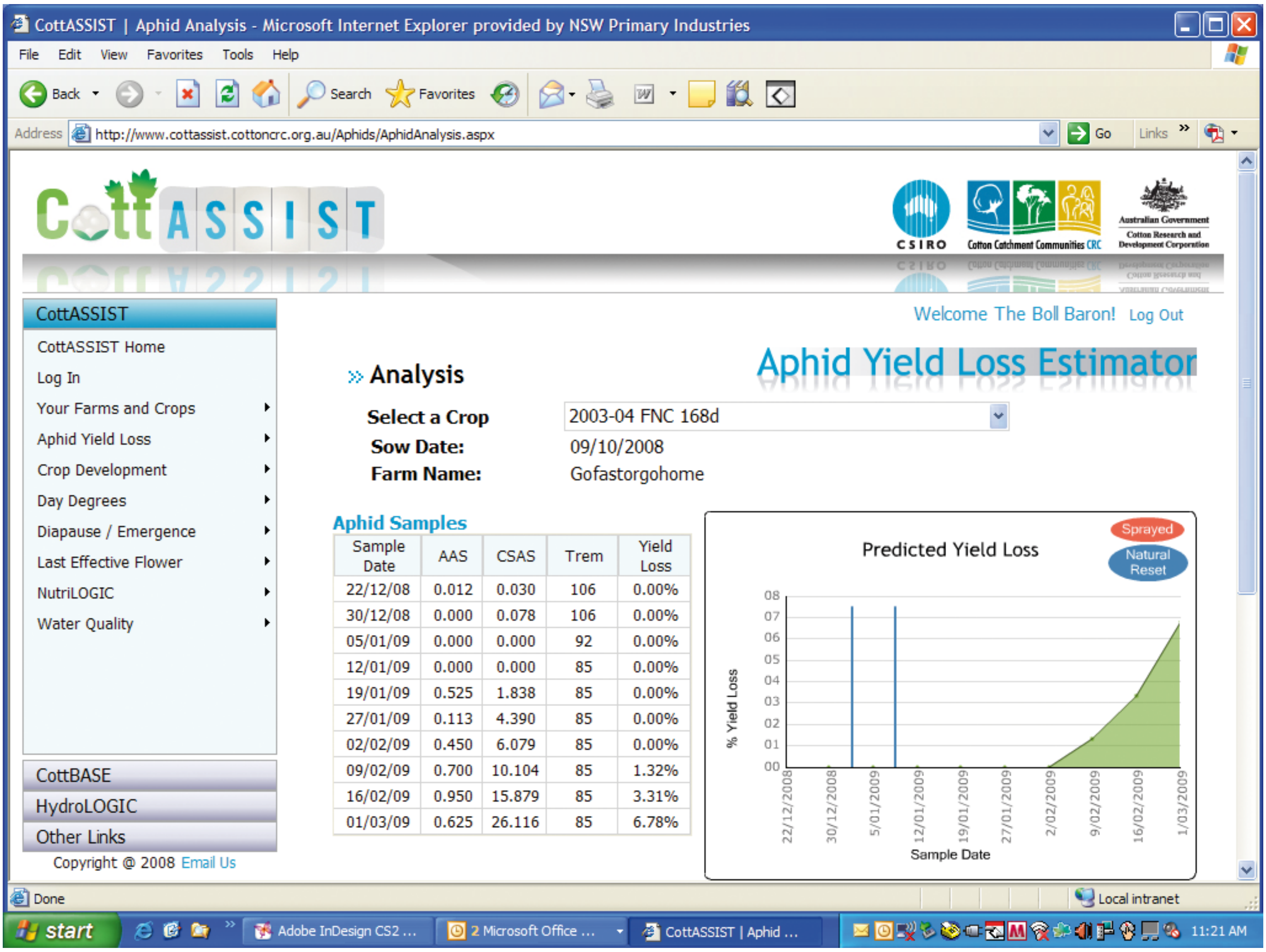
Score = **0**	Score =**1**	Score = **2**	Score = **3**	Score = **4**	Score = **5**
No aphids	1–10 aphids	11–20 aphids	21–50 aphids	51–100 aphids	> 100 aphids

STEP 3. USE THE APHID YIELD LOSS ESTIMATOR ON THE WEB.

In order to estimate yield loss, the Average Aphid Score must firstly be transformed into a Sample Aphid Score and then into a Cumulative Season Aphid Score. Record keeping and calculation of these Scores can be simplified by using the Aphid Yield Loss Estimator in CottASSIST on the web. The Tool allows users to keep records for multiple crops on multiple farms throughout the season. After initial set up, the user enters the Average Aphid Score from Step 2 and the date of each check. The Tool then calculates the Scores and tracks the estimate of yield loss. Find CottASSIST on the 'Industry' home page in the Cotton CRC website.

Alternatively, the Scores can be calculated manually by following Steps 4 and 5.

Example yield loss estimate from the Aphid Yield Loss Estimator web tool.



Sample Date	AAS	CSAS	Trem	Yield Loss
22/12/08	0.012	0.030	106	0.00%
30/12/08	0.000	0.078	106	0.00%
05/01/09	0.000	0.000	92	0.00%
12/01/09	0.000	0.000	85	0.00%
19/01/09	0.525	1.838	85	0.00%
27/01/09	0.113	4.390	85	0.00%
02/02/09	0.450	6.079	85	0.00%
09/02/09	0.700	10.104	85	1.32%
16/02/09	0.950	15.879	85	3.31%
01/03/09	0.625	26.116	85	6.78%

STEP 4. MANUAL CALCULATION OF THE CUMULATIVE SEASON APHID SCORE.

Use the Look Up Table below to firstly convert the Average Aphid Score calculated in Step 2 to a Sample Aphid Score. This step accounts for the length of time the observed aphids have been present in the crop. If aphids are found in the first assessment of the season, assume the 'Score last check' was '0' and that it occurred 5 days ago.

Find the value in the table where 'this check' and the 'last check' intersect. Multiply this value by the number of days that have lapsed between checks. This value is the Sample Aphid Score.

As the season progresses, add this check's Sample Aphid Score to the previous value to give the Cummulative Season Aphid Score.

When aphids are sprayed, or, if during the season the Average Aphid Scores return to '0' in 2 consecutive checks, reset the Cummulative Season Aphid Score to '0'. Disappearance of aphids can occur for reasons such as predation by beneficials, changes in the weather and insecticide application.

Average score last check	Average score this check										
	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
0	0.0	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.0	2.3	2.5
0.5	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.0	2.3	2.5	2.8
1.0	0.5	0.8	1.0	1.3	1.5	1.8	2.0	2.3	2.5	2.8	3.0
1.5	0.8	1.0	1.3	1.5	1.8	2.0	2.3	2.5	2.8	3.0	3.3
2.0	1.0	1.3	1.5	1.8	2.0	2.3	2.5	2.8	3.0	3.3	3.5
2.5	1.3	1.5	1.8	2.0	2.3	2.5	2.8	3.0	3.3	3.5	3.8
3.0	1.5	1.8	2.0	2.3	2.5	2.8	3.0	3.3	3.5	3.8	4.0
3.5	1.8	2.0	2.3	2.5	2.8	3.0	3.3	3.5	3.8	4.0	4.3
4.0	2.0	2.3	2.5	2.8	3.0	3.3	3.5	3.8	4.0	4.3	4.5
4.5	2.3	2.5	2.8	3.0	3.3	3.5	3.8	4.0	4.3	4.5	4.8
5.0	2.5	2.8	3.0	3.3	3.5	3.8	4.0	4.3	4.5	4.8	5.0

STEP 5. MANUAL CALCULATION OF THE YIELD LOSS ESTIMATE.

Use the table to estimate the yield loss that aphids have already caused, and note that this does not take into account risks of yield loss from Cotton Bunchy Top disease. The 'Time Remaining' in the season needs to be determined the first time aphids are found in the crop. The data set is based on 165 days from planting to 60% open bolls. If for example aphids are first found 9 weeks after planting, the Time remaining would be ~100 days. As the Season Aphid Score accumulates with each consecutive check, continue to read down the '100' days remaining column to estimate yield loss. When aphids are sprayed, or, if aphids disappear from the crop then reappear at a later time, reassess the time remaining based on the number of days left in the season at the time of their reappearance.

Crop sensitivity to yield loss declines as the crop gets older. The estimate takes into account factors that affect the rate of aphid population development, such as beneficials, weather and variety. Yield reductions >4% are highlighted, however the value of the crop and cost of control should be used to determine how much yield loss can be tolerated before intervention is required.

Cumulative Season Aphid Score	Time Remaining (days until 60% open bolls at the time when aphids are first observed)									
	100	90	80	70	60	50	40	30	20	10
0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
10	2	2	1	1	1	0	0	0	0	0
15	5	4	3	3	2	1	1	0	0	0
20	7	6	5	4	3	2	1	1	0	0
25	9	8	7	6	5	3	2	1	0	0
30	11	10	8	7	6	5	3	2	1	0
40	15	13	12	10	8	7	5	3	1	0
50	19	17	15	13	11	9	7	5	2	0
60	23	21	18	16	13	11	8	6	3	1
80	31	28	25	22	18	15	12	8	5	1
100	38	34	31	27	23	19	15	11	7	2
120	45	41	37	32	28	23	18	13	9	3

Mirids

Green mirid – *Creontiades dilutus*

Brown mirid – *Creontiades pacificus*

Both the green and brown mirids are similar in appearance, however brown mirids are slightly larger and carry more dark pigments. While the brown mirid can cause similar damage to green mirid at the boll stage, at the squaring stage they cause less damage than green mirids. Brown mirids are usually found in much lower numbers than the green mirids on cotton and they move into cotton crops later than green mirids.

Damage symptoms

Adults and nymphs cause early season damage to terminals and buds and mid season damage to squares and small bolls. Types of damage include blackening and death of terminals of young plants, rapid square loss without the presence of *Helicoverpa* spp. larvae and blackening of pinhead squares.

Square loss depends upon where the mirids are feeding and size of the squares. Feeding on ovules and anthers causes squares to drop but feeding on leaves or stems does not cause square loss. Small and medium sized squares usually drop from mirid feeding. Large squares do not drop but can develop parrot beaked boll if >70% anthers are damaged. This is why mirid numbers and square loss does not always match, and why retention as well as mirid numbers should be considered when making a spray decision. The rate of mirid feeding varies with temperature, with highest rates of feeding between at 27°C and 32°C, which also suggest that temperature plays a role in the different rates of damage observed in the field for the same mirid density.

Bolls that are damaged during the first 10 days of development will be shed, while bolls damaged later than this will be retained but not continue normal development and will incur yield loss. Black, shiny spots indicate feeding sites on the outside of bolls. When sliced open warty growths and discolouration of the immature lint can be seen within the boll.

Sampling

Sample for adults and nymphal instars of the pest. Mirids are a very mobile pest and are easily disturbed during sampling. It is important to include nymphs in the assessment as 4th and 5th instars cause similar amounts of damage to adults.

Sample fruit retention and types of plant damage that are symptoms of mirid feeding such as tip damage (early season) and boll damage (mid season).

Frequency

Sample at least 2 times/week.

Begin sampling at seedling emergence and continue sampling until last effective boll is at least 20 days old.

Methods

Distribution is usually clumped so sample throughout the field. Use visual assessment of whole plants, a beat sheet or sweep net. All methods give comparable estimates of mirid abundance when plants are young. As the season progresses, the efficacy of whole plant visual sampling declines. Once the crop reaches 9–10 nodes, sample using either the beat sheet or sweep net.

When beat sheeting, each sample consists of the row of plants being vigorously pushed 10 times with a 1 m stick towards the sheet. Preliminary research has shown that the number of samples required for a good estimation of mirid numbers is between 8–10.

When using a sweep net, a sample can consist of 20 sweeps along a single row of cotton using a standard (380 mm) sweep net. Preliminary research has shown that at least 6 sweep samples are required to achieve a good estimation of mirid numbers.

It is essential to monitor fruit retention and signs of fruit damage as part of gauging the impact mirids are having on the crop. Not all bolls that are damaged by mirids will be shed, so it is important to monitor bolls for mirid damage.

Thresholds

Yield loss due to mirid feeding varies with crop stage. Different thresholds apply at different times of the season, depending on the crop's capacity to compensate for the damage incurred. When applying the thresholds, always use the crop damage component together with the mirid numbers.

The highest risk stage is mid season when bolls are young. From first flower until the time when ~60% of bolls are 20 days old, the crop is most susceptible to fruit loss from mirid damage that will impact on yield. The crop has greater capacity to recover from earlier fruit loss during the squaring stage provided plants do not suffer from any other stress such as water stress. Once bolls are 20 days old the boll wall is hard enough to deter mirid feeding and minimal damage occurs.

		Planting to 1 flower/m	Flowering to 1 open boll/m	1 open boll/m to harvest
Adults or nymphs/m				
Visual Sampling	cool region	0.7	0.5	–
	warm region	1.3	1.0	–
Beatsheet Sampling	cool region	2	1.5	–
	warm region	4	3	–
Adults or nymphs/sample				
Sweep net Sampling*	cool region	2 adults + 1.1 nymphs	1.5 adults + 0.8 nymphs	–
	warm region	4 adults + 2.1 nymphs	3 adults + 1.6 nymphs	–
Crop damage				
Fruit retention		60%	60–70%	–
Boll damage		–	20%	20%
Tip damage (% of plants affected)		(light**) 50% (heavy***) 20%		

*After 9–10 nodes. **Light tip damage – embryo leaves within the terminal are black. ***Heavy tip damage – terminal and 2–3 uppermost nodes are dead.

The use of a beatsheet is recommended for counting the numbers of mirid adults and nymphs present in the crop. The relative importance of the % fruit retention and % boll damage reverses as the season progresses. From the start of squaring through until cut-out, place the emphasis on fruit retention. Not all bolls that are damaged by mirids will be shed. Bolls that are damaged between 10 and 24 days of age will be retained but develop with reduced boll size and lint yield. As the season progresses, the proportion of the retained bolls that are damaged becomes more critical.

Key beneficial insects

There are no beneficial species that are recognised to be regulators of mirid populations in cotton, however damsel bugs, big-eyed bugs, predatory shield bugs, as well as lynx, night stalker and jumping spiders are known to feed on mirid adults, nymphs and eggs.

Selecting an insecticide

The insecticide products registered for the control of green mirid in cotton in Australia are presented in Table 6 on page 20. The use of more selective insecticide options will help to conserve beneficial insects (see Table 3 on pages 8–9). For the last few years research by Qld DAFF entomologists has showed that salt mixed with low rate of chemical increase efficacy against mirid and stinkbug but reduce impact on beneficials. However, to date, only one chemical (Steward) has a registration to mix with salt. Early season use of dimethoate for the control of green mirids may inadvertently select for carbamate resistance in aphids, and also increase the risk of silverleaf whitefly outbreaks.

Resistance profile

Mirids aren't known to have developed resistance to insecticides in Australian cotton. Currently there is no resistance monitoring program for mirids. However it is possible that resistance could develop and the principles underlying the IRMS should be followed in making mirid control decisions. Many of the products registered for mirid control in cotton are also registered for the control of other pests. It is critical that mirid control decisions also consider sub-threshold populations of other pests that are present in the field.

Overwintering habit

Mirids are known to survive on weeds and native plant hosts surrounding cotton fields. They are also known to breed on native hosts in inland (central) Australia in winter and can migrate to cotton growing areas in spring in a similar way to the native budworm (see section on Native Budworm, page 12).

Alternative hosts

Mirids distinctly prefer lucerne to cotton. Lucerne strips or blocks can be used as trap crops to prevent the movement of mirids into cotton crops. If using lucerne to manage green mirids, the lucerne should not be allowed to flower, seed or hay-off. Slashing half the lucerne at 4 weekly intervals and irrigating will ensure that fresh lucerne regrowth is constantly available for mirid feeding, thus preventing the movement into cotton. Other crop hosts include soybeans, mungbeans, pigeon pea, safflower and sunflowers. It is assumed that mirids migrate between these crops. Weeds hosts include turnip weed, noogoora burr, variegated thistle and volunteer sunflowers.

Further Information:
Qld DAFF, Toowoomba, Moazzem Khan: (07) 4688 1310 or 0428 600 705
CSIRO, Narrabri, Mary Whitehouse: (02) 6799 1538 or 0428 424 205
NSW DPI, Narrabri, Robert Mensah: (02) 6799 1525 or 0429 992 087

TABLE 6: Control of mirids

Active ingredient	Concentration and formulation	Application rate of product	Comments
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.
Alpha-cypermethrin	100 g/L EC	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 levels as determined by field checks.#
Bifenthrin	100 g/L EC 250 g/L EC	0.6–0.8 L/ha 0.24–0.32 L/ha	Apply at recommended threshold levels as indicated by field checks. Use the higher rate for increased pest pressure and longer residual control.#
Clothianidin	200 g/L SC	0.125–0.25L/ha + Maxx Organsilicone Surfactant 0.02 L/L of water	Apply when numbers reach threshold levels requiring treatment
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. Use non-ionic surfactant at label rate.#
Fipronil	200 g/L SC 800 g/kg WG	0.0625–0.125 L/ha 15.5–30 g/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.#
Indoxacarb + Salt	150 g/L EC	0.3 or 0.4L/ha + Salt (NaCl) at 5 g/L spray volume by ground (100 L/ha) or 10 g/L spray volume by air (30 L/ha).	For controlling green mirids ONLY. Use the higher rate on infestations exceeding economic spray threshold levels and/or large canopy crops.#
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
Sulfoxaflor	240 g/L SC	0.2–0.3 L/ha	Use lower rate when infestation is predominately nymphs.#

#See label for instructions to minimise impact on bees.

Spider mites

Two-spotted spider mite – *Tetranychus urticae*
Bean spider mite – *T. ludeni*
Strawberry spider mite – *T. lambi*

The two-spotted spider mite is the main pest species, the other two species rarely colonise cotton and seldom cause economic damage. Even in high numbers, *T. lambi* infestations still result in very low levels of damage. Historically, two-spotted spider mite was the dominant mite species, but in recent years it is less common and bean spider mite and strawberry spider mite are more common. These species differ in damage potential so correct identification of the species present is crucial for good decisions.

Damage symptoms

All three species feed on the underside of leaves but the damage symptoms are quite different.

Two-spotted mite – nymphs and adults cause damage that appears as brownish areas on the lower leaf surface, usually starting at the junction of the petiole and leaf blade or in leaf folds. These areas show reddening on the upper surface. If damage is allowed to continue leaves will become completely red and will fall off.

Bean spider mite (this species is red in colour) – damage results in white, intensively stippled areas on the leaf underside, but there is generally no reddening of the upper surface. Severe damage may result in some leaf shedding.

Strawberry spider mite – this species can be very abundant but rarely, if ever, affects yield. Damage is a light, sparse stippling or white dots on the underside of the leaf. There is generally no reddening of the upper leaf surface.

Two spotted mite with egg (mite is 0.5 mm long).
(Lewis Wilson, CSIRO)

Sampling

'Sampling protocols for mites in cotton' are presented in full on page 23.

Look for the presence of any mite stages. Eggs and immature stages are difficult to see with the naked eye, so a hand lens should be used. Mites infest the underside of leaves. Sample the oldest leaf when plants are very young. As plants grow, choose leaves that are from 3, 4 or 5 nodes below the plant terminal.

Check which species is present. Two-spotted spider mite is pale green and has 2 distinct dark green spots on either side. Adults of bean spider mite are a dark red colour. Strawberry spider mite is smaller than the other two spider mites. Their bodies are pale green with 3 dark green spots on either side. They cause very little damage.

Frequency

Sample at least weekly. Begin at seedling emergence.

Sample more frequently if mite populations begin to increase, or if conditions are hot and dry, or if sprays which eliminate predators are used.

Methods

Presence/absence sampling allows many plants to be sampled quickly, thus increasing the likelihood of finding mites if they are present. It is helpful to plot the development of mite populations on a graph. This allows changes in mite population to be seen at a glance. The detailed sampling protocol for monitoring mite populations is on page 23.

Thresholds

Thresholds and yield loss charts and tools have been developed for two-spotted mites. These probably over-estimate yield loss for bean spider mite. No threshold is required for strawberry mite as it does not appear to reduce yield.

A general threshold of 30% of plants infested is advocated through the bulk of the season (squaring to first open boll). Yield loss due to mites depends on when mite populations begin to increase and how quickly they increase.

Seedling emergence to squaring

Mites are normally suppressed by predators, especially by thrips during this period. Mite populations only need to be controlled if they begin to increase, which indicates that natural controls are not keeping them in check. Use Table 7 on page 24 to determine whether the rate of increase warrants control.

Squaring to first open boll

Control if mite populations increase at greater than 1% of plants infested per day in two consecutive checks, or if more than 30% of plants are infested. Use Table 7 on page 24 for details.

First open bolls to 20% open bolls

Control is only warranted if mites are well established (greater than 60% plants infested) and are increasing rapidly (faster than 3% of plants infested per day). Use Table 7 on page 24 for details.

Crop exceeds 20% open bolls

Control is no longer warranted.

Mite Yield Loss estimator on the web

A simple relationship has been developed which allows prediction of yield loss from mites based on knowledge of the rate of increase in the population and the time remaining until defoliation. Record keeping and calculating can be simplified by using the Mite Yield Loss Estimator in CottASSIST on the web. Examples of charts generated by this tool are presented on page 25.

Mite population %. This is the percentage of leaves infested with mites.

Average rate of change. This is an average of the rates of change recorded for successive mite samples. Compared with the rate of change that you would expect if the yield loss from the mite population was 4%. This value (4%) is roughly when yield loss from mites would justify control, based on loss of revenue and cost of control. This may need to be adjusted for your particular situation.

Yield loss %. The yield loss calculation is based on the current percentage of plants infested with mites, the rate of change of the mite population and the number of days remaining in the season depending on the region. In general, zero or negative change in mite populations indicates that something has adversely affected population development such as mite spray, beneficials eating mites, heavy rainfall or a combination of these factors.

Mite yield reduction charts

As an alternative to the web tool, 'look-up' charts have been provided in Table 7, page 24 for areas with different season lengths:

Warmer – Bourke, Central Queensland, Macintyre Valley, St George and Walgett

Average – Dalby, Gwydir Valley, Lockyer Valley and Lower Namoi Valley

Cooler – Boggabri, Breeza, Cecil Plains – Pittsworth and Macquarie Valley

The charts use the rate of increase of the mite population. This is calculated by dividing the change in the percentage of plants infested between consecutive checks by the number of days between the checks. For example, if a field had 10% of plants infested a week ago and 24% infested now, this gives a rate of increase of 2% of plants infested per day.

To use the charts

- 1. Select the chart appropriate for your region.
- 2. Go to the section that is closest to the current infestation level of the field i.e. 10%, 30% or 60%.
- 3. Go to the column with the rate of increase closest to that of the mite population in the field.
- 4. Look down this column to the value that corresponds with the current age of the crop.

This value is the predicted yield loss that the mite population is likely to cause if left uncontrolled. It must be stressed that these charts only provide a guide for potential yield losses caused by mites.

You will need to take into account the vigour of the crop, other pests (you may be about to spray with a pyrethroid which may flare mites) and the conditions (that is, mites are generally favoured by hot dry conditions). Differences between the more mite resistant 'okra' leaf varieties and the normal leaf varieties are built into the charts. The effect of beneficials is also built is as high predation will result in lower rates of mite population growth and less risk of yield loss.

Key beneficial insects

Predators – thrips, minute two-spotted ladybird, mite-eating ladybird, damsel bug, big-eyed bug, brown lacewing adults, brown smudge bug, apple dimpling bug, tangleweb spiders.

Selecting a miticide

The miticide products registered for the control of spider mites in cotton in Australia are presented in Table 8 on page 25.

Amitraz, used for the control of *Helicoverpa spp*. early in the season, will tend to slow, or suppress, the development of mite populations that may also be in the field. Conversely, mite infestations may increase after the application of some broad-spectrum insecticides used for *Helicoverpa* or mirid control, such as synthetic pyrethroids, and organophosphates. This occurs because those sprays kill key beneficial species allowing mite populations to flourish.

Resistance profile – Two-spotted spider mite

WIDESPREAD, HIGH LEVELS OF RESISTANCE	WIDESPREAD, LOW/MOD LEVELS OF RESISTANCE
bifenthrin (SP)	
OCCASIONAL DETECTION OF HIGH LEVELS OF RESISTANCE	**OCCASIONAL DETECTION OF LOW LEVELS OF RESISTANCE**
	propargite

The two spotted mite causes economic damage and has a recent history of developing resistance to miticides. While current resistance levels are low for all products excluding OPs and pyrethroids, resistance can be selected very quickly. Avoid consecutive sprays of the same miticide. If mite numbers rebuild after a miticide application, rotate to a product from a different chemical group. Once cotton is ~8 nodes, thrips cease to be a pest and become veracious predators of mites. Where thrips are preserved, they can provide sustained suppression of mite populations at below damaging levels.

Abamectin resistance has occasionally been detected at high levels in two-spotted spider mite in horticulture, but not in cotton. The bifenthrin and chlorfenapyr resistance that has developed in mites in recent years has occurred largely due to the use of these compounds against other pests. When choosing a miticide, consider previous insecticide choices and avoid consecutive sprays from the same group.

There has been no research yet to establish if bean spider mite causes yield loss. However, if populations build to the point that leaves begin to drop then yield loss is possible and populations should be controlled with a product registered for that use to prevent this occuring.

Overwintering habit

Mites mostly survive the winter in cotton growing areas as active colonies on a wide range of broad-leaf weeds. While the lifecycle slows in cool temperatures, mites are adapted to exploit ephemeral hosts and to produce large numbers of offspring, especially as conditions warm up in spring.

Alternative hosts

Preferred winter weed hosts are turnip weed, marshmallow, deadnettle, medics, wireweed and sowthistle, although they can be found on almost any broad-leafed weed species. Alternative winter and spring host crops include safflower, faba beans and field peas.

Further Information:

CSIRO Plant Industries, Narrabri
Lewis Wilson: (02) 6799 1550 or 0427 991 550

NSW DPI, Camden
Grant Herron: (02) 4640 6471

SAMPLING PROTOCOLS FOR MITES IN COTTON

Population Monitoring

1. Walk into the field about 40 m. (Early in the season it is also advisable to sample near the field edges to see if significant influxes of mites have occurred).
2. Take a leaf from the first plant on the right or left. The leaf should be from the third, fourth or fifth main-stem node below the terminal. If the plant has less than three leaves, sample the oldest. Note that early in the season, up to the point that the plant has about five true leaves, it is simplest to pull out whole plants.
3. Walk five steps and take a leaf from the next plant, on the opposite side to the previous one, and so on until you have 50 leaves. (Wait until you have collected all the leaves before scoring them).
4. Once all the leaves have been collected score each leaf by turning it over, looking at the underside, firstly near the stalk, then scanning the rest of the leaf. If mites of any stage (eggs or motiles) are present score the leaf as infested. A hand lens will be needed to see mite eggs because they cannot be seen with the naked eye.
5. Repeat this simple procedure at several widely separated places in the field to allow for differences in mite abundance within the field. Depending on the size of the field, 4–6 sites are needed to obtain a good estimate of mite abundance.
6. When finished sampling, calculate the percentage of plants infested in the field.

Additional recommendations for monitoring mites in seedling cotton

On seedling cotton (up to 6–8 true leaves) sample regularly to determine the level of infestation using the standard presence/absence technique described above.

When more than 5% of plants are infested it is also advisable to count the numbers of mites on plants, and to score the mite damage level (ie. estimate the % of the plants total leaf area that is damaged by mites).

Continue to monitor mite numbers, damage levels and infestation levels at least weekly, or more frequently if infestation levels are high (> 30% of plants infested).

If the level of infestation, damage level or mite number per plant declines then control is unnecessary, but monitoring should continue.

If mite numbers per plant do not decline after about 6 weeks, if the damage levels exceed an average of 20% of plant leaf area, or if infestation levels increase, then predators are not abundant enough to control mites and a miticide should be applied.

After about 6–8 true leaves, specific mite counts and damage scoring can cease, but continue to use the presence/absence sampling method (points 1–6) until 20% open bolls.

Miticide Resistance Monitoring

1. If mites are being collected after a miticide application, ensure sufficient time has lapsed for the miticide to be fully activated. Depending on the product, this may take 7 to 10 days.
2. Collect 50 infested leaves per field. Only collect one sample per field. Keep samples from different fields separate. If mite numbers per leaf are very low, consider collecting up to 100 leaves.
3. Try to avoid collecting all the leaves from only 2 or 3 plants. Where possible collect infested leaves from different areas across the field.
4. Phone Grant Herron and let him know you are sending the sample. Avoid making collections and sending samples on Thursdays or Fridays.
5. Ensure samples are clearly labelled and that labels include the following information:

Farm Name ....

Field ....

Region (eg. Gwydir)...

Collector's Name ....

Phone No ....

Fax No..

Email address..

Date of collection .... /.......... /..........

Comments eg. details of the problem if a control failure has occurred.

Sending collections to EMAI

Pack the leaves loosely in a paper bag, fold and staple the top. Pack this in a 6-pack esky. Attach the sample details and send by overnight courier to:

Dr Grant Herron
NSW DPI,
Elizabeth McArthur Agricultural Institute,
Woodbridge Road,
Menangle NSW 2568. Phone: (02) 4640 6471

Sampling Tips

to save time in the field...

Aphids, mites and whitefly can all be sampled using the same leaves from the 3rd or 4th node below the terminal.

Assess for whitefly while collecting the leaves as adults are mobile. Then assess the collected leaves for both mites and aphids.

Collect leaves from several locations in the field.

While the whitefly sampling protocol requires a minimum of 10 leaves per location, aphid and mite sampling requires at least 20 leaves per location. Using 20 leaves will increase the accuracy of whitefly assessment.

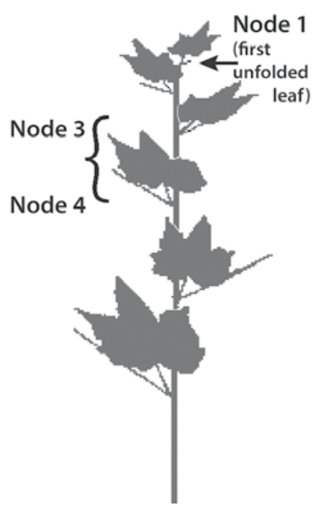
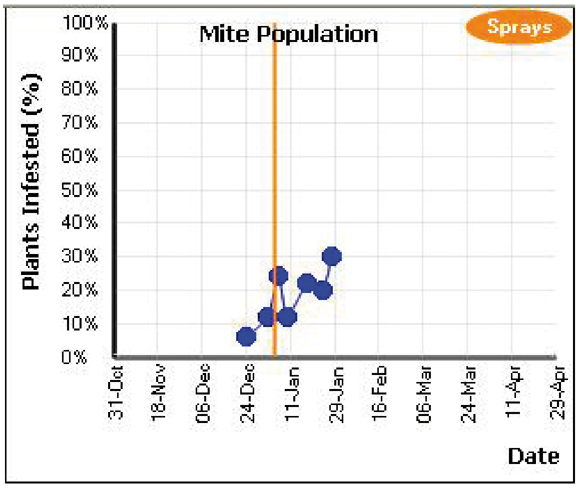


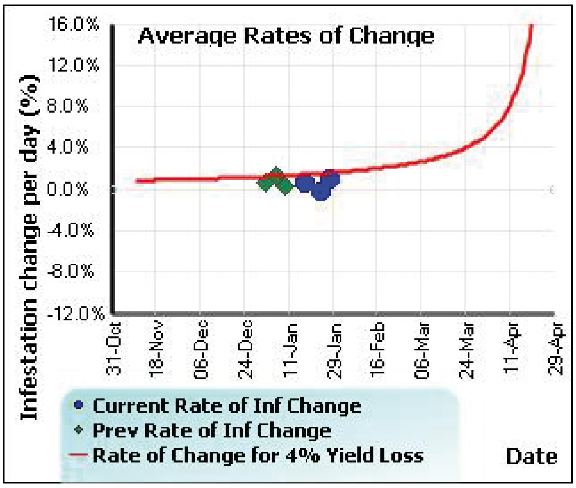
TABLE 7: Yield reduction caused by mites

The charts below can be used to estimate the percentage of yield reduction caused by mites, for different cotton growing regions.

Days from planting	Current % plants infested with mites																				
	10							30							60						
	Observed rate of increase (%/day)							Observed rate of increase (%/day)							Observed rate of increase (%/day)						
	0.5	1	1.5	2	3	5	7	0.5	1	1.5	2	3	5	7	0.5	1	1.5	2	3	5	7
Warmer regions; planting to 60% bolls open in 134–154 days. Biloela, Bourke, Emerald, Macintyre, Mungindi, St. George, Theodore and Walgett																					
10	1.1	4.0	8.6	14.9	32.8	89.3	100.0	1.8	5.2	17.2	10.3	36.1	94.7	100.0	3.1	7.3	13.2	20.8	41.2	100.0	100.0
20	1.0	3.5	7.4	12.9	28.2	76.7	100.0	1.6	4.6	9.0	14.9	31.2	81.6	100.0	2.6	5.8	10.3	16.0	31.2	76.7	100.0
30	0.9	3.0	6.3	10.9	23.9	65.0	100.0	1.5	4.0	7.8	12.9	26.7	69.6	100.0	2.6	5.8	10.3	16.0	31.2	76.7	100.0
40	0.7	2.5	5.3	9.2	20.0	54.3	100.0	1.3	3.5	6.7	10.9	22.6	58.4	100.0	2.4	5.2	9.0	13.9	26.7	65.0	100.0
50	0.6	2.1	4.4	7.6	16.5	44.5	86.2	1.1	3.0	5.6	9.2	18.8	48.3	91.5	2.2	4.6	7.8	11.9	22.6	54.3	99.6
60	0.5	1.7	3.6	6.1	13.3	35.7	69.1	1.0	2.5	4.7	7.6	15.4	39.1	73.8	2.0	4.0	6.7	10.0	18.8	44.5	81.1
70	0.4	1.4	2.8	4.8	10.4	27.9	53.9	0.9	2.1	3.8	6.1	12.3	30.9	58.0	1.8	3.5	5.6	8.4	15.4	35.7	64.5
80	0.3	1.1	2.2	3.7	7.9	21.0	40.5	0.7	1.7	3.1	4.8	9.5	23.7	44.1	1.6	3.0	4.7	6.8	12.3	27.9	49.9
90	0.3	0.8	1.6	2.7	5.7	15.1	29.1	0.6	1.4	2.4	3.7	7.1	17.4	32.2	1.5	2.5	3.8	5.5	9.5	21.0	37.1
100	0.2	0.6	1.1	1.9	3.9	10.2	19.5	0.5	1.1	2.8	2.7	5.1	12.1	22.1	1.3	2.1	3.1	4.2	7.1	15.1	26.2
110	0.1	0.4	0.7	1.2	2.4	6.3	11.9	0.4	0.8	1.3	1.9	3.4	7.7	13.9	1.1	1.7	2.4	3.2	5.1	10.2	17.2
120	0.1	0.2	0.4	0.6	1.3	3.3	6.1	0.3	0.6	0.8	1.2	2.0	4.3	7.6	1.0	1.4	1.8	2.3	3.4	6.3	10.0
130	0.1	0.1	0.2	0.3	0.5	1.2	2.3	0.3	0.4	0.5	0.6	1.0	1.9	3.2	0.9	1.1	1.3	1.5	2.0	3.3	4.8
140	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.2	0.2	0.3	0.3	0.3	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1.2	1.5
Average regions; planting to 60% bolls open in 161–170 days. Dalby, Gwydir, Lockyer, Lower Namoi																					
10	1.5	5.3	11.5	20.0	44.1	100.0	100.0	2.3	6.7	13.5	22.6	47.9	100.0	100.0	3.7	9.0	16.7	26.7	53.9	100.0	100.0
20	1.3	4.7	10.1	17.6	38.8	100.0	100.0	2.0	6.0	12.0	20.0	42.3	100.0	100.0	3.4	8.2	15.0	23.9	47.9	100.0	100.0
30	1.2	4.1	8.8	15.4	33.8	92.0	100.0	1.9	5.3	10.6	17.6	37.1	97.4	100.0	3.2	7.4	13.5	21.3	42.3	100.0	100.0
40	1.0	3.6	7.7	13.3	29.1	79.1	100.0	1.7	4.7	9.3	15.4	32.2	84.2	100.0	2.9	6.7	12.0	18.8	37.1	92.0	100.0
50	0.9	3.1	6.5	11.3	24.8	67.3	100.0	1.5	4.1	8.0	13.3	27.6	71.9	100.0	2.7	6.0	10.6	16.5	32.2	79.1	100.0
60	0.8	2.6	5.5	9.5	20.8	56.3	100.0	1.3	3.6	6.9	11.3	23.4	60.6	100.0	2.5	5.3	9.3	14.3	27.6	67.3	100.0
70	0.6	2.2	4.6	7.9	17.2	46.4	89.9	1.2	3.1	5.8	9.5	19.5	50.3	95.2	2.3	4.7	8.0	12.3	23.4	56.3	100.0
80	0.5	1.8	3.7	6.4	13.9	37.4	72.4	1.0	2.6	4.9	7.9	16.0	40.9	77.2	2.0	4.1	6.9	10.4	19.5	46.4	84.7
90	0.4	1.4	3.0	5.1	10.9	29.4	56.8	0.9	2.2	4.0	6.4	12.9	32.5	61.0	1.9	3.6	5.8	8.7	16.0	37.4	67.7
100	0.4	1.1	2.3	3.9	8.4	22.3	43.0	0.8	1.8	3.2	5.1	10.0	25.0	46.8	1.7	3.1	4.9	7.1	12.9	29.4	52.6
110	0.3	0.8	1.7	2.9	6.1	16.2	21.2	0.6	1.4	2.5	3.9	7.6	18.6	34.4	1.5	2.6	4.0	5.7	10.0	22.3	39.5
120	0.2	0.6	1.2	2.0	4.2	11.1	21.3	0.5	1.1	1.9	2.9	5.5	13.1	23.9	1.3	2.2	3.2	4.5	7.6	16.2	28.2
130	0.2	0.4	0.8	1.3	2.7	7.0	13.3	0.4	0.8	1.4	2.0	3.7	8.5	15.4	1.2	1.8	2.5	3.4	5.5	11.1	18.8
140	0.1	0.3	0.5	0.7	1.5	3.8	7.1	0.4	0.6	0.9	1.3	2.3	4.9	8.7	1.0	1.4	1.9	2.4	3.7	7.0	11.3
150	0.1	0.1	0.2	0.3	0.6	1.6	2.9	0.3	0.4	0.6	0.7	1.2	2.3	3.9	0.9	1.1	1.4	1.6	2.3	3.8	5.7
160	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.2	0.3	0.3	0.3	0.4	0.7	1.0	0.8	0.8	0.9	1.0	1.2	1.6	2.0
Cooler regions; planting to 60% boll open in > 170 days. Boggabri, Breeza, Cecil Plains, Pittsworth, Trangie																					
10	1.7	6.3	13.6	23.7	52.2	100.0	100.0	2.6	7.7	15.7	26.5	56.3	100.0	100.0	4.1	10.2	19.2	30.9	62.8	100.0	100.0
20	1.6	5.6	12.1	21.0	46.4	100.0	100.0	2.3	7.0	14.1	23.7	50.3	100.0	100.0	3.8	9.4	17.4	27.9	56.3	100.0	100.0
30	1.4	4.9	10.7	18.6	40.9	100.0	100.0	2.1	6.3	12.6	21.0	44.5	100.0	100.0	3.5	8.5	15.7	25.0	50.3	100.0	100.0
40	1.2	4.3	9.4	16.2	35.7	97.4	100.0	1.9	5.6	11.1	18.6	39.1	100.0	100.0	3.3	7.7	14.1	22.3	44.5	100.0	100.0
50	1.1	3.8	8.1	14.1	30.9	84.2	100.0	1.7	4.9	9.8	16.2	34.1	89.3	100.0	3.0	7.0	12.6	19.8	39.1	97.4	100.0
60	0.9	3.3	7.0	12.1	26.5	71.9	100.0	1.6	4.3	8.5	14.1	29.4	76.7	100.0	2.8	6.3	11.1	17.4	34.1	84.2	100.0
70	0.8	2.8	5.9	10.2	22.3	60.6	100.0	1.4	3.8	7.3	12.1	25.0	65.0	100.0	2.6	5.6	9.8	15.1	29.4	71.9	100.0
80	0.7	2.3	4.9	8.5	18.6	50.3	97.4	1.2	3.3	6.3	10.2	21.0	54.3	100.0	2.3	4.9	8.5	13.1	25.0	60.6	100.0
90	0.6	1.9	4.1	7.0	15.1	40.9	79.1	1.1	2.8	5.3	8.5	17.4	44.5	84.2	2.1	4.3	7.3	11.1	21.0	50.3	92.0
100	0.5	1.6	3.3	5.6	12.1	32.5	62.8	0.9	2.3	4.3	7.0	14.1	35.7	67.3	1.9	3.8	6.3	9.4	17.4	40.9	74.3
110	0.4	1.2	2.6	4.3	9.4	25.0	48.3	0.8	1.9	3.5	5.6	11.1	27.9	52.2	1.7	3.3	5.3	7.7	14.1	32.5	58.4
120	0.3	0.9	1.9	3.3	7.0	18.6	35.7	0.7	1.6	2.8	4.3	8.5	21.0	39.1	1.5	2.8	4.3	6.3	11.1	25.0	44.5
130	0.2	0.7	1.4	2.3	4.9	13.1	25.0	0.6	1.2	2.1	3.3	6.3	15.1	27.9	1.4	2.3	3.5	4.9	8.5	18.6	32.5
140	0.2	0.5	0.9	1.6	3.3	8.5	16.2	0.5	0.9	1.6	2.3	4.3	10.2	18.6	1.2	1.9	2.8	3.8	6.3	13.1	22.3
150	0.1	0.3	0.6	0.9	1.9	4.9	9.4	0.4	0.7	1.1	1.6	2.8	6.3	11.1	1.1	1.6	2.1	2.8	4.3	8.5	14.1
160	0.1	0.2	0.3	0.5	0.9	2.3	4.3	0.3	0.5	0.7	0.9	1.6	3.3	5.6	0.9	1.2	1.6	1.9	2.8	4.9	7.7
170	0.0	0.1	0.1	0.2	0.3	0.7	1.2	0.2	0.3	0.4	0.5	0.7	1.2	1.9	0.8	0.9	1.1	1.2	1.6	2.3	3.3

MITE YIELD LOSS ESTIMATOR CHARTS





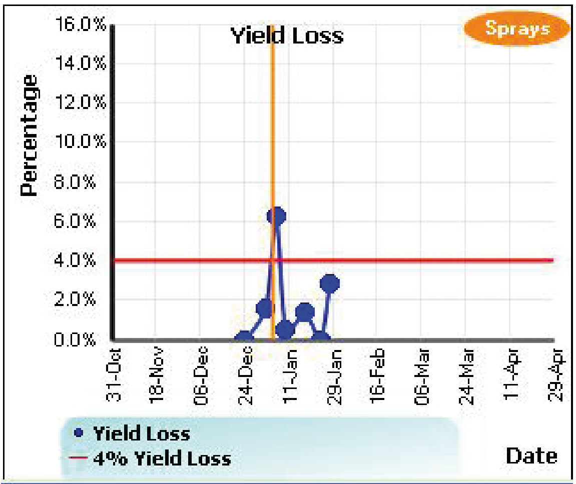


TABLE 8: Control of mites

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.#
Amitraz	200 g/L EC	2.0 L/ha	Suppression when used for controlling Helicoverpa
Bifenthrin	100 g/L EC 250g/L EC	0.6–0.8 L/ha 0.24–0.32L/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 480 g/L EC	4.0 L/ha 2.0 L/ha	NSW registration only. Apply by ground rig at first appearance of mites before row closure.#
Dimethoate	400 g/L EC	0.5 L/ha.	Will not control organophosphate-resistantmites. Do not harvest for 14 days after application. Do not graze or cut for stockfood for 14 days after application.#
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 .Refer to label for no-spray zones and record keeping.Best 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 at time of planting.
		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 & WA registration only.
Propargite	600 g/L EC	2.5 L/ha	Apply as spray before mite infestations reach damaging levels as maximum efficacy is not reached until 2 weeks after spraying.

#See label for instructions to minimise impact on bees.

Whitefly

Silverleaf whitefly (SLW) or B biotype – *Bemisia tabaci*

SLW is a major pest due to contamination of cotton lint by honeydew and resistance to many insecticides. Greenhouse whitefly (*Trialeurodes vaporiorum*) and Australian Native whitefly (*Bemisia tabaci*) are present in cotton but not considered pests, as their honeydew secretions do not cause problems for textile processing, and they are both susceptible to many of the insecticides used to control other pests.

Damage symptoms

SLW adults and nymphs cause contamination of lint through their excretion of honeydew. Silverleaf whitefly honeydew is considered to be worse than aphid honeydew because the main sugar in SLW honeydew, trehalulose, has a lower melting point and during the processing stage, can cause machinery to gum up and overheat.

Sampling

Sample for Species and Population.

Species: Verify which whitefly species are present before implementing any management strategies. Species composition may change rapidly during the season due to factors such as insecticide applications and climate. If large increases in population occur, this probably indicates the predominance of SLW. Consider insecticide application history for the crop as a clue to species composition.

Greenhouse whitefly can be visually differentiated from *Bemisia tabaci* by comparing their wing shape in adults and the presence/absence of hairs on the nymphs (see photographs this page).

The different biotypes of *Bemisia tabaci* cannot be distinguished by eye. While other biotypes of *Bemisia tabaci* such as Q-biotype haven't been detected in widespread monitoring of Australian cotton, it is important to continue to check for their presence. A molecular test is needed. This test and the industry's resistance monitoring program are being conducted by entomology staff at Qld DAFF, Toowoomba.

Collect a minimum of 50 4th instar whitefly from cotton leaves across the whole sampling area (i.e. do not collect nymphs from only 1 or 2 leaves).

Population: Once you have confirmed the presence of SLW, effective sampling is the key to successful management.

Note the gap between wings for SLW (left) compared with overlapping wings for Greenhouse whitefly (right). (Richard Lloyd, Qld DAFF)

Note absence of hairs on SLW nymph (left) compared to presence on Greenhouse whitefly (right). (Richard Lloyd, Qld DAFF)

Frequency

Sampling should commence at flowering and occur twice weekly from peak flowering (1300 Day Degrees).

1. Define your management unit

- A management unit can be a whole field or part of a field – no larger than 25 ha.
- Each management unit should have a minimum of 2 sampling sites.
- Sample 10 leaves/site (20 leaves/management unit).

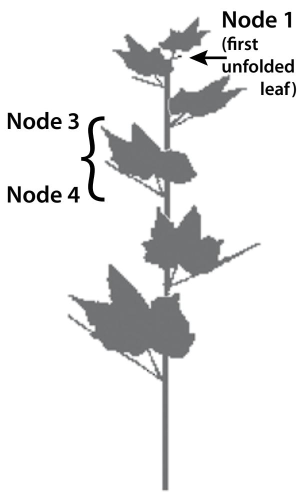
2. Choose a plant to sample

- Move at least 10 m into the field before choosing a plant to sample.
- Choose healthy plants at random, avoiding plants disturbed by sweep sampling.
- Take only one leaf from each plant.
- Sample along a diagonal or zigzag line. Move over several rows, taking 5–10 steps before selecting a new plant.

3. Choose a leaf

- From each plant choose a mainstem leaf from either the 3rd, 4th or preferably the 5th node below the terminal of the plant, as shown in the diagram.

Estimate Whitefly Abundance



Adults

Binomial sampling (presence/absence) is highly recommended as it is less prone to bias than averaging the number of whitefly/leaf.

Score leaves with 2 or more whitefly adults as 'infested'. Score leaves with 0 or 1 whitefly adults as 'uninfested'.

Calculate the percentage of infested leaves.

Nymphs

- Nymph abundance is not used in the Threshold Matrix. Use it as supporting information only.
- The presence of large nymphs on leaves at 6, 7 and 8 nodes below the plant terminal validate the assumptions about SLW population dynamics that underpin the spray thresholds. As leaves are assessed for SLW, they can be picked and used to monitor populations of aphids and mites.

Thresholds

For SLW, there are separate thresholds for early season suppression, control and for knockdown late in the season. Thresholds are based on rates of population increase relative to the accumulation of day degrees and crop development. A Threshold Matrix has been developed to assist in the interpretation of population monitoring data. Frequent population monitoring is essential in order to use the Threshold Matrix effectively (see page 29).

The SLW threshold matrix is designed to manage a population that builds gradually in the crop and hence follows a predictable growth trajectory. Large populations of adult silverleaf whitefly migrating into cotton crops will therefore reduce the reliability of the threshold matrix. This can occur if SLW adults leave crops that have been defoliated and seek new hosts. Decisions for management need to consider time of season, time to defoliation and evidence of honeydew. If the crop is maturing early in warmer conditions that the chance that eggs laid by immigrating whitefly will develop into nymph populations that could contaminate lint is high, where as if the crop is maturing later, when it is cooler this is less likely. Similarly, the closer to defoliation that the influx occurs the lower risk that a nymph population will have time to develop. Finally, honeydew on leaves is a good indicator of potential lint contamination. Once there is significant honeydew on lower leaves some remedial action should be taken to prevent contamination of bolls. In the worst case scenario, where cotton lint has been contaminated with honeydew, delaying harvest may assist in breaking down honeydew or expose the crop to rainfall that will remove most of the honeydew. However, if conditions remain dry reduction in the amount of honeydew on bolls will be slow, and there is a risk that contaminated cotton may still have sufficient honeydew to result in substantial penalties if harvested.

Parasitised SLW nymph. (Zara Hall, formerly Qld DAFF)

LATE SEASON SLW MASS IMMIGRATION SCENARIO DECISION CASE STUDY

Crop with low or no SLW experiences a mass immigration of SLW adults	>3 wks till leaf drop	Eggs may have time to develop to nymphs that could produce honeydew	Little or no honeydew on leaves in lower canopy	Monitor
			Heavily speckled leaves in lower canopy	Control (Admiral® or Movento®)
	<2 weeks till leaf drop	Too little time for nymph population to develop so manage adults.	Little or no honeydew on leaves in lower canopy	Monitor
			Heavily speckled leaves in lower canopy	Knockdown &/or defoliate early &/or delay picking if bolls contaminated

Key beneficial insects

Several species of whitefly parasitoids and parasites have been observed in Australia including several species of *Encarsia* and *Eretmocerus*. Predators of nymphs include big-eyed bugs, pirate bugs, lacewing larvae and ladybeetles.

Species verification and resistance monitoring

Sending collections to Qld DAFF Toowoomba

Pack the leaves in a paper bag and then inside a plastic bag. Pack this in an esky with an ice brick that has been wrapped in newspaper. Send by overnight courier to;

Richard Lloyd
Qld DAFF
203 Tor Street, Toowoomba QLD 4350
Phone (07) 4688 1315

Ensure samples are clearly labelled and include the following information:

Collector's Name ....

Phone No. ....

Farm Name ....

Fax No. ....

Email address..

Field .... Postcode ....

Region (e.g. Gwydir)..

Date of collection .... /.......... /..........

Comments ....

....

....

....

....

....

Selecting an insecticide

Natural enemies can play a vital role in the successful management of whitefly. Avoid early season use of broad spectrum insecticides, particularly synthetic pyrethroids and organophosphates. Currently there are few products registered for the control of whitefly in cotton in Australia. The SLW threshold matrix identifies the optimium strategic times for use of these limited products.

Resistance profile – SLW

When silverleaf whitefly was first identified in Australia in 1994 it already possessed resistance to many older insecticide groups. Four products all with different modes of action are currently registered for control of SLW in cotton. Refer to the SLW Threshold Matrix, page 29, for industry recommendations on the best way to utilise these products with the lowest risk of developing resistance. The SLW Threshold Matrix is designed to minimise the need to intervene with chemical control as well as to delay the development of resistance. Currently there are low levels of resistance to Admiral and Bifenthrin and no resistance to Pegasus and Movento. Compliance with the IRMS will ensure the limited products available for SLW control will remain efficacious into the future. To delay the development of resistance, ENSURE ONLY A SINGLE APPLICATION OF ADMIRAL OCCURS WITHIN A SEASON.

WIDESPREAD, HIGH LEVELS OF RESISTANCE	WIDESPREAD, LOW/MOD LEVELS OF RESISTANCE
pyrethroids (SP)	Insect Growth Regulators (IGRs)
CROSS RESISTANCE	
There is cross-resistance between other pyrethroids and Bifenthrin.	

Overwintering habit

Whitefly does not have an overwintering diapause stage. It relies on alternative host plants to survive. Generation times are temperature dependent, slowing down during winter months. From Biloela north, the winter generation time is 80 days, while in the Macintyre, Gwydir and Namoi valleys, generation time increases to 120 days.

Alternative hosts

The availability of a continuous source of hosts is the major contributing factor to a severe whitefly problem. Even a small area of a favoured host can maintain a significant whitefly population.

Preferred weed hosts include; sow thistle, melons, bladder ketmia, native rosella, rhynchosia, vines (cow, bell and potato), rattlepod, native jute, burr gerkin and other Cucurbitaceae weeds, Josephine burr, young volunteer sunflowers, Euphorbia weeds, poinsettia and volunteer cotton.

In cotton growing areas the important alternative crop hosts are soybeans, sunflowers and all cucurbit crops. Spring plantings of these crops may provide a haven for SLW populations to build up in and then move into cotton. Autumn plantings of these crops may be affected by large populations moving out of cotton. Do not plant cotton near good SLW host crops such as melons. Destroy crop residue from all susceptible crops immediately after harvest.

Minimising winter hosts, particularly sowthistle, is important in reducing the base population at the start of the cotton season. Smaller base populations will take longer to reach outbreak levels and reduce the likelihood that a particular field will need to be treated.

Further Information:

Qld DAFF, Toowoomba
Jamie Hopkinson: 07 4688 1152.
Richard Lloyd: (07) 4688 1315.
Paul Grundy: (07) 4688 1533 or 0427 929 172

Qld DAFF, Emerald
Richard Sequeria: (07) 4983 7410 or 0407 059 066.

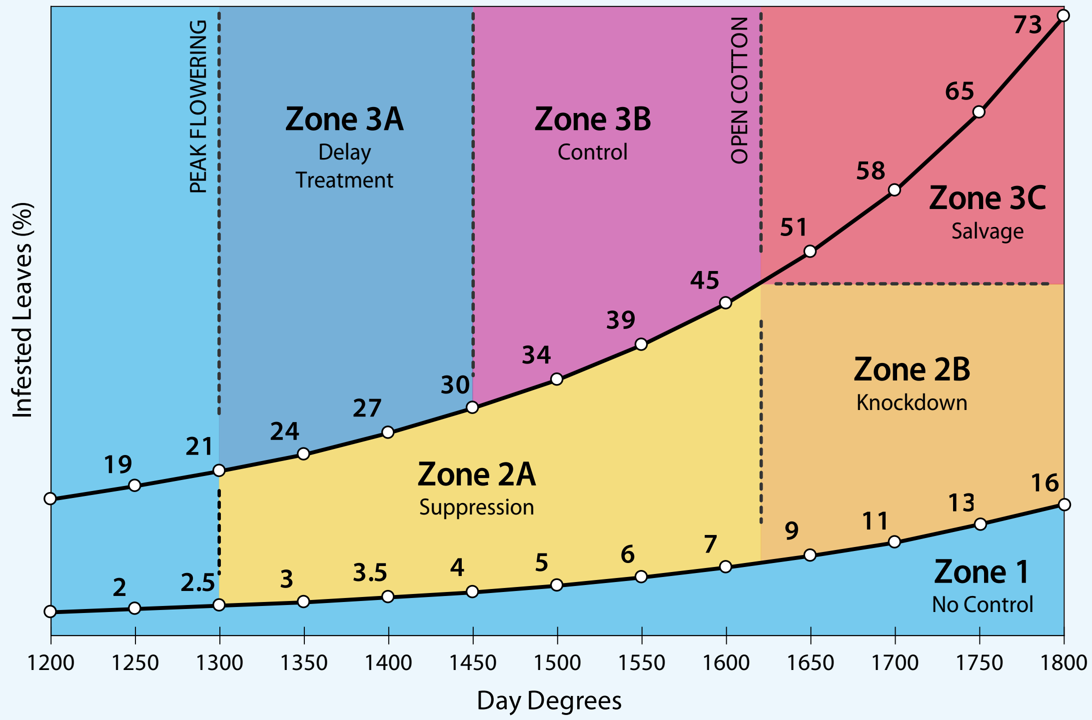
Silverleaf Whitefly Threshold tool on www.cottassist.com.au

TABLE 9: Control of silverleaf whitefly

Active ingredient	Concentration and formulation	Application rate of product	Comments
Silverleaf whitefly *Bemisia 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.#
Paraffinic oil	792 g/L SC	2% V/V (min 2L per sprayed ha)	Most effective when targetting low, early season populations. Apply in a minimum of 100 litres per hectare for ground applications. Multiple applications are more effective.
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.
Spirotetramat	240g/L SC	0.3–0.4L/ha + Hasten Spray Adjuvant 1.0L/ha	Use the higher rate when periods of high pest pressure or rapid crop growth are evident, and when crops are well advanced. Do not re-apply within 14 days. Do not apply more than 2 applications per crop. Spirotetramat may not control silverleaf whitefly adults and eggs, however a decline in the total silverleaf whitefly population will occur over time as the juvenile stages are controlled.

#See label for instructions to minimise impact on bees.

SLW THRESHOLD MATRIX



NOTES	
Sampling protocol	Sample 20 leaves 3rd, 4th or 5th node below the terminal/25 ha weekly from first flower (777 DD) and twice weekly from peak flowering (1300 DD). Convert to % Infested leaves. Infested leaves are those with 2 or more adults. Uninfested leaves are those with 0 or 1 adult.
Day Degrees	Daily Day Degrees (DD) are calculated using the formula; DD = [(Max °C – 12) + (Min °C – 12)] ÷ 2 For day degree information from your nearest SILO weather station visit www.cottassist.com.au For a mid-September planting in Emerald, long term average weather data predicts the duration of Zone 3A is 9 days, Zone 3B is 11 days and Zone 3C is 14 days.
Zone 1 No Control	Insecticide use is not warranted for fields with low SLW densities. In this zone the risk of yield loss or lint contamination is negligible, even when populations are sustained throughout flowering and boll fill.
Zone 2A Suppression	This Zone represents a wide window of opportunity for the most economic and low-risk control of SLW. Conventional (non-IGR) insecticides, such as diafenthiuron (Pegasus), can control or provide useful suppression of low-medium density populations. Movento can control a wide range of nymphal population densities.
Zone 2B Knockdown	Lint contamination can result from uncontrolled medium density populations in-crops with open bolls. Early action in Zone 2A can prevent the need for higher-risk remedial action in Zone 2B. Pegasus may be effective for remedial control (knockdown) of population densities up to 45% infested leaves in Zone 2B. (NOTE: The Pegasus label indicates that the product may not give satisfactory control of populations >25% infested leaves. This is based on an overseas sampling model. For Australian conditions this equates to ~45% infested leaves). Efficacy will depend upon coverage and environmental conditions. For higher densities approaching the Zone's upper boundary, an application of Zone 3B products may ultimately be required.
Zone 3A Delay Treatment	Controlling high density populations before 1450 DD is not recommended due to the likely resurgence of the population and need for additional control to protect lint from honeydew. Delay control until Zone 3B.
Zone 3B Control	Where populations are mid to high density, targeting an application when the crop is between 1450 and 1650 DD, (allowing the product to be come active prior to the onset of boll opening), greatly reduces the risk of lint contamination and the need for further controls. IGR products such as pryiproxifen, trade name Admiral, and non-IGR products such as Spirotetramat (trade name Movento), are effective in this zone. ENSURE ONLY A SINGLE APPLICATION OF ADMIRAL OCCURS WITHIN A SEASON. Delaying IGR use beyond 50% infested leaves or 1650 DD can result in yield loss, lower efficacy of the IGR and significant lint contamination. Do not apply more than 2 applications of Movento within a season. Use the higher rate when periods of high pest pressure or rapid crop growth are evident, when longer residual control is desired or when crops are well advanced.
Zone 3C Salvage	Once the populations exceeds 50% leaves infested, the use of an IGR by itself is unlikely to prevent lint contamination due to the inherent time delay in population decline following application. Rapid knockdown of the population using a conventional insecticide is required before applying the IGR (or similar). The lack of insecticides offering robust knockdown of SLW at high densities make this a 'high risk' zone.

Check the APVMA website for other control options that may become available in cotton under permit – www.apvma.gov.au

Thrips

Tobacco thrips – *Thrips tabaci*
Tomato thrips – *Frankliniella schultzei*
Western flower thrips – *F. occidentalis*

Damage symptoms

Nymphs and adults cause early season damage to terminals, leaves, buds and stems. While recognised as a pest, thrips are also a key predator of spider-mite eggs.

Sampling

Sample for the number of thrips /plant. Check for the presence of nymphs as well as adults. The presence of nymphs tells if the population is actively breeding. Crops that have had an insecticide seed treatment or in-furrow insecticide treatment may have adult thrips but no nymphs and little plant damage.

Sample for the severity of damage to the seedlings. Late season, thrips may reach high numbers in flowers and on cotton leaves, especially in-crops where there has been either little or no insecticide use. These thrips help to control mites. Late season thrips damage would rarely justify control.

Frequency

Sample at least weekly.

Begin sampling at seedling emergence and continue sampling until thrips abundance declines and plants begin to recover.

Methods

Use whole plant visual assessment, with the aid of a hand lens for the observation of nymphs. Check the number of thrips on 20–30 separate plants for every 50 ha of crop.

When assessing leaf damage, a rough guide is, if the average size of a thrips damaged leaf is less than 1 cm^2, then leaf area reduction is often greater than 80%.

Look for symptoms of tip damage. Tip damage caused by thrips appears as extensive crumpling and blackening of the edges of the small leaves within the terminal. For thrips to cause tip damage, they must be present in high numbers (> 30/plant).

Thresholds

As thrips occur in cotton in most years the most effective management option is to use a seed treatment or at planting insecticide applied with the seed. This protects plants during the establishment phase and has the advantage of being less likely of negatively affecting beneficial species (predators or parasites) than an insecticide applied to the crop after emergence. Thrips damage to leaves (very common) can result in delayed maturity or even yield loss if very severe. In warm/hot climates, plants have an ability to outgrow and compensate for thrips damage and yield loss due to thrips damage is only likely 1 year in 10. In regions with cooler climates early season, where season length is limited, there is less ability to compensate and yield loss may be incurred 1 year in 2. In both instances the seed treatment or at planting insecticide applied with the seed should provide sufficient control for plants to establish. Thrips populations will decline naturally in early December. Thrips are also often blamed for tipping out, but are rarely the cause.

In some instances, populations of thrips will remain high and plant growth delayed by cool, wet weather. In these situations, seed treatments or at planting insecticides may run out and supplementary control necessary according to the thresholds below.

Western flower thrips is not controlled by the current seed treatments or at planting insecticides, but this species is not normally abundant early season in cotton.

SEEDLING TO 6 TRUE LEAVES
80% reduction in leaf area + 10 thrips /plant (adults and nymphs)

Thrips can also be found in cotton in the mid and late season. These are usually Frankliniella spp. Adult thrips can be found in flowers where they feed on pollen, but it is unlikely that they affect pollination or fruit set. Eggs are laid on leaves and the hatching larvae may cause some damage to the undersides of leaves. Research has shown that high levels of damage would be required to affect yield, and control should not be considered unless >50% of leaf area is damaged and the crop is pre-cutout. These larvae are also predatory and will eat spider mite eggs, often presenting mites outbreaks from developing.

Key beneficial insects

Predators – pirate bug, green lacewing larvae, brown lacewing, ladybeetles.

Selecting an insecticide

The insecticide products registered for the control of thrips in cotton in Australia are presented in Table 10, page 31. When deciding whether or not to control thrips with an insecticide, an important consideration is the benefit of thrips to cotton crops as predators of spider mites.

Resistance profile – Western flower thrips

WIDESPREAD, HIGH LEVELS OF RESISTANCE	WIDESPREAD, LOW/MOD LEVELS OF RESISTANCE
pyrethroids (SP)	chlorpyrifos (OP)
OCCASIONAL DETECTION OF HIGH LEVELS OF RESISTANCE	**OCCASIONAL DETECTION OF LOW LEVELS OF RESISTANCE**
	dimethoate (OP)

No resistance to insecticides has been detected in Australia for tobacco thrips or tomato thrips.

Overwintering habit

Thrips prefer milder temperatures. Populations decline at temperatures greater than 30°C. Thrips are active and common through winter.

Alternative hosts

In spring, large numbers of thrips have been observed on flowers of cereal crops and winter weeds. Thrips then transfer to cotton as these hosts dry out or hay off. Cotton crops planted adjacent to cereal crops are particularly at risk of infestation by thrips. In the absence of pollen, thrips feed on other sources of protein such as mite eggs.

Further Information:

CSIRO Plant Industries, Narrabri
Lewis Wilson: (02) 6799 1550 or 0427 991 550.

NSW DPI, Camden
Grant Herron: (02) 4640 6471.

TABLE 10: Control of thrips

Active ingredient	Concentration and formulation	Application rate of product	Comments
Thrips (Tobacco thrip *Thrips tabaci* and Tomato thrip Frankliniella schultzei)			
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. Do not harvest for 14 days after application. Do not graze or cut for stockfood for 14 days after application.#
Fipronil	200 g/L SC 800 g/L WG	0.0625–0.125 L/ha 15.5 -30.0 g/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 at time of planting.
		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.

#See label for instructions to minimise impact on bees.

Australian plague locust

Chortoicetes terminifera

Very rarely are plague locusts a problem for cotton, but large swarms of plague locusts during autumn can result in significant egg lays. Locusts are able to travel up to 500 km in a night on the winds so can be a threat even if not experienced locally in the previous season. Whilst cotton is not a preferred food source for locust there have been a number of instances in southern NSW where control has been required.

Threat of attack could be from bands of hatchlings for instance in adjacent areas or from swarms that fly in from elsewhere. Locusts can actually mow the cotton plants down and can cause significant damage especially when cotton is at the seedling stage.

Damage symptoms

Severe damage directly attributed to chewing.

Sampling

An important aspect of responding to the threat of locust plagues is surveillance and monitoring. In NSW, land managers have a legal obligation to report the prescence of locusts on their properties to their Livestock Health and Pest Authorities (LPHA). In Queensland, landholders are asked to report the prescence of locusts to Biosecurity Queensland (BQ), although there is no legal requirement. While high numbers will be seen very easily visually, it will pay to inspect the perimeters of fields to detect the occurrence of any banding of emerging locust as early as possible. These state authorities may also implement surveillance and monitoring programs to determine the extent of locust outbreaks in an area and evaluate the success of control methods.

Threshold

Threshold based on plant damage. Locust can cause significant damage in a short period of time especially if cotton small.

Key beneficials

Birds do eat locusts yet there are no beneficials that could control the numbers present when swarming occurs.

Selecting an insecticide

In selecting control options it is essential to consider the risk of flaring secondary pests. Choosing an appropriate chemical that fits within the IRMS will be a challenge. As an occasional pest, there are few products registered for their control in cotton. Diazinon and chlorpyrifos are registered – check label for rates and further information. At times of high risk permit applications may be made. Contact Cotton Australia for more information. Seedling cotton may require quicker action.

Thrip damage to lower nodes with terminal showing new growth without damage. Plant is likely to recover however continue to monitor. (Photo: Lewis Wilson, CSIRO)

In some states free insecticide may be available for locust control in certain circumstances. In NSW, the LPHA coordinate locust control activities. The primary aim of this service is to protect crops and pastures, but the circumstances in which free insecticide may be provided may not be consistent with what is required to protect cotton crops. In NSW, free insecticide will only be provided to LPHA rate payers once locust nymphs have banded. BQ coordinates locust control in Qld, and undertake strategic aerial control of locusts where there is any threat of migration to/within the area where Local Governments make contribution to the Contingency Fund. BQ does not directly protect crops.

Further Information

In NSW – contact your local Livestock Health and Pest Authority. www.lhpa.org.au

In QLD – contact your local Biosecurity Officer 132523

Australian Plague Locust Commission (APLC) www.daff.gov.au/animal-plant-health/locusts

Green Vegetable Bug (GVBs)

Nezara viridula

Damage symptoms

Nymphs and adults cause dull to black shiny spots on the boll walls, warty growth inside the carpels and brown staining of lint in developing bolls. In severe case, it is hard to peel the carpel off the damaged lint which may result tight lock and yield loss. Damage symptoms cannot be distinguished from those caused by mirids. GVB damage varies with boll age, small bolls will suffer more damage than old bolls. Bolls aged up to 7 days old could drop. Eight to 24 days old bolls will not drop but still can suffer significant damage. Bolls aged 25 days and above will not suffer any damage.

Sampling

Sample for adults and nymphal instars of the pest. GVB instars four and five inflict the same amount of damage as adults. Third instar GVBs cause half the damage of adults, and a cluster (more than 10) of first and second instars cause as much damage as one adult.

It is important to correctly identify which instars are present to determine whether or not the population has reached the threshold.

Instar	Instar length (mm)	Description
1	1	Predominately orange
2	2	Black with 1 or 2 white spots
3	4	Mosaic pattern of green, black and red spots
4	7	More green spots, wings begin to develop during late 4th instar
5	10	Spots start to diminish to green, wings well developed
Adult	15	All green with wings

Monitor fruit retention as well as for the presence of the pest.

Frequency

Sample at least weekly.

The crop is most susceptible to damage from flowering through until one open boll/m. Monitor fruit retention and pest presence from the beginning of squaring.

TABLE 11: Control of green vegetable bug

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. Do not harvest for 14 days after application. Do not graze or cut for stockfood for 14 days after application.#
Fipronil	200 g/L SC	0.0625–0.125 L/ha	Apply when pests appear. Use higher rate when higher infestations are present.#
Clothianidin	200 g/L SC	0.125–0.25L/ha + Maxx Organsilicone Surfactant 0.02L/L of water	Use higher rate when heavy infestations is expected and longer control is required. Treated insects may still be on plant 2 or 3 days after application but will have stopped feeding.

#See label for instructions to minimise impact on bees.

GVB will use turnip weed as a host in spring. (Lewis Wilson, CSIRO)

Methods

GVBs are most visible early to mid morning making checking easier at this time. Visual sampling and beat sheets are equally effective checking methods while the crop is squaring. From flowering onwards when the crop is most susceptible to damage, beat sheeting is twice as efficient for detecting GVBs. Although beat sheet sampling is efficient it may tend to give a lower population than the actual number in the field. It has been found that the first and second instars tend to hide in the bracts and may be difficult to dislodge.

Even when pests are not observed, cut or squash 14 day old bolls to check for the presence of feeding damage. This will take the form of warty growths and/or brown staining of the developing lint.

Thresholds

Sampling Method	Flowering to First open boll	First open boll to Harvest
Visual	0.5 adults /m	0.5 adults /m
Beat Sheet	1.0 adult /m	1.0 adult /m
Damage to small bolls (14 days old)	20%	20%

Convert nymph numbers to adult equivalents and include in the counts. Fourth or fifth instars are each equivalent to 1.0 adult, each third instar counts as 0.5 adult and clusters of 10+ first/second instars count as 1.0 adult.

Comparing damage between stinkbugs using GVB adult equivalents

There are 5 more stinkbugs occasionally occur in cotton causing similar type of damage as GVB.

Other Stink Bugs	Proportion of damage compared to GVB	Threshold (based on GVB adult equivalents)
green stinkbug (GSB)	1/2	2
red banded shield bug (RBSB)	1/3	3
cotton stainer bug (CSB)	1/3	3
brown stinkbug (BSB)	1/4	4
harlequin bug (HRLQB)	1/4	4

Key beneficial insects

Parasites – *Trissolcus* is an egg parasite, they parasitise GVB eggs by inserting their eggs inside GVB eggs. After hatching they will remain inside GVB eggs to continue to feed and mature. *Trichopoda* is an adult parasite. They lay eggs on GVB adults and hatched out larvae bore into GVB and kill them.

GVB with 4 Trichopoda parasite eggs. (Hugh Brier DAFF Qld)

Selecting an insecticide

The insecticide products registered for the control of GVBs in cotton in Australia are presented in Table11. Mid-season use of dimethoate for GVB control could have implications for managing insecticide resistance in aphids.

Resistance profile

No GVB resistance to insecticides has been detected in Australia.

Overwintering habit

A high proportion of GVB adults enter a dormant phase (bronze colour) during late autumn. They overwinter in a variety of sheltered locations such as under bark, in sheds, and under the leaves of unharvested maize crops. A small proportion will remain green and active and will feed on whatever hosts are available.

Alternative hosts

In Queensland there are two GVB generations during the warmer part of the year. The preferred weed hosts of the first, spring generation include turnip weed, wild radish and variegated thistle. Early mungbean crops are also a favoured host in spring. The second generation breeds in late summer and early autumn. Pulse crops – particularly soybeans and mungbeans – are key hosts for this generation. GVB populations are usually much lower in mid summer, mainly due to a lack of suitable hosts. In NSW there is a summer/autumn generation, similar to the second generation in Queensland.

Further Information:

Qld DAFF, Toowoomba
Moazzem Khan: (07) 4688 1310 or 0428 600 705.

Pale cotton stainers
Dysdercus sidae

Damage symptoms

Pale cotton stainers are occasional pests of cotton in Australia. Economic damage is unusual because of their:

- Susceptibility to insecticides used for other pests;
- Inability to survive high temperatures (> 40°C); and,
- Need for free water to be present.

However in mild seasons Bollgard II crops may be a favourable environment for cotton stainers and they may need to be managed.

Pale cotton stainers are able to feed on both developing and mature cotton seed. Seed weight, oil content and seed viability all decline as a result of cotton stainer feeding. Loss of seed viability should be a consideration in pure seed crops.

Pale cotton stainers are able to damage bolls at any age. They will feed on young bolls, up to two weeks old, leading to boll shedding. Damage to older bolls, 20 days old onwards, usually shows no external symptoms and only small dark marks will be seen on the inside of the boll wall. At this stage most damage is to seeds, reducing their growth and sometimes lint production. Tightlock can result around damaged seeds, preventing the lint from fluffing out as the boll opens, and damaged locks (boll segments) often appear yellow or stained.

Juvenile pale cotton stainers are often found in aggregations low in the canopy. They will feed on developing bolls.
(Lewis Wilson, CSIRO)

Sampling

Sample for adults and nymphal instars of the pest as both stages can cause similar amounts of damage. Where adults and nymphs are observed feeding, monitor percentage damaged bolls.

Frequency

Sample at least weekly once bolls are present.

Usually cotton becomes infested by adults that fly into fields around the time of first open boll, though sometimes, perhaps due to seasonal conditions populations can be found earlier, during boll maturation. Flights of up to 15 km have been recorded. Adults will mate soon after arrival. The expanding population of developing nymphs is likely to cause economic damage.

Methods

Distribution through the field and through the canopy can be quite patchy, as adult females lay eggs in clusters in the soil or sometimes in open bolls. Ensure sampling occurs at multiple sites spread throughout the field. The beat sheet is a suitable sampling method however as some growth stages favour the lower canopy, visual searching is also a good complementary technique.

Bolls of varying ages should be cut open to confirm and monitor for signs of damage. Studies have shown pale cotton stainer bug cause almost no marking to the boll surface. Warty growths may be found on the inside of the boll wall if young bolls are damaged, but older bolls will not have these. To confirm damage bolls need to be opened and seeds cut and examined for browned, dried damage areas. After a week, the lint may begin to have a more yellow appearance and locks will be stuck to the boll wall – a good indication of pale cotton stainer feeding.

The mild, wet conditions that favour the survival of pale cotton stainers in cotton will also favour the occurrence of secondary infections by yeasts, Alternaria and bacteria in cracked bolls. These infections can cause tightlock and lint staining. The presence of pale cotton stainers when such damage occurs may be coincidental.

Thresholds

Action threshold during boll development:

When adults and nymphs are observed in the crop and damage to developing bolls is detected, an action threshold of 3 pale cotton stainers/m is recommended. This threshold is based on the relationship between cotton stainer damage and the damage caused by green vegetable bugs. Both nymphs (usually 3rd to 5th stage nymphs) and adults cause similar amounts of damage.

Action threshold after first open boll:

When adults and nymphs are observed feeding in open bolls, the threshold must consider the potential for quality downgrades of the lint as well as the loss of seed weight and seed viability. Where staining is observed a threshold of 30% of bolls affected should be used to prevent a colour downgrade.

Key beneficial insects

A range of natural enemies such as Tachinids (parasitic flies) and predatory reduvid bugs (e.g. assassin bugs) have been recorded in Africa. However, they have mainly exerted pressure when cotton stainers have been feeding on native hosts rather than in-cropping situations. The role of natural enemies in the control of developing populations of pale cotton stainers in Australia has not been studied.

Adult pale cotton stainers are often seen in maturing cotton, often as mating pairs. They can damage maturing bolls.
(Lewis Wilson, CSIRO)

Selecting an insecticide

As an occasional pest, there are few products registered for their control. The synthetic pyrethroids lambdacyhalothrin (Karate Zeon, Matador) and gamma-cyhalothrin (Trojan) are registered; check the labels of these products for more information. However their status as an occasional pest is influenced by their susceptibility to insecticides used for the control of Helicoverpa and other pests. Cotton stainers may be incidentally controlled when carbamates such as carbaryl or organophosphates such as dimethoate are used. Any decision to use broad spectrum insecticides such as SPs should take into account their impact on beneficial insects and the subsequent risk of flaring whitefly and other secondary pests should also be considered.

Resistance profile

Worldwide there are few records of resistance to insecticides developing in the field, however cotton stainers will react to selection pressure under laboratory conditions.

Overwintering habit

As there is no resting stage in the cotton stainer's lifecycle, cultural controls between cotton seasons assist greatly in limiting population development (see below).

Alternative hosts

Fuzzy cotton seed used for stockfeed is an important alternative source of food for cotton stainers. Avoid storing fuzzy seed in exposed places where cotton stainers can access this food source over long periods. Controlling ratoon and volunteer cotton is important for limiting cotton stainer's access to alternative food source.

Further Information
Qld DAFF, Toowoomba
Moazzem Khan: (07) 4688 1310 or 0428 600 705
CSIRO Plant Industry, Narrabri
Lewis Wilson: (02) 6799 1550

Solenopsis mealybug

Phenacoccus solenopsis

The solenopsis mealybug (*Phenacoccus solenopsis*) has been found in Burdekin, Central Queensland, Burnett and most recently Darling Downs cotton crops.

Damage symptoms

Nymphs and adults can affect plant growth at all stages of crop development. When infested during early development, plants exhibit distorted terminal growth, crinkled and bunchy leaves, and in severe cases plant death will occur. On older plants, mealybug can cause shedding of leaves, squares and small bolls as well as fewer, smaller and deformed bolls, and premature crop senescence. Heavy infestations (>500 mealybug in top 8 nodes at cut out) has been found to have an 80% reduction in harvestable bolls. Honeydew excreted by the insects onto the leaves and lint can promote the development of black sooty mould.

Sampling

At low densities, mealybugs can be present anywhere on the plant. Trials on mealybug distribution within the plant revealed that they like to aggregate on the underside of leaves and inside bracts of squares or bolls within the top 10 nodes. This suggests assessment of mealybug on these plant parts may give reliable estimations in the field.

Volunteer cotton in a field can be a source of mealybug within the crop. Volunteer cotton grows earlier than cultivated cotton and therefore attracts overwintering mealybug populations in the field (on the root zone of weed hosts or under the soil) and later disperses these to nearby cotton. Checking volunteer and adjacent cotton will help to detect early infestation in the field. Crop stress, such as waterlogging, may make cotton more susceptible to mealybug, so it is important to include stressed areas when checking e.g. tail drains. Investigate patches of stunted or dead plants. As solenopsis mealybug has a very wide host range, also monitor surrounding vegetation including gardens.

If mealybugs are found, contact: Melina Miles (07) 46881369 or Moazzem Khan (07) 4688 1310 to arrange identification and to help track distribution of the species.

Thresholds

Damage thresholds have been assessed, however it is important to note that there are no insecticides registered for the control

Mealy bug predators cryptolaemus lady beetle larva (left) and lacewing lavae (right), can look very similar to mealy bugs.
(Zara Hall and Paul Grundy, Qld DAFF)

of mealybugs and insecticides are not expected to be the main means of control. Trials on mealybug damage revealed that damage varies depending on which crop stage they commence establishment. The earlier they establish the more damage they cause. Establishment of mealybug up to early boll set stage causes significant yield loss. The damage thresholds of 25, 110 and 150 mealybugs per plant for seedling, squaring and early boll stages respectively, have been calculated. Once populations reach these points economic yield loss is expected.

Management strategy

There are a number of management options that can reduce the size of infestations, and the overall impact of this pest. Minimise the buildup of mealybug in volunteers, ratoons and weeds, particularly in fallows where cotton will be planted. Ensure effective crop destruction and continue to monitor fields post cotton for potential hosts. Natural enemies have proven to be very effective at reducing high mealybug populations, and minimising the build up of populations in-crops. Avoiding early season use of broad spectrum insecticides will help preserve natural enemies that may contribute to the control of mealybug infestations. Once mealybug are known to be in an area, consider increasing thresholds for other pests, and review all insecticides for their impact on mealybug predators prior to use. There is some anecdotal evidence that mealy bug may also be flared by foliar fertilisers.

- Monitor for presence of mealybug along with other pest monitoring. Include areas that are under stress where populations may develop first.
- Monitor abundance of adults, nymphs and natural enemies over time, this will provide a picture of whether the mealybug population is building up, stable or declining.
- Consider release of cryptolaemus and/or lacewings in hotspots.
- Be mindful of spreading infestations with machinery and passage of people through hotspots.
- Put into practice the industry Come-Clean-Go-Clean protocols to minimise the spread of mealybug.

Key beneficial insects

Predators – Three banded ladybird beetles, white collard lady beetles, lacewings, cryptolaemus, smudge bugs, earwigs and native cockroaches.

Aenaisus bamabwalei, a parasiotid of solenopsis mealybug parasitoids was reasonably wide spread during the 2012–13 season. Parasitoids are reportedly very effective in suppressing populations in India and Pakistan.

Survival

Key factors that contribute to solenopsis mealybug being a pest:

- All stages of mealybug can cause damage.
- They have a high reproductive rate. One female can produce hundreds of offspring. Eggs hatch out within in an hour.
- They shelter in protected positions on the cotton plant; in squares, bracts and under surfaces of leaves. The waxy coating on mealybugs is water repellent, making insecticide contact more difficult.
- They can be spread in the field by wind, surface water runoff, rain splash, birds, people and farm equipment. Mealybugs disperse as first instar 'crawlers'.
- Adults and large nymphs can survive for long periods without a host. Qld DAFF research found that the crawler stage can live for up to 6 days, and the 3rd instar stage for up to 50 days without food or water.

Over-wintering

Mealybugs, usually at the small and large nymph stage, can be found throughout winter on the root zone of weed hosts. During a severe winter they go under soil, loose soil and ant's nest on the ground help them to do so. Once the weather begins to warm, breeding and dispersal begins.

Alternative hosts

The solenopsis mealybug has a wide host range, and in Pakistan it has been recorded on 154 plant species including field crops, vegetables, ornamentals, weeds, and trees. In Australia, solenopsis mealybug has been recorded from a range of common weed species on farm such as pigweed, sow thistle, bladder ketmia, native rosella, vines (cow, bell and potato), crownbeard, stagger weed, marshmallow, verbena, raspweed, and volunteer cotton.

Further information:

Qld DAFF, Toowoomba
Melina Miles (07) 4688 1369
Paul Grundy (07) 4788 1533
Moazzem Khan (07) 4688 1310

Other pests

TABLE 12: Control of armyworm and cutworm

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 observed. Apply in a minimum of 100 L of water.#

#See label for instructions to minimise impact on bees.

TABLE 13: Control of wireworm

Active ingredient	Concentration and formulation	Application rate of product	Comments
Wireworm *Apryprius variabilis* and False wireworm *Pterohelaeus* spp.			
Bifenthrin	100 g/L EC 250 g/L EC	0.375 L/ha 0.15 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. Rate is based on 1m furrows.#
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.
Azadiractin A&B	5 g/L	0.8 L/ha	Apply product in the planting furrow to enable seed/soil contact. Apply in a minimum of 150 L of water per ha.

#See label for instructions to minimise impact on bees.

TABLE 14: Control of cotton leafhopper

Active ingredient	Concentration and formulation	Application rate of product	Comments
Cotton leafhopper (jassids) *Amrasca terraereginae*			
Beta-cyfluthrin	25g/L EC	0.06L/ha	Apply at recommended thresholds as indicated by field checks.#
Clothianidin	200 g/L SC	0.125–0.25L/ha + Maxx Organsilicone Surfactant 0.02 L/L of water	Apply when numbers reach threshold levels requiring treatment.
Dimethoate	400 g/L EC	0.35–0.375 L/ha (QLD&WA) 0.35 L/ha (NSW)	Do not harvest for 14 days after application. Do not graze or cut for stockfood for 14 days after application.#
Gamma- cyhalothrin	150 g/L CS	0.05 L/ha	Apply at recommended threshold levels as indicated by field checks.#
Lambda-cyhalothrin	250g/L	0.06 L/ha	Apply at recommended thresholds 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 and WA registration only.

#See label for instructions to minimise impact on bees.

TABLE 15: 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	100 g/L EC 250 g/L SC	0.3, 0.4 or 0.5 L/ha 0.12 or 0.16 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.#
Cypermethrin	200 g/L EC 250 g/L EC 260 g/L EC	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.#
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.
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

#See label for instructions to minimise impact on bees.

TABLE 16: 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	1.75L/ha 1.0 L/ha	WA & 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	2.5–3.5 L/ha 0.5–0.7 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.#

#See label for instructions to minimise impact on bees.

TABLE 17: Insect pest and damage thresholds

Insect pest	Planting to flowering (1 flower/m)	Flowering to 1 open boll/m	1 open boll/m to harvest: Up to 15% open	1 open boll/m to harvest: After 15% open	Comments
***Helicoverpa* spp. in conventional cotton**					
White eggs/m	–	–	–	–	**Egg thresholds** No egg threshold during pre-flowering due to high natural mortality. **Larval thresholds** Research on increasing the end of season thresholds has been carried out, and suggests that the threshold after 15% open can be raised to 5 total larvae/metre or 2 medium+large larvae /m. This research however, is preliminary and requires further analysis. The Helicoverpa development model in CottonLOGIC can be used to estimate the development of a given egg and larval population over the next three days, taking into account estimated natural mortality levels for the time of season.
Brown eggs/m	–	5	5	5	
Total larvae/m	2	2	3	5	
Medium and large larvae/m	1	1	1	2	
Helicoverpa Tip damage (% of plants affected)	100–200% (100% of plants tipped once or twice)	– –	– Helicoverpa control can cease at 30–40% bolls open.	–	
***Helicoverpa* spp. in Bollgard II cotton**					
		All season			
White eggs/m		–			
Brown eggs/m		–			
Total larvae/m (excluding larvae < 3 mm)		2/m over 2 consecutive checks			
Medium and large larvae/m		1/m on the first check			
Green mirids					
Adults and nymphs/m					The relative importance of the % fruit retention and % boll damage reverses as the season progresses. From the start of squaring through until cut-out, place the emphasis on fruit retention. Not all bolls that are damaged by mirids will be shed, so after cut-out it is important to monitor bolls for mirid damage. If only the terminal is blackened, damage could be considered light. If the terminal plus one or more true leaves are blackened, damage could be considered heavy.
cool region – visual	0.7	0.5	–		
warm region – visual	1.3	1.0	–		
cool region – beatsheet	2	1.5	–		
warm region – beatsheet	4	3	–		
Fruit retention	< 65%	< 65%	–		
Boll damage		20%	20%		
Tip damage (% of plants affected)					
(heavy)	20%	–	–		
(light)	50%	–	–		
Cotton aphid (check species)					
Presence of adults and nymphs	Calculate Cumulative Season Aphid Score*	Calculate Cumulative Season Aphid Score	50% infestation		Until 1% of the bolls are open calculate the Cumulative Season Aphid Score to determine the threshold. * When using this Score in very young cotton, yield loss predictions should be treated with caution as in many cases aphid populations will naturally decline.
Honeydew presence	–	monitor for the presence of honeydew	10% infestation if honeydew present		Once open bolls are present in the crop, use 50% infestation. When 1% of bolls are open and honeydew is present, the aphid threshold is reduced to 10% infestation. Check field borders and spray them separately where necessary. Some cotton aphid strains are resistant to organophosphates and carbamates. Aphids can carry and transmit cotton bunchy top virus. Monitor plants in aphid hotspots for symptoms of this disease, such as mottling of leaf margins.
Green peach aphid					
% of plants infested	25%				May be a problem early season, populations normally decline in hot weather. Some populations are resistant to organophosphates and carbamates.
Mites					
% of leaves infested	30% Normally suppressed by predators. Use the table on page 21.	30% or population increases at > 1% of infested plants/day in 2 consecutive checks	> 60% No effect on yield after 20% bolls open.		A nominal threshold of 30% of leaves infested is used from seedling emergence up to 20% of bolls open. Alternatively, use the table on page 24 to base thresholds on potential yield loss. Yield loss is estimated using time of infestation and rate of population increase.

TABLE 17: Insect pest and damage thresholds (continued)

Insect pest	Planting to flowering (1 flower/m)	Flowering to 1 open boll/m	1 open boll/m to harvest		Comments
			Up to 15% open	After 15% open	
Thrips					
Adults and nymphs/plant	10	–	–		Control is justified if there are 10 thrips/plant plus the reduction in leaf area due to thrips is greater than 80% (roughly leaves less than 1 cm long). Control is also justified if there is a reduction in leaf area of more than 50% once the plant has reached the six true leaf stage. Thereafter, thrips are unlikely to affect the yield or maturity date of cotton crops. If conditions were cool or the plant had another set-back then the thresholds could be reduced.
Damage (reduction in leaf area)	80%	–	–		
Green vegetable bug					
Visual	–	0.5	0.5		Green vegetable bug cause significantly more damage to bolls less than 21 days old and prefer bolls 10 days old or less. Older bolls are generally not preferred. Instars 4, 5 and adults do the same amount of damage. Instar 3 does half the damage of instar 4 and 5 and adults. A cluster (more than 10) of first and second instars does as much damage as one adult. Thresholds are in adult equivalents.
Beat sheet, OR	–	1	1		
Damage to small bolls (14 day old)	–	20%	20%		
Pale cotton stainers					
Visual	–	1.5	1.5		Threshold is based on relationship between cotton stainer damage and damage caused by other plant bugs. Both nymphs (usually 3rd to 5th stage nymphs) and adults cause similar amounts of damage.
Beat sheet		3	3		
Damaged bolls (%)		30%	30%		
Cotton leafhopper					
Jassids/m	50	–	–		
Tipworm					
Larvae/m	1–2	–	–		Sample for tipworm up until first flower. Larvae tend to burrow into the terminals and squares so may not be found using the beat sheet or sweep nets. Visual sampling methods are the most accurate. Bollgard II cotton provides good control of tipworm.
Tip damage (% of plants affected)					
(not entrenched)	100–200%	–	–		
(entrenched)	50–100%	–	–		
Armyworm					
Large larvae/m	1	–	–	–	
Small larvae/m	2	–	–	–	
Rough bollworm					
Larvae/m	2	3	3		Susceptibility to rough bollworm starts when there are more than 5 bolls/m over 2 weeks old. Susceptibility ceases when there are fewer than 5 growing bolls/m less than 2 weeks old. Bollgard II cotton provides good control of rough bollworm.
Damaged bolls (%)	–	3%	3%		
Pink spotted bollworm					
% bolls infested	–	5	5		The threshold for pink spotted bollworm is based on the infestation as determined by examining inner boll walls. Bollgard II cotton provides good control of pink spotted bollworm.
Loopers					
Larvae/m	–	20	50		

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TABLE 18: Insecticide trade names and marketers – Registered chemicals as at June 30, 2013*

Active Ingredient	Chemical Group	Insecticide Group	Concentration & formulation	Trade Name	Marketed by
Abamectin	avermectin	6	18 g/L EC	ABA 18	Genfarm Landmark
				ABA 18	Genfarm Landmark
				Abachem 18	Imtrade
				Abacin 18	Farmalinx
				Abaken 18	Kenso Agcare
				Abamect	Nufarm
				Abamectin 18	4Farmers, Apparent; Country; Chemtura; eChem; Mission Bell; Pacific; Rainbow; Titan AG
				Abamix 18	Hextar Chemicals
				Ac Whistler	Avichem
				Acarmik	Rotam Limited
				Agrimec	Syngenta
				AW Announce	AgriWest
				Biomectin	Jurox
				Catcher 18	Sinon
				Gremlin	Sipcam
				Kill-a-mite	Sevroc
				Mite Terminator	Rosmin
				Stealth	PCT Holdings
				Vantal 18 EC	Ospray
				Wizard 18	Farmoz
Acetamiprid	neonicitinoids	4A	225g/L SL	Acetemprid 225	eChem
				Crown 225 SL	Everris
				Intruder	Agnova
				Primal	Farmoz
				Supreme 225g/L	Nippon Soda
Alpha-cypermethrin	pyrethroid	3A	100 g/L EC	ACP Alphacyp 100	Australis Crop protection
				Alf 100 EC	AW
				Alpha 100	Biotis
				Alpha C 100 EC	Ozcrop
				Alpha Duo 100	Genfarm Landmark; Opal; Conquest
				Alpha Duop 100	Grow Choice
				Alphacyp 100	Australis Crop Protection
				Alpha-Cyp 100 DUO	eChem
				Alphacyper 100 EC	Farmalinx; Rygel; WSD
				Alpha-Cypermethrin 100 EC	WSD
				Alpha-cypermethrin	4Farmers; Chemforce; Country; Grass Valley; Halley; Masmart; Mission Bell; Ospray; Sabakem; Rainbow
				Alpha-Cypermethrin 100 Duo	Apparent
				Alpha-Duo 100	Titan AG
				Alpha-Scud Elite	Farmoz
				Alphasip Duo	Sipcam
				Antares 100	Campbell
				Astound Duo	Nufarm
				Centaur 100	Genfarm Landmark
				Buzzard	PCT International
				Dictate Duo 100	Imtrade
				Dominex Duo	FMC
				Fastac Duo	BASF
				Fastac Xcel	BASF
				Ken-Tac 100	Kenso AgCare
				Mascot Duo	Crop Care
				Unialphacyper 100	Ravensdown
				Unichoice 100 EC	United Phosphorus
Alpha-cypermethrin	pyrethroid	3A	250 g/L SC	Alpha forte 250 SC	Conquest
				Alpha forte 250 SC	Rygel Aust
				Alpha-cypermethrin 250SC	Genfarm Landmark
				Googly Alpha Duo 250SC	Sherwood

TABLE 18: Insecticide trade names and marketers – Registered chemicals as at June 30, 2013* (continued)

Active Ingredient	Chemical Group	Insecticide Group	Concentration & formulation	Trade Name	Marketed by
Amitraz	triazapentadiene	19	200 g/L EC	Amitraz 200 EC/ULV	ChemAg
				Amitraz 200 EC/ULV	Jurox
				Amitraz Duo	Genfarm Landmark Crop Protection
				Amitraz EC/ULV	eChem
				Amitraz Elite EC/ULV	Farmoz
				Hitraz 200 EC/ULV	Rotam
				Mitra 200 EC/ULV	United Phosphorus
				Opal Duo	Nufarm
				Ovasyn Options	Arysta Lifescience
Amorphous silica	not a member of any chemical group		450 g/L SC	Abrade Abrasive Barrier	Grow Choice
Azadiractin	UN	UN	5 g/L	Green Gold Neem	Friendly Ag products
Bacillus thuringiensis	Bt microbials	11	Btk* HD1** SC	Dipel SC	Valent BioSciences,Sumitomo Chemical Australia Chemical Australia
				Costar	Syngenta
				Agree	Certis
				BioCrystal kurkatis	Grevillia Ag
*Bacillus thuringiensis subspecies KURSTAKI. ** Strain type.					
Betacyfluthrin	pyrethroid	3A	25 g/L EC	Bulldock Duo	Bayer CropScience
Bifenthrin	pyrethroid	3A	100 g/L EC	AC Beast	Axichem
				Agfen 100 EC	AW
				Akostar	AAko
				Arrow 100 EC	Conquest
				Astrol 100 EC	Crop Care
				Bi-Thrin 100 EC	KD Plant Care
				BiFendoff 100	Grow Choice
				Bifenthrin 100 EC	4 Farmers; Country; David Grays; Genfarm Landmark; Imtrade; Ravensdown; Sabakem; Titan AG; Ospray; Farmalinx
				Bisect Duo 100 EC	United Phosphorus
				Compel	Ecofertiliser
				Disect 100 EC	UPL
				Fenithrin	Sipcam Pacific
				Fernstar 100 EC	Biotis Life Science
				Out of Bounds	Barmac
				Sarritor	Nuchem
				Tal-Ken 100	Kenso Agcare
				Talstar 100 EC	FMC
				Venom 100 EC	Farmoz
			250 g/L EC	Astrol	Crop Care
				Bifenthrin 250EC	Enviromax; Ospray
				Stockade	Apparent
				Talstar 250 EC	FMC
			300 g/L EC	Bifenthrin Ultra 300 EC	Imtrade
Chlorantraniliprole	diamides	28	350 g/kg	Altacor	Dupont
Chlorpyrifos	organophosphate	1B	500 g/L EC	AW Chop 500	AgriWest
				Chemicide 500	Hextar
				Chlorban 500 EC	United Phosphorus
				Chlorpos	Farmalinx
				Chlorpyrifos 500	4Farmers; Agro Alliance; Agspray; Chemforce; Conquest; Crop Smart; David Grays; Ezycrop; FMC; Genfarm Landmark; Halley; Imtrade; Novaguard; Shondong Rainbow; Spalding; Ravensdown; Agrimart industries; Apparent; Mission Bell; Nufarm; Ozcrop; Sabakem; Sabero; WSD

TABLE 18: Insecticide trade names and marketers – Registered chemicals as at June 30, 2013* (continued)

Active Ingredient	Chemical Group	Insecticide Group	Concentration & formulation	Trade Name	Marketed by
Chlorpyrifos	organophosphate	1B	500 g/L EC	Cutter Chlorpyrifos	Ivory Chem Aust
				Cyren 500	Ospray
				Fortune 500	PCT International
				Generifos	Grow Choice
				Kensban 500	Kenso Corporation
				Lorsban 500	Dow AgroSciences
				Strike-out 500 EC	Farmoz
Clothianidin	neo-nicotinoids	4A	200 g/L SC	Shield	Sumitomo Chemical Australia
Cypermethrin	pyrethroid	3A	200 g/L	ULV Boom 200	Genfarm Landmark
			200 g/L EC	Cypermethrin 200	Halley
				ULV Boom 200	Genfarm Landmark
				Cypermethrin 200 EC	Halley; Titan AG; United Farmers Co-op; WSD
				Cypershield 200	Imtrade
				Cyrux 200EC	United Phosphorus
				Ken-Cyper 200	Kenso AgCare
				Scud Elite	Farmoz
			250 g/L EC	Arrivo 250EC	FMC
				Arrivo 250EC	FMC
				Cyper 250 Plus	Genfarm Landmark
				Cypermethrin 250 EC	Country
				Cyrux 250 EC	United Phosphorus
			260 g/L EC	Cypermthrin 260 EC	AW; 4Farmers
Deltamethrin	pyrethroid	3A	27.5 g/L EC	Deltaguard ULV	PCT International
				Akodelthrin	Aako
				Ballistic Elite	Farmoz
				Decis Options	Bayer CropScience
				Delta Duo	Imtrade
				Deltamethrin Duo	Apparent; Echem; Halley
				Deltashield 27.5	ChemAg
				Dicast	Sinon
				D-Sect	Cropro
				Surefire Deltashield	PCT International
Diafenthiuron	organotonin miticides	12B	500 g/L SC	Difen 500 SC	eChem
				Pegasus	Syngenta
				Receptor	Farmoz
Dicofol	organochlorine	UN	240 g/L EC	Miti-Fol EC	Farmoz
			480 g/L EC	Kelthane MF	Cropcare
Dimethoate (See permit 13155)	organophosphate	1B	400 g/L EC	Danadim	Ospray
				Danadim	Ospray
				Dimethoate	Imtrade
				Dimethoate 400	Nufarm; 4Farmers; Accensi; Aust. Crop Protection; Conquest; Farmoz; Halley; Superway; Titan AG
				Dimetholinx	Farmalinx
				Rogor	Ospray
				Rover	Sipcam
Dimethoate (See permit 13155)	organophosphate	1B	400 g/L EC	Saboteur	Crop Care
			400 g/L EC	Stalk	PCT Holdings
			400 g/L EC	Unidime 400	United Farmers Co-op
			400 g/L EC	Saboteur	Crop Care
			400 g/L EC	Stalk	PCT Holdings
			400 g/L EC	Unidime 400	United Farmers Co-op
Emamectin benzoate	avermectin	6	17 g/L EC	Affirm	Syngenta
Esfenvalerate	pyrethroid	3A	50 g/L EC	Sumi-Alpha Flex	Sumitomo Chemical Australia
Etoxazole	Etoxazole	10B	110 g/L SC	ParaMite	Sumitomo Chemical Australia
				Swoop	Nufarm
Fipronil	phenyl pyrazole	2B	200 g/L SC	Albatross 200 SC	Farmoz
				Ancestor	Crop Culture
				Fipronil 200 SC	Enviromax; Sherwood
				Flak	AgriWest
				Kaiser	Campbell
				Legion	Crop Care

TABLE 18: Insecticide trade names and marketers – Registered chemicals as at June 30, 2013* (continued)					
Active Ingredient	Chemical Group	Insecticide Group	Concentration & formulation	Trade Name	Marketed by
Fipronil	phenyl pyrazole	2B	200 g/L SC	Onslaught	Apparent
				Regent 200 SC	BASF
				Rhyme	Ospray
				Surefire Vista	PCT
			800 g/L WG	Fipronil 800 WG	Gharda; Mission Bell; 4Farmers
				Regal 800 WG	Imtrade
				Regent 800 WG	BASF
Gamma -cyhalothrin	pyrethroid	3A	150 g/L CS	Trojan	Dow AgroSciences, Ospray
Helicoverpa NPV	nuclear polyhedrosis virus		5 x 10^9 PIB/mL **LC	Vivus Max + Optimal	Ag Biotech
			2000 MObs/mL	Gemstar	Sipcam
			2x10*5 MLObs	Heliocide	Agrichem
Imidacloprid	neonicitinoids	4A	200 g/L SC	Annihilate	Imtrade
				Annihilate 200 SC	Imtrade
				Confederate 200SC	Hextar
				Confidor 200 SC	Bayer CropScience
				Couraze 200 SC	Ospray
				IMI 200 SC	Farmalinx
				Imidacloprid 200 SC	Agrimart; Agro-Alliance; Apparent ; EnviroMax; Genfarm Landmark; Mission Bell; 4Farmers; Pacific; Superway
				Imi-flow 200	Masmart
				Kohinor 200	Farmoz
				Komondor 200 SC	Crop Culture
				Nuprid 200SC	Nufarm
				Provado	Bayer
				Rygel Imidacloprid 200 SC	Profeng
				Savage 200	Kenso
				Sindor 200 SC	Sinon
				Surefire Spectrum 200SC	PCT Holdings
				Umiforce Utility	Sherwood Chemicals
				Utility	Chaindrite
			350 g/L SC	Nuprid 350 SC	Nufarm
				Couraze Classic	Ospray
			700 g/L WG	Senator 700 WG	Crop Care
Indoxacarb	oxadiazine	22A	150 g/L EC	Steward	Dupont
Lambda -cyhalothrin	pyrethroid	3A	250 g/L CS	Agro lambda 250SC	Novaguard
				Cyhella	Zelam
				Flipper 250 CS	Sherwood
				Lambda 250 CS	Ezycrop; Novaguard
				Lambda –cyhalothrin 250	4Farmers; Chemtura; Mission Bell; Shondong Rainbow
Lambda -cyhalothrin	pyrethroid	3A	250 g/L CS	Limit 250 CS	Sinochem
			250 g/L ME	Karate Zeon	Syngenta
				Kung Fu 250	Imtrade
				Matador Zeon	Crop Care
Magnet	UN	UN		Magnet	Ag Biotech
Methidathion	organophosphate	1B	400 g/L EC	Ridacide	Aako
			400 g/L EC	Suprathion 400 EC	Farmoz
Methomyl	carbamate	1A	225 g/L AC	Marlin	DuPont
				Methomyl 225	Ospray; Hextar Chemicals
				Sinmas 225	Sinon Australia
			225 g/L EC	Electra 225	Farmoz
			225 g/L LC	Lannate L	Cropcare
				Methomyl 225	FMC; Imtrade; Mission Bell
				Nudrin 225	Crop Care
			225 g/L SC	ACP Methomyl 225	Australis Crop protection
				KDpc Metho	KD Plant Care
				Methomyl 225	EzyCrop; Novaguard; Shandong Rainbow; Titan Ag
				Seneca	Ronic International

TABLE 18: Insecticide trade names and marketers – Registered chemicals as at June 30, 2013* (continued)

Active Ingredient	Chemical Group	Insecticide Group	Concentration & formulation	Trade Name	Marketed by
Omethoate	organophosphate	1B	800 g/L SL	Folimat 800	Ayrsta Lifescience
				Sentinel 800	ChemAg
Paraffinic oil	petroleum spray oil (PSO)		792 g/L EC	Canopy	Caltex
			814 g/L EC	Summer Insecticidal Spray Oil	Sacoa
			838 g/L EC	Cropshield	Sacoa
			846 g/L EC	Broadcoat	Caltex
			861 g/L EC	Empower	Victorian Chemical Co
			827 g/L LC	D-C-Tron	Caltex
			859 g/L LC	CottOil	Sacoa
Phorate	organophosphate	1B	100 g/kg G	Thimet 100	Barmac
				Umet 100G	UPL
			200 g/kg G	Thiamet 200G	Barmac
				Umet 200G	UPL
				Zeemet 200G	UPL
Piperonyl butoxide	synergist	synergist	800 g/L EC	Enervate	Nufarm
				PBO 800 EC	Farmoz
				Piperonyl Butoxide –	Agspray
				Puppet	Imtrade
				Summit PBO Synergist –	Sipcam
				Synergy	Crop Care
Pirimicarb	carbamate 1A 500 g/kg WDG	1A	500 g/kg WDG	Aphidex WG	Farmoz
				Atlas 500 WG	Titan AG
				Diri-ken 500 WG	Agcare
				Piri-ken 500 WG	Kenso Agcare
				Piricarb WG	Farmalinx; Shondong
				Piricarb 500 WG	Rainbow
				Pirimicarb 500 WG	Ospray; Genfarm Landmark; Apparent; Imtrade; OzCrop; 4Farmers
				Pirimidex WG	Conquest
				Pirimor WG	Syngenta
			500 g/kg WP	Aphidex 500 WP	Farmoz
				Pirimicarb 500 WP	4Farmers
Propargite	propargite	12C	600 g/L EC	Bullet	Crop Care
				Comite	Chemtura Australia
				Dyna-Mite 600	Farmoz
				Mitigate	United Phosphorous
				Propamite	Sipcam Pacific
				Treble	Nufarm
Pymetrozine	pymetrozine	9B	500 g/kg WDG	Fulfill	Syngenta
Pyriproxyfen	pyriproxyfen	7C	100 g/L EC	Admiral	Sumitomo Chemical Australia
Spirotetramat	spirotetramat	23	240 g/L SC	Movento	Bayer Cropscience
Thiamethoxam	Neo-nicotinoids	4A	250 g/kg wdg	Actara	Syngenta
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	Thiodicarb 800 WG	Mission Bell
Sulfoxaflor	Sulfoximines	4C	240 g/L SC	Transform	Dow Agrosciences

(*Some products that are registered but no longer commercially available have been omitted)

TABLE 19: Insecticide seed treatment trade names and marketers – Registered chemicals as at June 30, 2013

Active ingredient	Chemical group	Insecticide group	Concentration and formulation	Trade name	Marketed by
Imidacloprid*	4A	Neo-nicotinoids	600 g/L FS	Gaucho	Bayer
				Genero	eChem
Imidacloprid + Thiodicarb	4A/1A	Neo-nicotinoids/Carbamates	350 + 250 g/L FS	Amparo	Bayer
Thiamethoxam	4A	Neo-nicotinoids	350 g/L FS	Cruiser 350 FS	Syngenta
	4A	Neo-nicotinoids	600 g/L FS	Cruiser Extreme 600 FS	Syngenta

*There are multiple other registrations for Imidacloprid, however these are currently not commercially available through CSD.