

## **CHANGES TO THE RESISTANCE MANAGEMENT STRATEGIES FOR CONVENTIONAL INSECTICIDES AND BT TRANSGENIC COTTON (1997/98 - 1998/99)**

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The Australian cotton industry has been practising curative conventional insecticide resistance management and preventative Bt transgenic cotton resistance management for fifteen and two years now, respectively. The actual strategies are reviewed and reformulated at the end of each season at a series of industry meetings which include representatives of growers, consultants, researchers, resellers, agrochemical industry and aerial operators. The ACGRA (Australian Cotton Growers' Research Association) TIMS (Transgenic and Insecticide Management Strategy) committee is responsible for coordinating this annual process for both strategies. The strategies outlined below are the result of the input of a large number of talented people, both within the TIMS committee but also throughout the wider cotton industry in general and their assistance and dedication is gratefully acknowledged.

### Conventional Insecticide Resistance Management Strategy

Over the past two seasons, pyrethroid and carbamate resistance have continued to deteriorate to very high levels, endosulfan resistance has stabilised at moderate levels, while organophosphate resistance has remained generally lower. So far no resistance has been detected in *Helicoverpa armigera* to foliar Bts or amitraz. There have been a number of changes instigated to the Conventional Insecticide Resistance Management Strategy for each of the past two seasons since the last Australian Cotton Conference. They are outlined below:-

#### **1997/98 Strategy (changes from the previous season) -**

- Rewording of the pre-flowering heliothis threshold to read: two small/very small or one medium or two total larvae per metre.
- A longer Stage II window, increased from 30 to 41 days, a full generation rather than the part generation previously. Earlier start December 10, same finish January 20.
- Maximum number of Talstar® (bifenthrin) pyrethroid applications (including both mite and heliothis sprays) reduced from three to two.
- Additional restriction of no foliar Bt sprays to be used on Bt transgenic (Ingard®) cotton as well as the previous restriction of no foliar Bt sprays on the designated refuge crops.

- Carbamates restricted to Stage III only, except for the use of the ovicidal rate of methomyl in Stage I on  $\leq 10\%$  *Helicoverpa armigera*, as indicated by a LepTon® test on eggs. Larvin® (thiodicarb) restricted to high larvicidal rate only in Stage III, preferably on cut-out cotton. Still only a maximum of four carbamate sprays per season in total, including mixtures.

- Maximum number of profenofos sprays reduced from four to three. This restriction on profenofos had been facilitated by the introduction of higher, more effective rates of chlorpyrifos (maximum of two) for heliothis control.

- New miticide Pegasus® (diafenthiuron) introduced and incorporated into the current miticide rotation strategy - that is, a maximum of two applications of any product and non-consecutive use of the same miticide.

#### **1998/99 Strategy** (changes from the previous season) -

- Pyrethroids removed out of Stage I to facilitate early season IPM.

- Stage II dates moved earlier to start on December 10 and to finish on January 10 (endosulfan left at January 20 close).

- Ovicidal rate of methomyl allowed in all Stages (to offer an alternative ovicide resistance management option to amitraz). There is some concern that this could possibly exacerbate the carbamate resistance problem but research has not been able to substantiate this with the low ovicidal rate of the short residual product methomyl. On the other hand, the high larvicidal rate of the more residual thiodicarb has been shown to be a clear resistance risk and remains restricted to the Stage III period only.

- Tracer® (spinosad) added. At this stage, not restricted to any particular use period.

- Foliar Bts can now be used on all Bt transgenic (Ingard®) crops in all Stages (allows a soft option 'top up' spray for situations of declining efficacy in Ingard® crops) and on conventional sprayed refuge crops in Stage I only (allows an early season soft option for those not wishing to disrupt early season IPM programmes). These changes will also be both especially welcome in environmentally sensitive areas. The resistance models were revisited and were shown to indicate only a low resistance risk for the use of foliar Bt 'top up' sprays on Ingard® cotton compared to the benefits of improved IPM and less potential for environmental disruption, while research has indicated no survival of heliothis larvae through to moths in the Stage I period before row closure.

- No more than two consecutive sprays of any one group, either alone or in mixtures (Stages II and III only). This will promote a more rational approach to the use of mixtures in the industry. This rotation by spray numbers is not as ideal as say rotation

by insect generation but it is the only practical solution given the limited number of effective heliothis control products now available.

#### Bt transgenic (Ingard®) Cotton Resistance Management Strategy

The 1998/99 season will be the third year of commercial use of Bt transgenic (Ingard®) cotton in Australia. In the first year (1996/97), 10% of the Australian cotton area was sown to this technology; in the second year, 1997/98, this was increased to 15% and the recommendation from the ACGRA TIMS committee to the National Registration Authority for the 1998/99 season is for 20% of the total area. This cautious approach to release is due to the industry's concern about the possible development of resistance to this technology, which still currently relies on only one gene (producing CryIAc protein) for protection. Whilever there is only single gene protection for Bt transgenic cotton, it has been suggested that there should be a cap on the maximum percentage area grown and the present thinking is that this should be around 30% of the the total cotton area. When two gene Bt transgenic cotton becomes commercially available, this cap will most likely be removed. However, the limitations stipulated by the industry agreed and legally binding Bt Transgenic Cotton Resistance Management strategy, will still remain.

The inaugural **1996/97 Bt Transgenic (Ingard®) Strategy** is reproduced below:-

##### 1. Refuges

Each grower will be required to grow a refuge crop to produce Bt susceptible *Helicoverpa* moths that will mate with any resistant survivors from Bt cotton crops and thus maintain Bt cotton resistance at low levels. For each 100 hectares of transgenic Bt cotton planted, a grower is required to plant a minimum of one of the following:-

i) an area of conventional irrigated cotton of 10 hectares which will be untreated for any reason with products to control *Helicoverpa*. If the Bt cotton crop is dryland, then the refugia crop may also be dryland.

ii) an area of conventional irrigated cotton of 50 hectares which can be sprayed with insecticides for *Helicoverpa* or other pests BUT not with conventional foliar applied Bt (that is *Bacillus thuringiensis* var. *kurstaki*) products. If the Bt cotton crop is dryland, then the refugia crop may also be dryland.

iii) an area of irrigated sorghum or corn of 20 hectares which will be untreated for any reason with products that control *Helicoverpa* and managed to flower from January 15 to February 28.

General conditions for all refuges are:-

a) Refuge crops are to be planted and managed so that the refuge is attractive to *Helicoverpa* during the growing period of the Bt cotton crop.

b) All refuges are to be planted within the farm unit growing the Bt cotton crop, preferably on one side of, or adjacent to, the Bt cotton field.

## 2. Planting window

All Bt cotton crops (irrigated and dryland) to be planted into moisture or watered up by the 15th of November.

## 3. Pupae destruction

Each grower will be required to undertake *Helicoverpa* pupae destruction as soon as possible after harvest in Bt cotton fields, according to the industry guidelines. Sprayed refuge crops should also be similarly cultivated to manage resistance to conventional insecticides. Unsprayed refuge crops should preferably be left uncultivated.

## 4. *Heliothis* spray thresholds

The Bt cotton should be carefully monitored throughout the season for sucking pests and *Helicoverpa*. For preventative resistance management of *Helicoverpa*, late season larval populations must be controlled with an effective insecticide if a threshold of 3 small larvae (second instar) or 1 medium larva (third/fourth instar) per metre of row, continue to survive over two consecutive checks. Specifically exclude all VS (very small = neonates / first instar) larvae from the spray threshold.

### **1997/98 Strategy** (changes from the previous season) -

- Area of sprayed cotton refuge increased to 100 hectares for every 100 hectares of Bt transgenic Ingard® cotton. This then made a more conservative 1:1 ratio for Ingard® versus the sprayed conventional cotton refuge (previously this was 2:1).

- The location of the on-farm refuges were more precisely defined: "All refuges are to be planted within the farm unit growing Ingard® cotton, preferably on one side of, or adjacent to, the Ingard® cotton fields, but with a separation of no more than two kilometers from the Ingard® crops."

- Controls on volunteer cotton introduced (either Ingard® plants within back to back conventional cotton fields or conventional plants within Ingard® fields). Volunteer plants should be removed as soon as possible from all fields being planted with Ingard® and from fallows after Ingard®.

- Heliothis spray threshold section dropped from the grower agreement to become recommendations only.

- Recommendation added that no foliar Bt sprays be applied to any Ingard® crop.

- Because of the earlier crops and therefore lower rates of diapause in central Queensland, an extra trap cropping recommendation was added to the Strategy in these more northerly areas to compensate for the lower effectiveness of post-harvest cultivation for overwintering pupae destruction.

**Proposed 1998/99 Strategy** (recommended changes from the previous season) -

- Foliar Bts to be allowed on all Bt transgenic (Ingard®) crops in all Stages and on conventional sprayed refuge crops in Stage I only, for reasons outlined above.

At the time of writing, the National Registration Authority had not given its final approval for the 1998/99 Bt Transgenic (Ingard®) Cotton Resistance Management Strategy, so it is not able to be reproduced in full here.

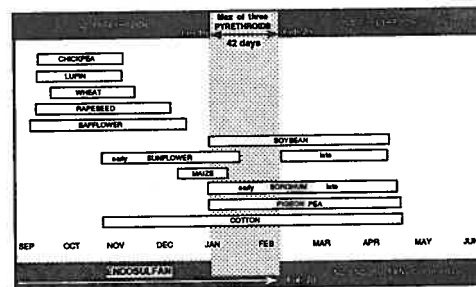
## % SURVIVING DISCRIMINATING DOSE

STUDY AREA	SEASON	FENVALERATE			ENDOSULFAN			PROFENOFOS		
		I	II	III	I	II	III	I	II	III
Namoi/Gwydir	1983/84	9.3	9.5	14.6	-	-	-	-	-	-
	84/85	7.5	12.9	27.9	-	-	-	-	-	-
	85/86	7.8	13.0	44.5	-	-	-	-	-	-
	86/87	32.2	36.7	42.9	7.1	16.7	20.1	-	-	-
	87/88	19.8	30.1	38.4	7.3	17.6	23.0	-	-	-
	88/89	19.6	42.4	60.7	8.8	13.2	10.6	-	-	-
	89/90	24.7	45.3	62.5	9.2	14.8	15.9	-	-	-
	90/91	55.7	61.1	61.5	12.2	22.7	31.3	-	-	-
	91/92	46.0	64.1	68.4	9.2	32.4	40.6	-	-	-
	92/93	33.9	34.0	41.9	24.7	35.2	27.7	-	0.9	0.2
	93/94	31.3	50.3	66.1	30.5	32.2	32.6	-	0.7	2.0
	94/95	63.5	71.6	74.6	39.1	38.6	40.6	2.2	1.6	1.6
	95/96	79.0	78.0	80.0	45.8	37.2	33.3	0.9	6.6	4.0
	96/97	-	-	76.8	-	-	-	-	-	-
97/98	-	-	85.1	-	-	-	-	-	-	
Emerald	1985/86	6.8	17.1	14.4	-	-	-	-	-	-
	86/87	8.8	26.5	29.8	7.7	20.6	17.3	-	-	-
	87/88	15.9	27.1	27.0	9.5	14.3	13.7	-	-	-
	88/89	19.8	38.7	44.3	8.1	13.6	7.1	-	-	-
	89/90	27.9	44.6	54.6	3.1	21.0	20.9	-	-	-
	90/91	24.7	52.2	34.5	10.1	37.1	16.0	-	-	-
	91/92	32.1	52.7	62.1	7.9	50.5	47.3	-	-	-
	92/93	40.2	50.6	59.1	25.9	51.6	59.5	-	-	1.1
	93/94	66.0	61.8	79.8	50.0	48.7	52.3	-	-	-
	94/95	56.0	74.0	92.8	38.8	53.1	42.5	3.2	4.2	1.2
	95/96	-	89.2	-	-	-	-	-	14.9	15.4
Inverell	1987/88	10.2	20.4	19.0	11.3	10.5	5.8	-	-	-
	88/89	21.9	28.9	41.7	9.4	4.8	5.4	-	-	-
	89/90	22.1	32.7	38.2	4.0	5.2	7.1	-	-	-
	90/91	47.8	34.6	45.1	3.4	8.5	10.8	-	-	-
	91/92	37.8	55.3	55.5	24.2	17.3	14.0	-	-	-
	92/93	-	-	-	-	-	-	-	-	-
St. George	1991/92	-	80.2	90.9	-	60.9	67.4	-	-	-
	92/93	63.7	76.0	80.4	29.9	59.7	57.5	-	1.4	3.7
	93/94	-	71.2	81.8	-	45.4	34.7	-	-	11.4
	94/95	72.3	76.0	87.2	48.5	55.4	53.7	-	4.5	6.0
	95/96	83.1	88.8	-	-	43.1	-	-	-	3.2

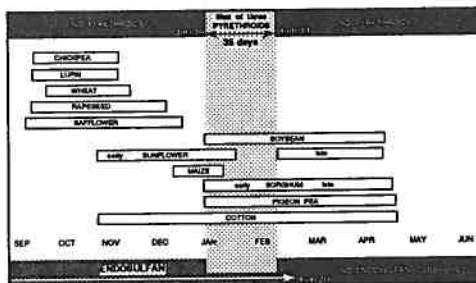
Average pyrethroid, profenofos (Curacron®) and endosulfan resistance levels in *Heliothis armigera* for each Stage( I, II & III ) of the Resistance Management Strategy, for 4 study areas (the Namoi and Gwydir valleys of northern NSW, the Emerald Irrigation Area of central Queensland, the St. George Irrigation Area of southern Queensland and a sample of the unsprayed refugia area centred on Inverell in northern NSW).

# Australian Summer Crops Resistance Management Strategies (for northern NSW and southern Queensland) 1983/84 to 1996/97

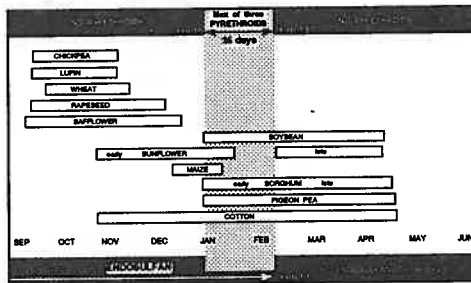
1983/84 to 1988/89 (six seasons)  
SUMMER CROP RESISTANCE MANAGEMENT STRATEGY



1989/90 SUMMER CROP  
RESISTANCE MANAGEMENT STRATEGY



1990/91 to 1992/93 (three seasons)  
SUMMER CROP RESISTANCE MANAGEMENT STRATEGY



COTTON RESISTANCE MANAGEMENT STRATEGY for 1993/94 season

Stage I	Stage II	Stage III	Post-harvest
CHLORFENVINPHOS - USE IN THE FIRST TWO TO THREE SEASON APPROVAL	PYRETHROIDs - USE LATER THAN USE IN EARLY SEASON APPROVAL		Cultivate to destroy over-wintering pupae as soon as possible after picking and certainly by no later than the end of August.
Resistant (short-statured) (R)			
LARVIN	HELDX - USE OF 2 - AFTER CRY ANT (Stage I) AND BEFORE STAGE I		
DELTHALH	PROFENOFOS - USE OF A, INCLUDING SYSTEMIC		

COTTON RESISTANCE MANAGEMENT STRATEGY for 1994/95 season

Stage I	Stage II	Stage III	Post-harvest
CHLORFENVINPHOS - USE IN THE FIRST TWO TO THREE SEASON APPROVAL			Cultivate to destroy over-wintering pupae as soon as possible after picking and certainly by no later than the end of August.
PYRETHROIDs - MAKE 1 SPRAY IN STAGE I - USE LARVIN FIRST AT TO AVOID HELICIDIA ANNIHILATA - CHECK FOR SPIN, PARTICULARLY IN STAGE I - NO CONSECUTIVE TALESTARS			
Resistant (short-statured) (R)			
LARVIN - DO NOT USE IN LATE STAGE I	HELDX - USE OF 2 - AFTER CRY ANT (Stage I) AND BEFORE STAGE I		


COTTON RESISTANCE MANAGEMENT STRATEGY for 1995/96 season

Stage I	Stage II	Stage III	Post-harvest
CHLORFENVINPHOS - USE IN THE FIRST TWO TO THREE SEASON APPROVAL			Cultivate to destroy over-wintering pupae as soon as possible after picking and certainly by no later than the end of August.
ENOSULFAN - USE LATER THAN USE IN EARLY SEASON APPROVAL			
PYRETHROIDs - MAKE 1 SPRAY IN STAGE I - USE LARVIN FIRST AT TO AVOID HELICIDIA ANNIHILATA - CHECK FOR SPIN, PARTICULARLY IN STAGE I - NO CONSECUTIVE TALESTARS, USE OF 2	LARVIN - MAKE OF 2 AT END OF STAGE I, INCLUDING SYSTEMIC		
Resistant (short-statured) (R)			

COTTON RESISTANCE MANAGEMENT STRATEGY for 1996/97 season

Stage I	Stage II	Stage III	Post-harvest
(1) CHLORFENVINPHOS - USE IN THE FIRST TWO TO THREE SEASON APPROVAL			Cultivate to destroy over-wintering pupae as soon as possible after picking and certainly by no later than the end of August.
ENOSULFAN - USE LATER THAN USE IN EARLY SEASON APPROVAL			
PYRETHROIDs & PYRETHROID SPINNS - MAKE 1 SPRAY IN STAGE I - MAKE 1 FINAL HIGH CONCENTRATION - USE LARVIN FIRST AT TO AVOID HELICIDIA ANNIHILATA - CHECK FOR SPIN, PARTICULARLY IN STAGE I - NO CONSECUTIVE TALESTARS, MAKE OF 2	HELDX - MAKE OF 2 - AFTER CRY ANT (Stage I) AND BEFORE STAGE I		
Resistant (short-statured) (R)			

**COTTON RESISTANCE MANAGEMENT STRATEGY  
for 1997/98 season  
(for northern NSW and southern Queensland)**

	Stage I Dec 10	Stage II 41 days	Stage III Jan 20	Post-harvest	
<b>Heliiothis</b>	( Pre - flowering Heliiothis threshold = 2 small / very small or 1 medium or 2 total larvae / metre, monitor first position fruit retention )			Cultivate to destroy over-wintering pupae as soon as possible after picking and certainly by no later than the end of August	
	<b>ENDOSULFAN</b> - USE LEPTON® TEST KIT TO AVOID <i>HELICOVERPA ARMIGERA</i>				
	<b>PYRETHROIDS &amp; PYRETHROID MIXES</b> <ul style="list-style-type: none"> <li>- MAX 1 SPRAY IN STAGE I</li> <li>- MAX 2 PBO, NON-CONSECUTIVE</li> <li>- USE LEPTON® TEST KIT TO AVOID <i>HELICOVERPA ARMIGERA</i></li> <li>- CHECK FOR MITES, PARTICULARLY IN STAGE I</li> <li>- NON-CONSECUTIVE TALSTARS, MAX OF 2, INCLUDING MITE SPRAYS</li> </ul>				
	<i>Bacillus thuringiensis (Bt)</i> - NOT TO USED ON INGARD® TRANSGENIC COTTON OR ASSOCIATED REFUGES				
			MAX OF 4 SPRAYS PER SEASON IN TOTAL, INCLUDING MIXTURES		<b>THIODICARB</b> - LARVICIDAL RATE ONLY
	<b>METHOMYL</b> - ovicidal rate only on ≤ 10% armigera, as indicated by a LepTon® test on eggs				<b>METHOMYL</b>
	<b>AMITRAZ</b>				
			<b>CHLORPYRIFOS</b> - MAX OF 2, INCLUDING MIXTURES		
			<b>PROFENOFOS</b> - MAX OF 3, INCLUDING MIXTURES		
			<b>TALSTAR</b> - NON-CONSECUTIVE, MAX OF 2, INCLUDING HELIOTHIS SPRAYS		
<b>Mites</b>	<b>DICOFOL</b> - GROUND APPLICATION ONLY <b>COMITE</b> - DO NOT APPLY TO PRE-SQUARING COTTON, FULL RATE ONLY <b>AGRIMEC</b> <b>PEGASUS</b>				
			1. MAXIMUM OF 2 APPLICATIONS PER PRODUCT 2. NON CONSECUTIVE USE OF THE SAME MITTICIDE, THAT IS, ROTATE CHEMISTRY		

**COTTON RESISTANCE MANAGEMENT STRATEGY**  
**for 1998/99 season**  
 (for northern NSW and southern Queensland)

	Stage I Dec 10	Stage II	Stage III Jan 10	Post-harvest
Heliiothis	( Pre - flowering Heliiothis threshold = 2 small / very small or 1 medium or 2 total larvae / metre, monitor first position fruit retention )		STAGES 2 & 3 ONLY NO MORE THAN 2 CONSECUTIVE SPRAYS OF ANY ONE GROUP* EITHER ALONE OR IN MIXTURES	
	ENDOSULFAN - USE LEPTON® TEST KIT TO AVOID HELICOVERPA ARMIGERA		Jan 20	Cultivate to destroy over-wintering pupae as soon as possible after picking and certainly by no later than the end of August
	Follar Bts - ON ALL COTTON ( CONVENTIONAL & INGARD® ), EXCLUDING REFUGES FOR INGARD® COTTON IN STAGES II & III - ON SPRAYED REFUGES FOR INGARD® COTTON STAGE 1 ONLY			
			PYRETHROIDS & PYRETHROID MIXTURES - TALSTARS, MAX OF 2 , NON-CONSECUTIVE, INCLUDING MITE SPRAYS - PBO, MAX OF 2	
	TRACER - MAX OF 3			
	METHOMYL - OVICIDAL RATE ONLY			
	N.B. Max of 4 methomyl and/or thiodicarb sprays per season, including mixtures		METHOMYL - ANY RATE	
			THIODICARB - LARVICIDAL RATES ONLY	
	AMITRAZ			
			CHLORPYRIFOS - MAX OF 2, INCLUDING MIXTURES	
		PROFENOFOS - MAX OF 3, INCLUDING MIXTURES		
Mites			TALSTAR - MAX OF 2, NON-CONSECUTIVE, INCLUDING HELIOTHIS SPRAYS	
	DICOFOL - GROUND APPLICATION ONLY	} 1. MAXIMUM OF 2 APPLICATIONS PER PRODUCT 2. NON CONSECUTIVE USE OF THE SAME MITICIDE, THAT IS, ROTATE CHEMISTRY		
	COMITE - DO NOT APPLY TO PRE-SQUARING COTTON, FULL RATE ONLY			
AGRIMEC PEGASUS				



- \* GROUPS - 1) Endosulfan                      4) Spinosad                      7) Chlorpyrifos  
 - 2) Pyrethroids                                5) Bts                                8) Profenofos and other Organophosphates  
 - 3) Carbamates (methomyl/thiodicarb)    6) Amitraz                            eg. Methyl parathion

## All areas combined - DiPel®

% Surviving the Discriminating Dose of DiPel® (*Bacillus thuringiensis* var. *kurstaki*)

Species and collection season	Early season collections (October - January)	Mid / late season collections (February - May)	Season total
<b><i>Heliothis armigera</i></b> (expected survival range at the 1% error level = 0 to 0.8%)			
1993 / 94	0.4 (n=226)	1.7 (n=1,128)	1.5 (n=1,354)
1994 / 95	0.1 (n=1,336)	0.8 (n=5,294)	0.6 (n=6,630)
1995 / 96	0.2 (n=1,571)	0.2 (n=3,911)	0.2 (n=5,482)
1996 / 97	0.1 (n=2,278)	0.4 (n=3,871)	0.3 (n=6,149)
1997 / 98	0.7 (n=3,017)	0.7 (n=4,563)	0.7 (n=7,580)

<b><i>Heliothis punctigera</i></b> (expected survival range at the 1% error level = 0.1 to 1.3%)			
1993 / 94	0.8 (n=2,788)	1.1 (n=1,021)	0.9 (n=3,809)
1994 / 95	0.5 (n=1,390)	0.4 (n=998)	0.5 (n=2,388)
1995 / 96	0 (n=2,497)	0.1 (n=825)	0.1 (n=3,322)
1996 / 97	0.5 (n=1,567)	0.5 (n=221)	0.5 (n=1,788)
1997 / 98	1.3 (n=1,645)	1.9 (n=54)	1.3 (n=1,699)

## All areas combined - Xentari®

% Surviving the Discriminating Dose of Xentari® (*Bacillus thuringiensis* var. *aizawai*)

Species and collection season	Early season collections (October - January)	Mid / late season collections (February - May)	Season total
<b><i>Heliothis armigera</i></b> (expected survival range at the 1% error level = 0 to 0.8%)			
1995 / 96	0.2 (n=546)	0.1 (n=1,792)	0.1 (n=2,338)
1996 / 97	0.1 (n=1,653)	0.5 (n=3,327)	0.4 (n=4,980)
1997 / 98	0.2 (n=1,921)	0.3 (n=1,209)	0.2 (n=3,130)

<b><i>Heliothis punctigera</i></b> (expected survival range at the 1% error level = 0.1 to 1.3%)			
1995 / 96	0 (n=1,740)	0 (n=51)	0 (n=1,791)
1996 / 97	0.5 (n=1,080)	1.3 (n=75)	0.5 (n=1,155)
1997 / 98	0.4 (n=974)	-	0.4 (n=974)

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1996 / 97 Season - DiPel®

% Surviving the Discriminating Dose of DiPel® (*Bacillus thuringiensis* var. *kurstaki*)

Species and collection area	Host	Early season collections (October - January)	Mid / late season collections (February - May)	Season total
<b><i>Heliothis armigera</i></b>		(expected survival range at the 1% error level = 0 to 0.8%)		
Namoi/Gwydir, NSW	cotton maize	0 (n=743)	0.6 (n=1,872)	0.4 (n=2,615)
Emerald, QLD	cotton	0.7 (n=134)	0.2 (n=499)	0.3 (n=633)
Bundaberg, QLD	tomatoes		0.4 (n=238)	0.4 (n=238)
Darling Downs, QLD	cotton	0 (n=185)	0 (n=648)	0 (n=833)
Dawson/Callide QLD	cotton	0 (n=275)	0 (n=55)	0 (n=330)
Macintyre, NSW/QLD	cotton	0 (n=103)	0 (n=187)	0 (n=290)
St. George, QLD	cotton	0 (n=146)	0 (n=35)	0 (n=181)
Lockyer Valley, QLD	cotton maize	0 (n=99)	0 (n=85)	0 (n=184)
South Burnett, QLD	navy beans cotton maize sorghum	0.5 (n=183)		0.5 (n=183)
Macquarie, NSW	cotton	0 (n=33)	0.9 (n=107)	0.7 (n=140)
Mareeba, QLD	tobacco	0 (n=185)		0 (n=185)
Kununurra, WA	cotton	0 (n=192)		0 (n=192)
Griffith, NSW	maize		2.1 (n=47)	2.1 (n=47)
Mungindi, NSW	cotton		0 (n=98)	0 (n=98)
<b>Total of all sites</b>		0.1 (n=2,278)	0.4 (n=3,871)	0.3 (n=6,149)

***Heliothis punctigera***

(expected survival range at the 1% error level = 0.1 to 1.3%)

Namoi/Gwydir, NSW	cotton	0.5 (n=979)	0.7 (n=135)	0.5 (n=1,114)
St. George, QLD	cotton	0 (n=85)		0 (n=85)
Dawson/Callide, QLD	cotton	0 (n=23)		0 (n=23)
Macquarie, NSW	cotton	0.8 (n=256)	0 (n=64)	0.6 (n=320)
Bourke, NSW	cotton	0 (n=55)	0 (n=3)	0 (n=58)
Lockyer Valley, QLD	cotton	0 (n=5)		0 (n=5)
South Burnett, QLD	cotton navy beans	0 (n=90)		0 (n=90)
Darling Downs, QLD	cotton	0 (n=4)		0 (n=4)
Macintyre, QLD	cotton	1.4 (n=70)	0 (n=19)	1.1 (n=89)
<b>Total of all sites</b>		0.5 (n=1,567)	0.5 (n=221)	0.5 (n=1,788)

## 1997 / 98 Season - DiPel®

% Surviving the Discriminating Dose of DiPel® (*Bacillus thuringiensis* var. *kurstaki*)

Species and collection area	Host	Early season collections (October - January)	Mid / late season collections (February - May)	Season total
<b><i>Heliothis armigera</i></b>		(expected survival range at the 1% error level = 0 to 0.8%)		
Lower Namoi valley, NSW	cotton, maize, lab lab, faba bean, field peas	0.6 (n=1,098)	0.7 (n=1,659)	0.7 (n=2,757)
Upper Namoi valley, NSW	cotton		0.8 (n=124)	0.8 (n=124)
Gwydir valley, NSW	cotton, soyabean	0 (n=162)	0.4 (n=512)	0.3 (n=674)
Emerald, QLD	cotton, maize, pigeon peas	0 (n=183)	1.0 (n=388)	0.7 (n=571)
Bundaberg, QLD	tomatoes	0 (n=128)	0.9 (n=449)	0.7 (n=577)
Childers, QLD	tomatoes	0.6 (n=179)	0 (n=218)	0.3 (n=397)
Darling Downs, QLD	cotton, maize, sorghum	1.4 (n=279)	0.9 (n=564)	1.1 (n=843)
Biloela, QLD	cotton	2.7 (n=37)		2.7 (n=37)
Theodore, QLD	cotton	1.6 (n=129)		1.6 (n=129)
Macintyre, NSW/QLD	cotton	1.0 (n=198)	0 (n=39)	0.8 (n=237)
St. George, QLD	cotton	0 (n=157)	0.4 (n=243)	0.3 (n=400)
Lockyer Valley, QLD	tomatoes		0 (n=40)	0 (n=40)
South Burnett, QLD	cotton, maize, navy beans	2.9 (n=104)	0 (n=25)	2.3 (n=129)
Mareeba, QLD	tobacco	0 (n=300)		0 (n=300)
Mungindi, NSW	cotton	0 (n=63)	1.2 (n=84)	0.7 (n=147)
Walgett, NSW	cotton		0.9 (n=218)	0.9 (n=218)
Total of all sites		0.7 (n=3,017)	0.7 (n=4,563)	0.7 (n=7,580)

***Heliothis punctigera***

(expected survival range at the 1% error level = 0.1 to 1.3%)

Lower Namoi valley, NSW	cotton, lab lab, faba beans	1.4 (n=1,015)	2.4 (n=42)	1.4 (n=1,057)
Gwydir valley, NSW	cotton	0 (n=65)	0 (n=6)	0 (n=71)
Emerald, QLD	cotton	0 (n=7)	0 (n=6)	0 (n=13)
St. George, QLD	cotton	0 (n=6)		0 (n=6)
Bundaberg, QLD	tomatoes	1.8 (n=271)		1.8 (n=271)
Childers, QLD	tomatoes	0.9 (n=109)		0.9 (n=109)
South Burnett, QLD	cotton navy beans	0 (n=10)		0 (n=10)
Darling Downs, QLD	cotton	1.0 (n=101)		1.0 (n=101)
Kununurra, WA	cotton	0 (n=61)		0 (n=61)
Total of all sites		1.3 (n=1,645)	1.9 (n=54)	1.3 (n=1,699)

## 1996 / 97 Season - Xentari®

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 % Surviving the Discriminating Dose of Xentari® (*Bacillus thuringiensis* var. *aizawai*)
 

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Species and collection area	Host	Early season collections (October - January)	Mid / late season collections (February - May)	Season total
<b><i>Heliothis armigera</i></b>		(expected survival range at the 1% error level = 0 to 0.8%)		
Namoi/Gwydir, NSW	cotton maize	0.2 (n=629)	0.7 (n=1,827)	0.6 (n=2,456)
Emerald, QLD	cotton	0 (n=130)	0.4 (n=489)	0.3 (n=619)
Macquarie, NSW	cotton		0 (n=103)	0 (n=103)
Darling Downs, QLD	cotton	0 (n=161)	0.2 (n=652)	0.1 (n=813)
Dawson/Callide, QLD	cotton	0 (n=269)	0 (n=49)	0 (n=318)
Macintyre, NSW/QLD	cotton	0 (n=94)	0 (n=173)	0 (n=267)
St. George, QLD	cotton	0 (n=126)	0 (n=34)	0 (n=160)
Lockyer Valley, QLD	cotton maize	0 (n=86)		0 (n=86)
South Burnett, QLD	navy beans cotton maize sorghum	0.6 (n=158)		0.6 (n=158)
Total of all sites		0.1 (n=1,653)	0.5 (n=3,327)	0.4 (n=4,980)

<b><i>Heliothis punctigera</i></b>		(expected survival range at the 1% error level = 0.1 to 1.3%)		
Namoi/Gwydir, NSW	cotton	0.2 (n=864)	0 (n=25)	0.2 (n=889)
St. George, QLD	cotton	0 (n=57)		0 (n=57)
Macquarie, NSW	cotton	1.9 (n=159)	2.0 (n=50)	1.9 (n=209)
Total of all sites		0.5 (n=1,080)	1.3 (n=75)	0.5 (n=1,155)

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## 1997 / 98 Season - Xentari®

% Surviving the Discriminating Dose of Xentari® (*Bacillus thuringiensis* var. *aizawai*)

Species and collection area	Host	Early season collections (October - January)	Mid / late season collections (February - May)	Season total
<b><i>Heliothis armigera</i></b>		(expected survival range at the 1% error level = 0 to 0.8%)		
Lower Namoi valley, NSW	cotton, maize, lab lab, faba bean, field peas	0.2 (n=886)	0.4 (n=790)	0.3 (n=1,676)
Emerald, QLD	cotton, maize, pigeon peas	0 (n=163)		0 (n=163)
Gwydir valley, NSW	cotton, soyabean	0 (n=162)	0.7 (n=140)	0.3 (n=302)
Darling Downs, QLD	cotton, maize, sorghum	0.3 (n=347)		0.3 (n=347)
Bundaberg, QLD	tomatoes		0 (n=126)	0 (n=126)
Macintyre, NSW/QLD	cotton	0 (n=125)		0 (n=125)
St. George, QLD	cotton	0 (n=120)	0 (n=153)	0 (n=273)
Mareeba, QLD	tobacco	0 (n=118)		0 (n=118)
Total of all sites		0.2 (n=1,921)	0.3 (n=1,209)	0.2 (n=3,130)

***Heliothis punctigera***

(expected survival range at the 1% error level = 0.1 to 1.3%)

Lower Namoi valley, NSW	cotton, lab lab, faba beans	0.5 (n=798)		0.5 (n=798)
Gwydir valley, NSW	cotton	0 (n=18)		0 (n=18)
Bundaberg, QLD	tomatoes	0 (n=74)		0 (n=74)
Childers, QLD	tomatoes	0 (n=84)		0 (n=84)
Total of all sites		0.4 (n=974)		0.4 (n=974)

## 1997 / 98 Season - MVP® on neonates

% Surviving the Discriminating Dose of MVP® (CryIAC delta endotoxin encapsulated in killed *Pseudomonas fluorescens* cells)

Species and collection area	Host	Early season collections (October - January)	Mid / late season collections (February - May)	Season total
<b><i>Heliothis armigera</i></b>				
Lower Namoi valley, NSW	cotton, maize, lab lab, faba bean, field peas	0 (n=313)	0 (n=800)	0 (n=1,113)
Upper Namoi valley, NSW	cotton		0 (n=58)	0 (n=58)
Gwydir valley, NSW	cotton, soyabean	0 (n=110)	0 (n=82)	0 (n=192)
Emerald, QLD	cotton, maize, pigeon peas	0 (n=176)	0 (n=47)	0 (n=223)
Darling Downs, QLD	cotton, maize, sorghum	0 (n=392)	0 (n=24)	0 (n=416)
Macintyre, NSW/QLD	cotton	0 (n=112)		0 (n=112)
St. George, QLD	cotton	0 (n=95)	0 (n=109)	0 (n=204)
South Burnett, QLD	cotton, maize, navy beans	0 (n=155)		0 (n=155)
Mungindi, NSW	cotton		0 (n=20)	0 (n=20)
Walgett, NSW	cotton		0 (n=80)	0 (n=80)
Total of all sites		0 (n=1,353)	0 (n=1,220)	0 (n=2,573)

### *Heliothis punctigera*

Lower Namoi valley, NSW	cotton, lab lab, faba beans	0.2 (n=661)	0 (n=230)	0.1 (n=891)
Upper Namoi valley, NSW	cotton		0 (n=9)	0 (n=9)
Gwydir valley, NSW	cotton	0 (n=54)	0 (n=37)	0 (n=91)
Emerald, QLD	cotton	0 (n=6)		0 (n=6)
St. George, QLD	cotton	0 (n=25)	0 (n=27)	0 (n=52)
South Burnett, QLD	cotton	0 (n=32)		0 (n=32)
Darling Downs, QLD	cotton	0 (n=29)		0 (n=29)
Macintyre, NSW/QLD	cotton	0 (n=66)		0 (n=66)
Mungindi, NSW	cotton		0 (n=6)	0 (n=6)
Walgett, NSW	cotton		0 (n=35)	0 (n=35)
Total of all sites		0.1 (n=873)	0 (n=344)	0.1 (n=1,217)

## 1997 / 98 Season - MVP® on early third instars

% Surviving the Discriminating Dose of MVP® (CryIAc delta endotoxin encapsulated in killed *Pseudomonas fluorescens* cells)

Species and collection area	Host	Early season collections (October - January)	Mid / late season collections (February - May)	Season total
<b><i>Heliothis armigera</i></b>				
Lower Namoi valley, NSW	cotton, maize, lab lab, faba bean, field peas	0.3 (n=861)	0.2 (n=1,619)	0.2 (n=2,480)
Gwydir valley, NSW	cotton, soyabean	1.8 (n=164)	0 (n=350)	0.6 (n=514)
Emerald, QLD	cotton, maize, pigeon peas	0 (n=155)	0 (n=302)	0 (n=457)
Bundaberg, QLD	tomatoes	1.3 (n=77)	0.2 (n=426)	0.4 (n=503)
Childers, QLD	tomatoes		0 (n=100)	0 (n=100)
Darling Downs, QLD	cotton, maize, sorghum	0.4 (n=485)	0 (n=272)	0.3 (n=757)
Macintyre, NSW/QLD	cotton	0 (n=146)	0 (n=6)	0 (n=152)
St. George, QLD	cotton	0 (n=125)	0.4 (n=258)	0.3 (n=383)
South Burnett, QLD	cotton, maize, navy beans	1.6 (n=126)		1.6 (n=126)
Mungindi, NSW	cotton		0 (n=76)	0 (n=76)
Walgett, NSW	cotton		0 (n=106)	0 (n=106)
<b>Total of all sites</b>		<b>0.5 (n=2,139)</b>	<b>0.1 (n=3,515)</b>	<b>0.3 (n=5,654)</b>

### ***Heliothis punctigera***

Lower Namoi valley, NSW	cotton, lab lab, faba beans	0 (n=922)		0 (n=922)
<b>Total of all sites</b>		<b>0 (n=922)</b>		<b>0 (n=922)</b>