Cotton Research and Development Corporation

FINAL REPORT

"Management of resistance to synthetic insecticides i) Namoi/Gwydir, Emerald and St. George"

DAN 80C

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Abstract

Pyrethroid resistance levels in *Helicoverpa armigera* have continued to escalate slowly to around 80-90% but endosulfan resistance has stabilised at about half that level. Resistance to the partial resistance breaking pyrethroid bifenthrin has increased slightly but on average, resistance levels to this product are about half those to the other conventional synthetic pyrethroids. Profenofos resistance is still low in all areas except for an incipient problem in central Queensland. Via tolerance curve analyses indicate the emergence of elevated levels of pyrethroid resistance mechanisms. These are synergisable by alternative mfo (mixed function oxidase) inhibitors to Pbo (piperonyl butoxide) and are overcome by synergophore pyrethroid analogues such as Series Two and prallethrin but not by esterase inhibitors nor by a non-ester pyrethroid analogue (silafluofen). This indicates the possible development of new isomorphs of P450 monooxygenases (mfos) synergised by alternate chemical classes of mfo inhibitors such as the propynyl ethers but not fully synergisable by Pbo. Laboratory studies indicated some potential synergists for field evaluation (ethion, malathion, phosmet) but most compounds tested were ineffective, including profenofos, trichlorfon, phoxim, azamethiphos and other esterase and glutathione inhibitors. Cyclodiene resistance did not give cross resistance to the avermectins. Baseline susceptible data and discriminating doses were evaluated for three classes of new insecticides; spinosad, the pyrrole chlorfenapyr and the avermectins (abamectin and emamectin benzoate). Abamectin was identified as a potential new replacement for endosulfan for early season *Helicoverpa punctigera* control. *Helicoverpa punctigera* resistance levels to both endosulfan and pyrethroids have remained low.

AIMS

i) To evaluate the levels of resistance to pyrethroids, endosulfan and profenofos in field populations of *Heliothis armigera* in the Namoi/Gwydir, Emerald & St. George cotton growing areas (and other regions where sampling opportunities arise).

ii) To determine the importance of the mixed function oxidase (mfo), esterase and nerve insensitivity pyrethroid resistance mechanisms in field populations of *H. armigera* in the Namoi/Gwydir, Emerald & St. George cotton growing areas (and other regions where sampling opportunities arise).

iii) To screen new resistance breaking pyrethroids and synergists for action against mfo and esterase mediated pyrethroid resistance and to field test the most promising compounds.

iv) To evaluate the levels of resistance to pyrethroids and endosulfan in field populations of *Heliothis punctigera* in the Namoi/Gwydir, Emerald & St. George cotton growing areas (and other regions where sampling opportunities arise).

INTRODUCTION

Pyrethroids and endosulfan account for the vast majority of insecticides used against *Heliothis* in Australian cotton. Although the industry's voluntary resistance management Strategy has managed to retard the development of resistance to both products, resistance levels continue to increase. The use of mixtures (with synergists such as piperonyl butoxide and the biological insecticide *Bacillus thuringiensis*) have extended the effectiveness of both pyrethroids and endosulfan against resistant *H. armigera* but it is important to continually assess the relative importance of the various resistance mechanisms to confidently predict continued efficacy and to advise appropriate mixing partners.

The use of profenofos is also increasing in response to the increasing endosulfan and pyrethroid resistance levels. The withdrawal of chlorfluazuron has also resulted in a further increase in reliance on this product for *Heliothis* control. Although the resistance levels to profenofos are currently relatively low, increased selection pressure will evennually result in significant resistance to this product as well.

The industry will continue to rely heavily on conventional synthetic insecticides for some time (another 5-10 years perhaps) until effective alternative technologies are developed and implemented in commercially significant quantities. Until then, the industry will continue to require a detailed knowledge of the constantly changing resistance status to the most widely used insecticides in cotton. particularly now that successful commercial development of the *Heliothis* identification kit has resulted in a much more flexible use pattern for pyrethroids and endosulfan.

RESULTS & DISCUSSION

1. *Resistance levels to pyrethroids, endosulfan and profenofos*

Pyrethroid resistance levels have continued to increase slowly in all areas. By the 1995/96 season, the resistance levels in cotton areas averaged between 80-90% resistance. The Via tolerance curve analysis of the F1 progeny of the pyrethroid discriminating dose survivors, indicates a shift to homozygosity for the mfo (mixed function oxidase) mediated pyrethroid resistance mechanism over the first ten years following the implementation of the Insecticide Resistance Management Strategy. However, after a further 2-3 seasons, elevated levels of an unknown resistance mechanism (or combination of mechanisms) have arisen, probably due to increasing pyrethroid/mixture selection pressure. Synergist and pyrethroid synergophore studies were conducted on larvae bred from field collected eggs. A number of synergists were studied with Pbo (piperonyl butoxide) shown to be partially effective and the propynyl ether TCPB fully effective in combination with fenvalerate. The methylated biphenyl alcohol pyrethroid bifenthrin was partially effective (similar to Pbo), reducing resistance to about half that of the conventional synthetic pyrethroid fenvalerate. The simple benzyl alcohol pyrethroid (Series Two) and the propynyl bonded pyrethroid prallethrin, were both full resistance breakers despite both being ester bonded synthetic pyrethroids. The non-ester bonded pyrethroid silafluofen was not effective nor was the combination of profenofos plus fenvalerate, indicating that blocking of esterases did not break resistance. The full activity of the alternate mfo inhibitor TCPB and the synergophore synthetic pyrethroids Series Two and prallethrin and the declining effectiveness of Pbo, indicate the possible evolution of a new mfo, less suppressible by Pbo (whose efficacy has declined over time) but still suppressible by a different mfo inhibitor group. The esterases being studied by Dr. Gunning at Tamworth might well be secondary scavengers on hydroxylated pyrethroid metabolites previously detoxified by mfos (hydroxylated pyrethroids are known to be much better substrates for esterases).

Endosulfan resistance levels have levelled off now at about 40-50%. This is most likely a function of the decreasing reliance on endosulfan because of increasing problems with environmental issues such as fish toxicity and residues in grazing animals. However, the recent droughts and subsequent low early season *Helicoverpa punctigera* abundance have also reduced endosulfan use and hence endosulfan selection pressure.

Profenofos useage is increasing as a consequence of increasing resistance problems with the other heliothis products and resistance levels are now starting to creep up slowly, particularly in areas such as central Queensland. It should not be too long before we have a significant organophosphate resistance problem in *Helicoverpa armigera* in Australia, particularly now with the newly developed carbamate resistance problem reducing thiodicarb useage and thus increasing profenofos useage and selection pressure on late season *H. armigera.*

2. *Laboratory evaluation of various mfo synergists*

Pbo and the acaricidal propynyl sulphite propargite are the synergists used in the field for control of pyrethroid resistant *Helicoverpa armigera.* In the search for new synergist combinations, we looked at a number of potential compounds. Most of the organophosphates proved unsuccessful (profenofos, trichlorfon, phoxim, azamethiphos and the esterase and glutathione transferase inhibitors

TPP, DEM and DEF, in addition to the ones tested previously) but some proved potentially useful (eg. phosmet, ethion and malathion). More field development work is required with these potential pyrethroid synergists. Further work on propargite analogues indicated no outstanding alternatives to propargite.

3. *Endosulfan cross resistance*

Endosulfan acts on the GABA receptor which is also one of the putative modes of action of avermectins. As abamectin and emamectin benzoate are being developed for the Australian cotton market, it was important to determine if historical cyclodiene resistance would be a problem for the avermectins. Increased endosulfan selection pressure did result in high levels of resistance to endosulfan and its isomers, the sulphate metabolite and dieldrin but no cross resistance to the abamectin analogue epimethylamino abamectin, indicating activity on a separate distinct site of the GABA receptor.

4. *Baseline susceptibility studies on new Heliothis insecticides*

There are three new insecticide classes being developed for Australian cotton. The spinosyns from Dow Elanco, the pyrroles (chlorfenapyr) from Cyanamid and the abamectin/emamectin benzoate compounds from Novartis (previously Merck Sharpe & Dohme). Ideally, it is far more preferable to establish the baseline susceptible response of pest populations to an insecticide before its commercial introduction and thus before selection pressure commences. In most cases it does not happen this way, as a product is introduced, overused and resisted before resistance management studies are commenced. However, in this case, baseline susceptibility data and discriminating dose calibrations have been generated for all three insecticide groups before their commercial introduction. In addition, it was shown that abamectin was unusually active in the laboratory on *Helicoverpa punctigera* (at least relative to *H. armigera*), so this product should be evaluated as an alternative to endosulfan for early season *Helicoverpa punctigera* control.

5. *Resistance in* Helicoverpa punctigera

Helicoverpa punctigera is usually the most abundant *Helicoverpa* species in Australian cotton and receives significant selection pressure from both pyrethroids and endosulfan. However, it has never developed significant field resistance problems to any insecticide, most likely because of its huge dilution potential. Indeed, it is important to continue to document the ability of *H. punctigera* to 'manage its own resistance' as this is the same ecological basis as for the theory of Bt transgenic cotton resistance management and would thus engender confidence that we may be able to 'imitate nature'.

Helicoverpa punctigera have been screened regularly for both pyrethroid and endosulfan resistance for a number of years. Resistance has been detected to both products but never at significant levels. Further selections of closed populations from these individuals have resulted in low levels of pyrethroid resistance (about 10x) on two separate occasions. In late 1993/94 and for the whole 1994/95 season, a detailed survey was conducted because of some concerns about pyrethroid resistance developing in *Helicoverpa punctigera*. Over 50 *H. punctigera* colonies from all over Australia were tested and the resistance levels ranged from 0 to 15.0% (average = 3.3%).

Future work arising from this project

i) Evaluate ethion, malathion and phosmet as potential commercial synergists.

ii) Develop abamectin for control of early season *Helicoverpa punctigera.*

iii) Introduce discriminating dose assays for the new insecticides spinosad, chlorfenapyr and emamectin benzoate.

iv) Investigate the cross resistance potential between fipronil and endosulfan.

v) Continue monitoring the effectiveness of bifenthrin as a partial resistance breaking pyrethroid.

vi) Investigate the elevated pyrethroid resistance mechanisms in order to devise ways of overcoming them.

vii) Continue to check on the stability of 'self resistance management' for *Helicoverpa punctigera* in order to generate supporting evidence for adoption of the same principle for Bt transgenic cotton resistance management.

Publications arising from this work

A). Contributions to tecbnical conferences

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FORRESTER, N. W. (1994). The need for adaptation to change in Insecticide Resistance Management Strategies: the Australian experience. World Cotton Research Conference-1. Brisbane, Australia.

FORRESTER, N.W. & BIRD, L. J. (1994). Cross resistance studies for endosulfan resistant *Helicoverpa armigera* in Australia. World Cotton Research Conference-1, Brisbane, Australia.

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FORRESTER, N.W. (1997). Maize and cotton growing in harmony. 3rd Australian Maize Conference, Tamworth, NSW.

FORRESTER, N.W. (1997). The development and implementation of Pest Management Strategies for the preservation of a viable cotton industry. FMC Asia Area meeting, Maroochydoore, Qld.

B). Advisory articles

FORRESTER, N.W. (1993). Insecticide resistance management in *Heliothis armigera* in Australia : past successes, present situation and future prospects. *Resistant Pest Management* 5(1) : 29-34.

FORRESTER, N.W. & ANDERSON, I. (1993). The Australian Summer Crop Resistance Management Strategy : Update for the 1992-93 season. *Resistant Pest Management* 5(1) : 28-29.

FORRESTER, N.W., ANDERSON, I. & PYKE, B. (1993). Changes to the insecticide resistance strategy. *The Australian Cotton Grower* 14(5) : 8-11.

FORRESTER, N.W., ANDERSON, I. & PYKE, B. (1993). Insecticide resistance management strategy for *Heliothis* 1993-94. in *Cotton Pesticides Guide 1993-94*. NSW Agriculture, Agdex 151/680, 8-11.

FORRESTER, N.W. (1993). Guidelines for using the new heliothis identification kit. in *Cotton Pesticides Guide 1993-94*. NSW Agriculture, Agdex 151/680, 11-13.

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FORRESTER, N.W., BUERGER, P., GUNNING, R.V., GIBB, D., PYKE, B. & WILSON, L. (1996). Insecticide Resistance Management Strategy: Cotton 1996/97. Extension pamphlet published by the Cotton Research & Development Corporation, the Australian Insecticide Resistance Action Committee, the Co-operative Research Centre for Sustainable Cotton Production and the Transgenic and Insecticide Resistance Management Committee of the Australian Cotton Growers' Research Association.

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C). Refereed research publications

FORRESTER, N.W., CAHILL, M., BIRD, L.J. & LAYLAND, J.K. (1993) Management of pyrethroid and endosulfan resistance in *Helicoverpa armigera* (Lepidoptera: Noctuidae) in Australia. *Bulletin of Entomological Research. Special Supplement* **1**, 1-132.

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STOKES, N.H., MCKECHNIE, S.W. & FORRESTER, N.W. (1997). Multiple allelic variation in a sodium channel gene from populations of Australian *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) detected via temperature gradient gel electrophoresis. *Australian Journal of Entomology* **36**, 191-196.

Budget Summary ($)

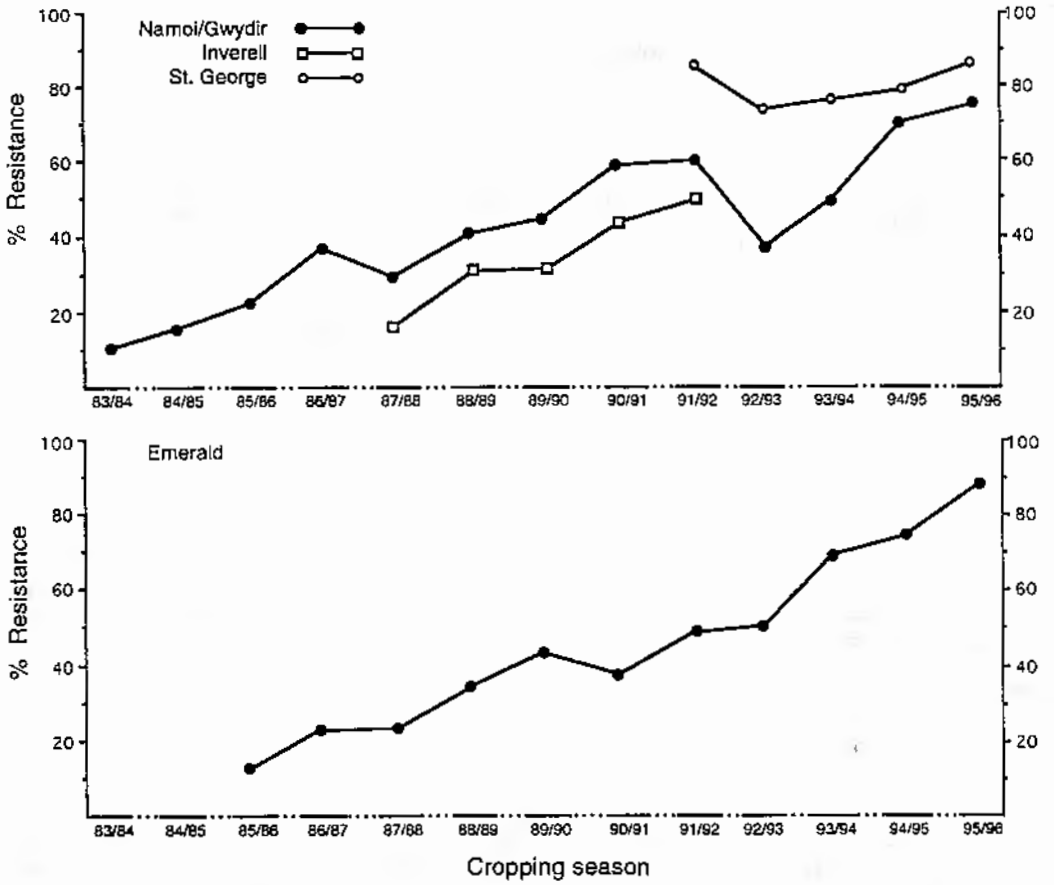
	CRDC funds	NSW Agriculture funds
1993/94	145,000	120,000
1994/95	157,654	120,000
1995/96	164,795	120,000

% SURVIVING DISCRIMINATING DOSE

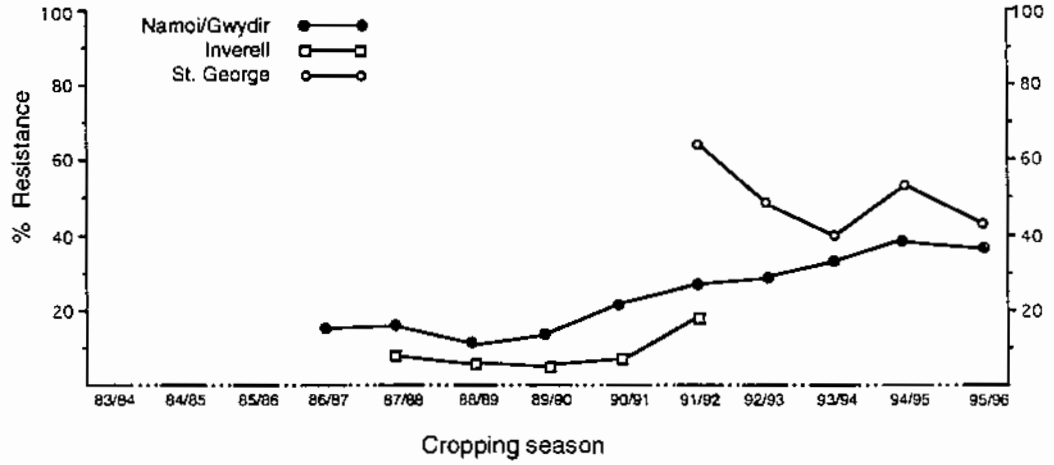
		FENVALERATE			ENDOSULFAN			PROFENOFOS		
STUDY AREA	SEASON	I	II	III	I	II	III	I	II	III
Namoi/Gwydir	1983/84	9.3	9.5	14.6	-	-	-	-	-	-
	84/85	7.5	12.9	27.9	-	-	-	-	-	-
	85/86	7.8	13.0	44.5	-	-	-	-	-	-
	86/87	32.2	36.7	42.9	7.1	16.7	20.1	-	-	-
	87/88	19.8	30.1	38.4	7.3	17.6	23.0	-	-	-
	88/89	19.6	42.4	60.7	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
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).

Fenvalerate resistance - Average of Stages I, II & III



Endosulfan resistance - Average of Stages I, II & III



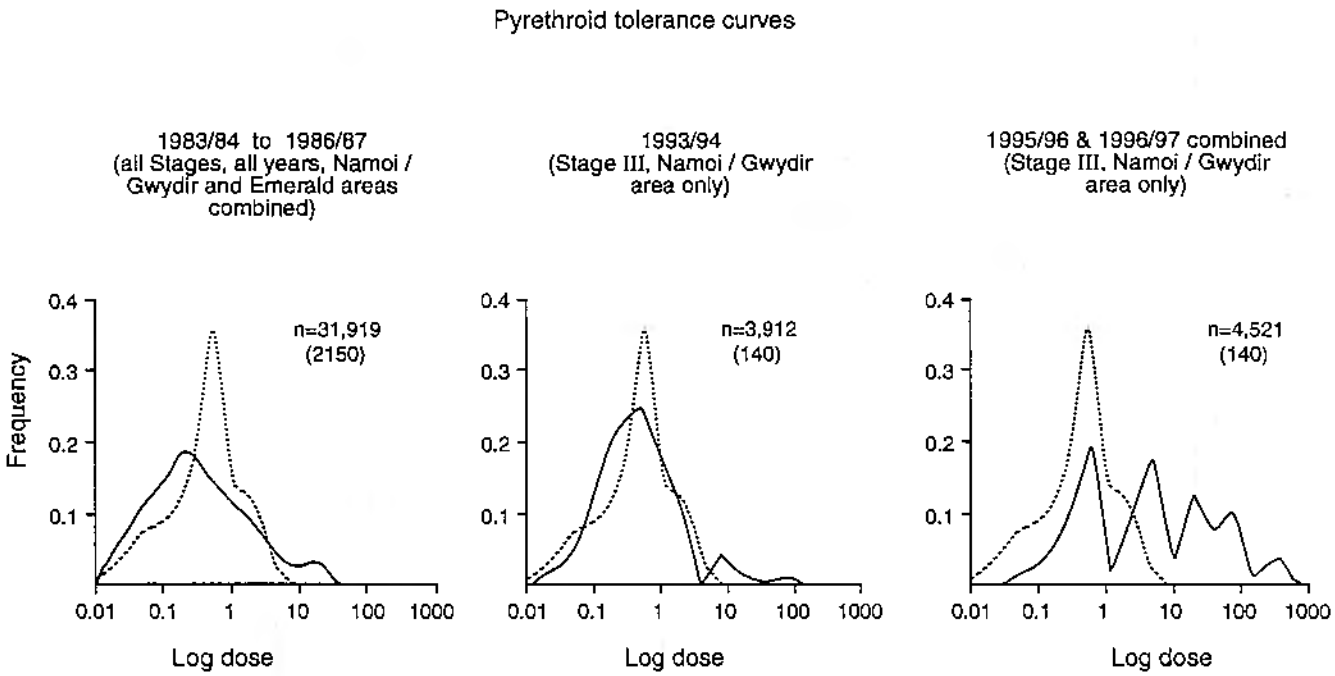


Fig. 1. Tolerance curves (after Via, 1986) for the fenvalerate bioassay of F1 progeny of *Helicoverpa armigera* fenvalerate discriminating dose survivors from the Namoi/Gwydir and Emerald study areas. Data from 1983/84 to 1986/87 pooled for all Stages over all years for both areas (from Fig. 18, Forrester *et al.* 1993). Data for the other seasons from Stage III in the Namoi/Gwydir only. Abscissa - log dose (µg/30-40 mg larva). Ordinate - incremental kill frequency for that dose. n = total number of larvae tested. Number of putative female parents in brackets. Dotted background figure is the tolerance curve for the fenvalerate bioassay of a strain heterozygous for a resistance mechanism fully suppressible by piperonyl butoxide (presumably a microsomal monooxygenase), (from Fig. 14, Forrester *et al.* 1993).

Emerald Stage I,1994/5

Week	Date	% *H.armigera* on cotton	*Heliothis armigera*								*Heliothis punctigera*	
			No. dead No. tested	Fenvalerate %res ± s.e.	No. dead No. tested	Endosulfan % res ± s.e.	No. dead No. tested	Fen/Pbo % res ± s.e.	No. dead No. tested	Profenofos % res ± s.e.	No. dead No. tested	Fenvalerate %res ± s.e.
4	29 Nov - 5 Dec	92.8 (125)	20/41	51.2 ± 7.9	27/40	32.5 ± 7.5	37/44	15.9 ± 5.6			15/15	0.0 ± 0.0
5	6 - 12 Dec	89.8 (254)	24/59	59.3 ± 6.4	47/79	40.5 ± 5.6	29/29	0.0 ± 0.0	51/53	3.8 ± 2.7	21/22	4.6 ± 4.6
6	13 - 19 Dec	52.9 (240)	18/41	56.1 ± 7.8	24/41	41.5 ± 7.8			40/41	2.4 ± 2.4	99/103	3.9 ± 1.9
Average		**76.1 (619)**	**62/141**	**56.0 ± 4.2**	**98/160**	**38.8 ± 3.9**	**66/73**	**9.6 ± 3.5**	**91/94**	**3.2 ± 1.8**	**135/140**	**3.6 ± 1.6**

Emerald Stage II, 1994/5

			Helicoverpa armigera													*Helicoverpa punctigera*	
Week	Collection date	Average % Ha on cotton	No. dead No. tested	Fenvalerate %res ± s.e.	No. dead No. tested	Endosulfan % res ± s.e.	No. dead No. tested	Fen/Pbo mix % res ± s.e.	No. dead No. tested	Series II 0.1 % res ± s.e.	No. dead No. tested	Bifenthrin 0.1 % res ± s.e.	No. dead No. tested	Profenofos1.0 % res ± s.e.	No. dead No. tested	Fenvalerate % res ± s.e.
1	20 - 26 Dec	55.7 (61)	8/24	66.7 ± 9.8											16/16	0
2	27 Dec - 2 Jan															
3	3 - 9 Jan	92.7 (1251)	46/146	68.5 ± 3.9	62/124	50.0 ± 4.5	105/140	25.0 ± 3.7	124/136	8.8 ± 2.4	85/141	39.7 ± 4.1	135/138	2.1 ± 1.2	67/69	2.9 ± 2.5
4	10 - 16 Jan	96.1 (623)	23/69	66.7 ± 5.7	38/65	41.6 ± 6.2	36/62	41.9 ± 6.3	60/61	1.6 ± 1.6	27/63	57.1 ± 6.3	62/64	3.1 ± 2.2	19/19	0
5	17 - 23 Jan	99.3 (268)	4/44	90.9 ± 4.4	23/51	54.9 ± 7.0	39/58	32.8 ± 6.2			35/60	41.7 ± 6.5	54/55	1.8 ± 1.8	3/3	0
6	24 - 30 Jan	79.3 (372)	13/79	83.6 ± 4.2	22/69	68.1 ± 5.7							68/76	10.6 ± 3.6	52/53	1.9 ± 1.9
	Average	**91.4 (2575)**	**94/362**	**74.0 ± 2.3**	**145/309**	**53.1 ± 2.8**	**180/260**	**30.8 ± 2.9**	**184/197**	**6.6 ± 1.8**	**147/258**	**43.0 ± 3.1**	**319/333**	**4.2 ± 1.1**	**157/160**	**1.9 ± 1.1**

Week	No. dead No. tested	TCPB 20 + Fen 0.2 % res ± s.e.	No. dead No. tested	Curacron 0.05 + Fen 0.2 % res ± s.e.
3	104/122		38/118	
Control mortality	0/47		0/29	
Adjusted mortality	104/122	14.8 ± 3.2	38/118	67.8 ± 4.
4	60/64		18/53	
Control mortality	0/27		0/21	
Adjusted mortality	60/64	6.3 ± 3.1	18/53	66.0 ± 6.7
Average	**164/186**	**11.8 ± 2.4**	**56/171**	**67.3 ± 3.6**

Emerald Stage III, 1994/5

			Heliothis armigera												*Heliothis punctigera*	
Week	Collection date	Average %Ha on cotton	No. dead No. tested	Fenvalerate %res ± s.e.	No. dead No. tested	Endosulfan % res ± s.e.	No. dead No. tested	Fen/Pbo mix % res ± s.e.	No. dead No. tested	Series II 0.1 % res ± s.e.	No. dead No. tested	Bifenthrin 0.1 % res ± s.e.	No. dead No. tested	Profenofos1.0 % res ± s.e.	No. dead No. tested	Fenvalerate % res ± s.e.
1	31 Jan - 6 Feb	100 (42)	3/40	92.5 ± 4.2											16/16	0
2	7 - 13 Feb															
3	14 - 20 Feb	83.0 (324)	9/87	89.7 ± 3.3	46/80	42.5 ± 5.6							84/85	1.2 ± 1.2		
4	21 - 27 Feb	68.8 (192)	4/94	95.7 + 2.1											51/56	8.9 ± 3.8
5	28 Feb - 6 Mar	38.0 (50)													28/29	3.4 ± 3.4
Average		**76.0 (608)**	**16/221**	**92.8 ± 1.7**	**46/80**	**42.5 ± 5.6**							**84/85**	**1.2 ± 1.2**	**95/101**	**5.9 ± 2.4**

Namoi/Gwydir Stage I,1994/5

			Heliothis armigera												*Heliothis punctigera*	
Week	Collection date	Average %Ha on cotton	No. dead No. tested	Fenvalerate % res ± s.e.	No. dead No. tested	Endosulfan % res ± s.e.	No. dead No. tested	Fen/Pbo mix % res ± s.e.	No. dead No. tested	Series II 0.1 % res ± s.e.	No. dead No. tested	Bifenthrin 0.1 % res ± s.e.	No. dead No. tested	Profenofos1.0 % res ± s.e.	No. dead No. tested	Fenvalerate % res ± s.e.
3	22 - 28 Nov	62.3 (257)	46/106	56.6 ± 4.8	50/82	39.0 ± 5.4	70/79	11.4 ± 3.6	80/81	1.2 ± 1.2	77/84	8.3 ± 3.0			116/116	0.0 ± 0.0
4	29 Nov - 5 Dec	62.3 (710)	57/126	54.8 ± 4.5	65/97	33.0 ± 4.8	79/99	20.2 ± 4.0	92/97	5.2 ± 2.3	85/100	15.0 ± 3.6	72/72	0.0 ± 0.0	118/131	9.9 ± 2.6
5	6 - 12 Dec	63.0 (1463)	69/199	65.3 ± 3.4	90/145	37.9 ± 4.0	110/149	26.2 ± 3.6	132/141	6.4 ± 2.1	94/138	31.9 ± 4.0	134/135	0.7 ± 0.7	181/199	9.0 ± 2.0
6	13 - 19 Dec	74.4 (745)	30/122	75.4 ± 3.9	52/98	46.9 ± 5.1	75/105	28.6 ± 4.4	66/87	24.1 ± 4.6	47/87	46.0 ± 5.4	99/105	5.7 ± 2.3	54/56	3.4 ± 2.4
Average		**66.7 (3184)**	**202/553**	**63.5 ± 2.0**	**257/422**	**39.1 ± 2.4**	**334/432**	**22.7 ± 2.0**	**370/406**	**8.9 ±1.4**	**303/409**	**25.9 ± 2.2**	**305/312**	**2.2 ± 0.8**	**558/593**	**5.9 ± 1.0**

	Heliothis armigera			
Week	No. dead No. tested	TCP020 + Fen 0.2 % res ± s.e.	No. dead No. tested	Curacron 0.05 + Fen 0.2 % res ± s.e.
3	78/79	1.3 ± 1.3		
Control mortality	0/22			
Adjusted mortality	78/79	1.3 ± 1.3		
4	92/92	0.0 ± 0.0		
Control mortality	0/51			
Adjusted mortality	92/92	0.0 ± 0.0		
5	153/156	1.9 ± 1.1	64/159	59.7 ± 3.9
Control mortality	0/61		0/48	
Adjusted mortality	153/156	1.9 ± 1.1	64/159	59.7 ± 3.9
6	95/113	6.6 ± 3.7	42/96	56.3
Control mortality	0/54		2/50=4.0	
Adjusted mortality	95/113	15.9 ± 3.4	39.7/96	58.6 ± 5.1
Average	**418/440**	**5.0 ±1.0**	**103.7/255**	**59.3 ± 3.1**

Namoi/Gwydir Stage II,1994/5

			Heliothis armigera												*Heliothis punctigera*			
Week	Collection date	Average % Ha on cotton	No. dead No. tested	Fenvalerate % res ± s.e.	No. dead No. tested	Endosulfan % res ± s.e.	No. dead No. tested	Fen/Pho mix % res ± s.e.	No. dead No. tested	Series II 0.1 % res ± s.e.	No. dead No. tested	Bifenthrin 0.1 % res ± s.e.	No. dead No. tested	Profenofos1.0 % res ± s.e.	No. dead No. tested	Fenvalerate % res ± s.e.	No. dead No. tested	Endosulfan % res ± s.e.
1	20 - 26 Dec	98.6 (141)	33/123	73.2 ± 4.0	61/99	38.4 ± 4.9	81/102	20.6 ± 4.0	87/99	12.1 ± 3.3	80/102	21.6 ± 4.1	107/107	0.0 ± 0.0	2/2			
2	27 Dec - 2 Jan	54.7 (148)	17/59	71.2 ± 5.9	44/59	25.4 ± 5.7							67/67	0.0 ± 0.0	69/69	0.0 ± 0.0		
3	3 - 9 Jan	44.8 (1549)	27/91	70.3 ± 4.8	61/86	29.1 ± 4.9	63/92	31.6 ± 4.9	69/79	12.7 ± 3.8	54/74	27.0 ± 5.2	88/90	2.2 ± 1.6	183/188	2.7 ± 1.2	250/253	1.2 ± 0.7
4	10 - 16 Jan	71.8 (2522)	30/87	65.5 ± 5.1	102/170	40.0 ± 3.8	122/176	30.7 ± 3.5	149/173	13.9 ± 2.6	142/188	24.5 ± 3.1	180/185	2.7 ± 1.2	186/199	6.6 ± 1.9	185/187	1.1 ± 0.8
5	17 - 23 Jan	63.7 (319)	27/95	71.6 ± 4.7	44/89	50.6 ± 5.3							108/111	2.7 ± 1.6	136/141	3.6 ± 1.6	129/130	0.8 ± 0.8
6	24 - 30 Jan	67.4 (316)	16/74	78.4 ± 4.8	47/82	42.7 ± 5.5							87/87	0.0 ± 0.0	121/123	1.6 ± 1.1		
Average		62.9 (5111)	150/529	71.6 ± 2.0	359/585	38.6 ± 2.0	266/370	28.1 ± 2.3	305/351	13.1 ± 1.8	276/364	24.2 ± 2.2	637/647	1.6 ± 0.5	697/722	3.5 ± 0.7	564/570	1.1 ± 0.4

	Heliothis armigera			
Week	No. dead No. tested	TCPB20 + Fen 0.2 % res ± s.e.	No. dead No. tested	Curacron 0.05 + Fen 2.0 % res ± s.e.
1	88/107	17.8	23/91	74.7
Control mortality	0/39		0/53	
Adjusted mortality	88/107	17.8 ± 3.8	23/91	74.7 ± 4.6
2				
Control mortality				
Adjusted mortality				
3	60/64	6.3	32/77	58.4
Control mortality	0/54		1/34 = 2.9	
Adjusted mortality	60/64	6.3 ± 3.1	30.7/77	60.1 ± 5.6
4	147/158	7.0 ± 2.0	51/133	61.7
Control mortality	0/53		1/37 = 2.7	
Adjusted mortality	147/158	7.0 ± 2.0	48.7/133	63.4 ± 4.2
Average	295/329	10.3 ± 1.7	102.4/301	66.0 ± 2.7

Namoi/Gwydir Stage III,1994/5

			Heliothis armigera																	*Heliothis punctigera*			
Week	Collection date	Average *Hel* on cotton	No. dead No. tested	Fenvalerate % res ± s.e.	No. dead No. tested	Endosulfan % res ± s.e.	No. dead No. tested	Fen/Pbo mix % res ± s.e.	No.dead No. tested	Series II 0.1 % res ± s.e.	No. dead No. tested	Difenthiuron 0.1 % res ± s.e.	No. dead No. tested	Profenofos1.0 % res ± s.e.	No. dead No. tested	Sthalfluofen % res ± s.e.	No. dead No. tested	Prallethrin % res ± s.e.	No. dead No. tested	Fenvalerate % res ± s.e.	No. dead No. tested	Endosulfan % res ± s.e.
1	31 Jan - 6 Feb	67.2 (988)	46/138	66.7 ± 4.0	66/128	48.4 ± 4.4	71/107	33.6 ± 4.6			72/110	34.6 ± 4.6	120/122	1.6 ± 1.1					172/178	3.4 ± 1.4	73/73	0
2	7 - 13 Feb	54.5 (1428)	34/163	79.3 ± 3.2	66/125	47.2 ± 4.5	81/122	33.6 ± 4.3	115/115	0	77/121	36.4 ± 4.4	123/123	0					215/222	3.2 ± 1.2	220/226	2.7 ± 1.1
3	14 - 20 Feb	79.3 (1621)	67/195	65.6 ± 3.4	111/180	38.3 ± 3.6	98/170	42.4 ± 3.8	182/182	0	117/170	31.2 ± 3.6	180/183	1.6 ± 0.1					214/223	4.0 ± 1.3	157/158	0.6 ± 0.6
4	21 - 27 Feb	64.7 (1333)	66/160	58.8 ± 3.9	86/132	34.8 ± 4.2			136/136	0			137/137	0	20/135	85.2 ± 3.1	109/120	9.2 ± 2.6	256/258	0.8 ± 0.6	187/187	0
5	28 Feb - 6 Mar	94.0 (1340)	65/294	77.9 ± 2.4	147/234	37.2 ± 3.2			234/235	0.4 ± 0.4			251/253	0.8 ± 0.6	27/226	88.1 ± 2.2	212/227	6.6 ± 1.7	83/88	5.7 ± 2.5		
6	7 - 13 Mar	94.4 (1813)	74/327	77.4 ± 2.3	143/235	39.1 ± 3.2			256/256	0			251/259	3.1 ± 1.1	41/260	84.2 ± 2.3	259/295	12.2 ± 1.9	142/146	2.7 ± 1.3		
7	14 - 20 Mar	97.8 (1573)	27/193	86.0 ± 2.5	128/221	42.1 ± 3.3			208/208	0			232/234	0.9 ± 0.6	27/226	88.1 ± 2.2	207/219	5.5 ± 1.6	41/42	2.4 ± 2.4		
8	21 - 27 Mar	97.6 (820)	28/129	78.3 ± 3.6	87/155	43.9 ± 4.0			150/150	0			126/132	4.6 ± 1.8	13/139	90.6 ± 2.5	147/164	10.4 ± 2.4	26/27	3.7 ± 3.7		
9	28 Mar - 3 April	92.0 (817)			86/140	38.6 ± 4.1													69/75	8.0 ± 3.6		
10	4 - 10 April	98.2 (279)																				
11	11 - 17 April	93.7 (868)																				
Average		83.4 (12880)	407/1600	74.6 ± 1.1	920/1550	40.6 ± 1.2	250/399	37.3 ± 2.4	1281/1282	0.1 ± 0.1	266/401	33.7 ± 2.4	1420/1443	1.6 ± 0.3	128/986	87.0 ± 1.1	934/1025	8.9 ± 0.9	1218/1259	3.3 ± 0.5	637/644	1.1 ± 0.4

	Heliothis armigera			
Week	No. dead No. tested	TCPB 20 + Fen 0.2 % res ± s.e.	No. dead No. tested	Curacron 0.05 + Fen 0.2 % res ± s.e.
1	107/113	5.3		
Control mortality	0/50			
Adjusted mortality	107/113	5.3 + 2.1		
2	101/119	15.1		
Control mortality	1/36			
Adjusted mortality	100.6/119	15.5 ± 3.3		
3	170/187	9.1	64/167	61.7
Control mortality	0/39		0/37	
Adjusted mortality	170/187	9.1 ± 2.1	64/167	61.7 + 3.8
4			43/129	66.7
Control mortality			0/46	
Adjusted mortality			43/129	66.7 ± 4.2
5			60/213	71.8
Control mortality			1/50=2.0	
Adjusted mortality			56.9/213	73.3 ± 3.0
6			92/261	64.8
Control mortality			2/48=4.2	
Adjusted mortality			84.6/261	67.6 ± 2.9
7			36/218	83.5
Control mortality			0/41	
Adjusted mortality			36/218	83.5 + 2.6
8			30/152	80.3
Control mortality			1/75=1.3	
Adjusted mortality			27.8/152	81.7 ± 3.1
Average	377.6/419	9.9 ± 1.5	312.3/1140	72.6 ± 1.3

St George Stage I,1994/5

			Heliothis armigera								*Heliothis punctigera*	
Week	Date	*%H.armigera* on cotton	No. dead No. tested	Fenvalerate %res ± s.e.	No. dead No. tested	Endosulfan % res ± s.e.	No. dead No. tested	Fen/Pbo % res ± s.e.	No. dead No. tested	Profenofos %res ± s.e.	No. dead No. tested	Fenvalerate %res ± s.e.
5	6 - 12 Dec	41.0 (239)	9/30	70.0 ± 8.5	17/33	48.5 ± 8.8	25/33	24.2 ± 7.6			129/131	1.5 ± 1.1
6	13 - 19 Dec	19.2 (99)	4/17	76.5 ± 10.6							75/77	2.6 ± 1.8
Average		**34.6 (338)**	**13/47**	**72.3 ± 6.6**	**17/33**	**48.5 ± 8.8**	**25/33**	**24.2 ± 7.6**			**204/208**	**1.9 ± 1.0**

St. George Stage II, 1994/5

			Heliothis armigera												*Heliothis punctigera*			
Week	Collection date	Average %Ha on cotton	No. dead No. tested	Fenvalerate %res ± s.e.	No. dead No. tested	Endosulfan % res ± s.e.	No. dead No. tested	Fen/Pbo mix % res ± s.e.	No. dead No. tested	Series II 0.1 % res ± s.e.	No. dead No. tested	Bifenthrin 0.1 % res ± s.e.	No. dead No. tested	Profenofos1.0 % res ± s.e.	No. dead No. tested	Fenvalerate % res ± s.e.	No. dead No. tested	Endosulfan % res ± s.e.
1	20 - 26 Dec	64.3 (42)	4/27	85.2 ± 7.0											12/13	7.7 ± 7.7		
2	27 Dec - 2 Jan	69.6 (158)	31/68	54.4 ± 6.1											79/88	10.2 ± 3.2		
3	3 - 9 Jan	72.7 (1049)	29/71	59.1 ± 5.9	40/74	45.9 ± 5.8	66/84	21.4 ± 4.5	77/80	3.8 ± 2.2	67/83	19.3 ± 4.4	87/89	2.2 ± 1.6	135/142	4.9 ± 1.8	120/126	4.8 ± 1.9
4	10 - 16 Jan	60.3 (858)	12/63	81.0 ± 5.0	27/63	57.1 ± 6.3	50/73	31.5 ± 5.5	53/53	0	35/55	36.4 ± 6.6	44/47	6.4 ± 3.6	134/141	5.0 ± 1.8	166/167	0.6 ± 0.6
5	17 - 23 Jan	85.5 (523)	14/94	85.1 ± 3.4	34/83	59.0 ± 5.4					45/78	42.3 ± 5.6	94/99	5.1 ± 2.2	60/63	4.8 ± 2.7		
6	24 - 30 Jan	59.6 (514)	8/86	90.7 ± 3.1	28/69	59.4 ± 6.0					29/72	59.7 ± 5.8	73/77	5.2 ± 2.6	168/174	3.4 ± 1.4		
Average		69.0 (3144)	**98/409**	**76.0 ± 2.1**	**129/289**	**55.4 ± 2.9**	**116/157**	**26.1 ± 3.6**	**130/133**	**2.3 ± 1.3**	**176/288**	**38.9 ± 2.9**	**298/312**	**4.5 ± 1.2**	**588/621**	**5.3 ± 0.9**	**286/293**	**2.4 ± 0.9**

	Heliothis armigera			
Week	No. dead No. tested	TCPB 20 + Fen 0.2 % res ± s.e.	No. dead No. tested	Curacron 0.05 + Fen 0.2 % res ± s.e.
3	74/92	19.6	27/76	64.4
Control mortality	0/38		0/27	
Adjusted mortality	74/92	19.6 ± 4.2	27/76	64.4 ± 5.6
4	38/49		12/34	
Control mortality	0/9		0/28	
Adjusted mortality	38/49	22.4 ± 6.0	12/34	64.7 ± 8.3
Average	**112/141**	**20.6 ± 3.4**	**39/110**	**64.6 ± 4.6**

St. George Stage III, 1994/5

			Heliothis armigera																*Heliothis punctigera*			
Week	Collection date	Average oviposition	No. dead No. tested	Fenvalerate % res ± s.e.	No. dead No. tested	Endosulfan % res ± s.e.	No. dead No. tested	Fen/Pbo mix % res ± s.e.	No. dead No. tested	Series II 0.1 % res ± s.e.	No. dead No. tested	Bifenthrin 0.1 % res ± s.e.	No. dead No. tested	Profenofos 1.0 % res ± s.e.	No. dead No. tested	Silafluofen % res ± s.e.	No. dead No. tested	Prallethrin % res ± s.e.	No. dead No. tested	Fenvalerate % res ± s.e.	No. dead No. tested	Endosulfan % res ± s.e.
1	31 Jan - 6 Feb	83.9 (1316)	20/146	86.3 ± 2.9	47/122	61.5 ± 4.4	68/113	39.8 ± 4.6	127/127	0	51/113	54.9 ± 4.7	106/124	14.6 ± 3.2	-	-	-	-	99/106	6.6 ± 2.4	-	-
2	7 - 13 Feb	68.4 (1329)	14/120	88.3 ± 2.9	72/115	37.4 ± 4.6	58/111	47.7 ± 4.8	101/103	1.9 ± 1.4	36/97	62.9 ± 4.9	93/99	6.1 ± 2.4	-	-	-	-	141/148	4.7 ± 1.7	135/135	0
3	14 - 20 Feb	84.4 (1202)	15/101	85.1 ± 3.6	42/111	62.2 ± 4.6	64/103	37.9 ± 4.8	107/107	0	43/104	58.7 ± 4.9	99/104	4.8 ± 2.1	-	-	-	-	128/137	5.6 ± 2.1	-	-
4	21 - 27 Feb	63.2 (1099)	12/113	89.4 ± 2.9	-	-	-	-	111/111	0	-	-	108/111	2.7 ± 1.6	15/99	84.8 ± 3.6	86/105	18.1 ± 3.8	179/187	4.3 ± 1.5	93/96	3.1 ± 1.8
5	28 Feb - 6 Mar	79.4 (848)	13/129	89.9 ± 2.7	-	-	-	-	144/144	0	-	-	118/124	4.8 ± 1.9	15/136	89.0 ± 2.7	114/143	20.3 ± 3.4	144/149	3.4 ± 1.5	-	-
6	7 - 13 Mar	87.9 (770)	15/89	83.1 ± 4.0	-	-	-	-	92/92	0	-	-	87/88	1.1 ± 1.1	7/86	91.9 ± 3.0	76/97	21.6 ± 4.2	61/65	7.6 ± 3.3	-	-
7	14 - 20 Mar	90.1 (171)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6/7		-	-
8	21 - 27 Mar	93.2 (311)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14/15		-	-
9	28 Mar - 1 Apr	79.6 (88)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Average		78.3 (7129)	89/698	87.2 ± 1.3	161/348	53.7 ± 2.7	190/327	41.9 ± 2.7	682/684	0.3 ± 0.2	130/314	58.6 ± 2.3	611/650	6.0 ± 0.9	37/321	88.5 ± 1.8	276/345	20.0 ± 2.2	772/814	5.2 ± 0.8	228/231	1.3 ± 0.7

	Heliothis armigera			
Week	No. dead No. tested	TCPB 20 + Fen 0.2 % res ± s.e.	No. dead No. tested	Curacron 0.05 + Fen 0.2 % res ± s.e.
1	56/108		15/123	
Control mortality	0/46		0/35	
Adjusted mortality	56/108	39.8 ± 4.7	15/123	87.8 ± 3.0
2	81/104	22.1	15/99	84.8
Control mortality	0/31		0/22	
Adjusted mortality	81/104	22.1 ± 4.1	15/99	84.8 ± 4.3
3	78/103	24.3	20/94	78.7
Control mortality	0/43		0/43	
Adjusted mortality	78/103	24.3 ± 4.2	20/94	78.7 ± 4.2
4				
Control mortality				
Adjusted mortality				
5				
Control mortality				
Adjusted mortality				
6			8/95	
Control mortality			0/10	
Adjusted mortality			8/95	91.6 ± 2.9
Average	215/315	31.7 ± 2.6	58/411	85.9 ± 1.7

Season long average resistance levels in *Helicoverpa armigera* for conventional insecticides and *Bacillus thuringiensis* in Australian cotton areas for the 1995/96 season

Fenvalerate resistance

Mungindi	92.0
Emerald	89.2
St George	86.0
Lower Namoi	79.0
Gwydir	73.6
Darling Downs	70.9
Dawson / Callide	68.6
Upper Namoi	67.2
South Burnett	50.6
Lockyer Valley	48.2

Bifenthrin = Talstar® resistance

Namoi	30.9
Gwydir	20.3
Darling Downs	12.1

Pbo/pyrethroid resistance

Namoi	42.3
Gwydir	32.7
Darling Downs	29.1
Dawson / Callide	21.7

Bacillus thuringiensis var. *kurstaki* (DiPel®) (expected survival range 0 - 0.8%)

South Burnett	0.6
Dawson/Callide	0.4
Namoi/Gwydir	0.2
St. George	0.2
Emerald	0
Bundaberg	0
Darling Downs	0
Macintyre	0
Mungindi	0
Lockyer Valley	0

Endosulfan resistance

Mungindi	47.6
St George	43.1
Lower Namoi	38.8
Bundaberg	35.3
Upper Namoi	33.9
Dawson / Callide	29.8

Bacillus thuringiensis var. *aizawaii* (Xentari®) (expected survival range 0 - 1.0%)

Namoi/Gwydir	0.1
Bundaberg	0
Darling Downs	0
Lockyer Valley	0

Thiodicarb resistance

Namoi	17.1
Emerald	17.0
St George	16.4
Macintyre	14.7
Dawson / Callide	12.2
Bundaberg	10.0
Gwydir	8.7
South Burnett	8.6
Darling Downs	7.9
Lockyer Valley	5.8

Methomyl resistance

Emerald	80.0
Dawson / Callide	79.7
St George	71.4
Namoi	70.1
Darling Downs	69.7

Profenofos resistance

Emerald	15.0
Dawson / Callide	9.3
Darling Downs	4.0
Lower Namoi	3.8
Macintyre	3.8
St George	3.2
Gwydir	2.7
Bundaberg	1.6
South Burnett	1.6

Bundaberg 1995/6

Percentage of larvae (reared from field collected eggs) surviving the discriminating dose of various insecticides (expected survival at the discriminating dose = 0 to 2%)

				Helicoverpa armigera									*Helicoverpa punctigera*			
Week	Collection date	Average % Ha (80 cotton)	Fenvalerate (pyrethroid) % res (no. tested)	Endosulfan % res ± se(no. tested)	Fen/Pbo mix % res ± se(no. tested)	Series II % res ± se(no. tested)	Bifenthrin (Talstar®) % res ± se(no. tested)	Profenofos (Curacron®, Sabre®) % res ± se(no. tested)	Thiodicarb (Larvin®) % res ± se(no. tested)	Methomyl (as a larvicide) % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± se(no. tested)	Fenvalerate (pyrethroid) % res ± se(no. tested)	Endosulfan % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± se(no. tested)
Stage I																
1	12 - 18 Nov															
2	19 - 25 Nov															
3	26 Nov - 2 Dec															
4	3 - 9 Dec															
Average																
Stage II																
1	10 - 16 Dec															
2	17 - 23 Dec															
3	24 - 30 Dec															
4	31 Dec - 6 Jan															
5	7 - 13 Jan															
6	14 - 20 Jan															
7	21 - 26 Jan															
Average																
Stage III																
1	27 Jan - 3 Feb															
2	4 - 10 Feb															
3	11 - 17 Feb															
4	18 - 24 Feb								12.4 ± 3.6 (89)		0 ± 0 (98)	0 ± 0 (97)				
5	25 Feb - 2 Mar															
6	3 - 9 Mar			35.3 ± 5.8 (68)				1.6 ± 1.6 (63)	3.4 ± 1.6 (132)		0 ± 0 (80)	0 ± 0 (86)				
7	10 - 16 Mar															
8	17 - 23 Mar							1.7 ± 1.7 (60)	18.7 ± 4.6 (75)		0 ± 0 (72)					
9	24 - 30 Mar															
10	31 Mar - 6 Apr															
11	7 - 13 Apr															
12	14 - 20 Apr															
13	21 - 27 Apr			36.8 ± 3.4 (204)				5.0 ± 1.6 (199)	3.5 ± 1.3 (201)	57.1 ± 3.8 (175)	0 ± 0 (130)	0 ± 0 (147)				
14	28 Apr - 9 May															
Average				36.4 ± 2.9 (272)				3.7 ± 1.1 (322)	7.4 ± 1.2 (497)	57.1 ± 3.8 (175)	0 ± 0 (380)	0 ± 0 (330)				

Darling Downs 1995/6

Percentage of larvae (reared from field collected eggs) surviving the discriminating dose of various insecticides (expected survival at the discriminating dose = 0 to 2%)

									Helicoverpa armigera				*Helicoverpa punctigera*			
Week	Collection date	Average % Ha on cotton	Fenvalerate (pyrethroid) % res (no. tested)	Endosulfan % res ± se(no. tested)	Fen/Pho mix % res ± se(no. tested)	Series II % res ± se(no. tested)	Bifenthrin (Talstar®) % res ± se(no. tested)	Profenofos (Curacron®, Sabre®) % res ± se(no. tested)	Thiodicarb (Larvin®) % res ± se(no. tested)	Methomyl (as a larvicide) % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *entomocidus* (Xentari®) % res ± se(no. tested)	Fenvalerate (pyrethroid) % res ± se(no. tested)	Endosulfan % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *entomocidus* (Xentari®) % res ± se(no. tested)
Stage I																
1	10 - 16 Nov															
2	17 - 23 Nov															
3	24 - 30 Nov															
4	1 - 7 Dec															
5	8 - 14 Nov															
Average																
Stage II																
1	15 - 21 Dec															
2	22 - 28 Dec															
3	29 Dec - 4 Jan															
4	5 - 11 Jan	87.5 (176)							4.6 ± 23.6 (65)							
5	12 - 18 Jan															
6	19 - 25 Jan	86.9 (337)							2.8 ± 1.2 (181)	69.7 ± 5.3 (76)			2.5 ± 2.5 (40)			
7	26 Jan - 1 Feb															
Average		87.1 (513)							3.2 ± 1.1 (247)	69.7 ± 5.3 (76)			2.5 ± 2.5 (40)			
Stage III																
1	2 - 8 Feb															
2	9 - 15 Feb	94.2 (1025)	76.1 ± 4.1 (109)		25.2 ± 4.2 (107)	5.3 ± 2.1 (114)		4.2 ± 1.7 (143)	10.4 ± 2.2 (202)		0 ± 0 (124)	0 ± 0 (105)	0 ± 0 (44)			
3	16 - 22 Feb	98.3 (458)						3.9 ± 1.6 (154)	9.7 ± 2.9 (103)		0 ± 0 (158)					
4	23 - 29 Feb	99.4 (342)						2.1 ± 1.5 (96)	7.4 ± 2.4 (122)		0 ± 0 (78)					
5	1 - 7 Mar															
6	8 - 14 Mar	100 (856)	64.4 ± 5.2 (87)		33.0 ± 4.6 (106)	3.2 ± 1.8 (93)	12.1 ± 3.4 (92)	6.1 ± 2.7 (82)	11.3 ± 2.7 (141)		0 ± 0 (101)	0 ± 0 (94)				
7	15 - 21 Mar															
8	22 - 28 Mar															
Average		97.4 (2681)	70.9 ± 3.3 (196)		29.1 ± 3.1 (213)	4.3 ± 1.4 (207)	12.1 ± 3.4 (92)	4.0 ± 0.9 (475)	9.9 ± 1.3 (568)		0 ± 0 (461)	0 ± 0 (199)	0 ± 0 (44)			

Dawson/Callide Valley 1995/6

Percentage of larvae (reared from field collected eggs) surviving the discriminating dose of various insecticides (expected survival at the discriminating dose = 0 to 2%)

								Helicoverpa armigera					*Helicoverpa punctigera*			
Week	Collection date	Average % Ha on cotton	Fenvalerate (pyrethroid) % res (no. tested)	Endosulfan % res. ± se(no. tested)	Fen/Pbo mix % res. ± se(no. tested)	Series II % res. ± se(no. tested)	Bifenthrin (Talstar®) % res. ± se(no. tested)	Profenofos (Curacron®, Sabre®) % res. ± se(no. tested)	Thiodicarb (Larvin®) % res. ± se(no. tested)	Methomyl (as a larvicide) % res. ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res. ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res. ± se(no. tested)	Fenvalerate (pyrethroid) % res. ± se(no. tested)	Endosulfan % res. ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res. ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res. ± se(no. tested)
Stage I																
1	12 - 18 Nov															
2	19 - 25 Nov															
3	26 Nov - 2 Dec															
4	3 - 9 Dec															
Average																
Stage II																
1	10 - 16 Dec															
2	17 - 23 Dec	42.1 (411)	68.8 ± 6.4 (54)	29.8 ± 6.7 (47)							0 ± 0 (37)		4.3 ± 3.0 (46)	2.3 ± 2.3 (43)	0 ± 0 (107)	
3	24 - 30 Dec															
4	31 Dec - 6 Jan															
5	7 - 13 Jan															
6	14 - 20 Jan															
7	21 - 26 Jan	96.2 (235)						10.6 ± 3.8 (66)	1.8 ± 1.8 (57)	79.7 ± 4.6 (79)						
Average		61.8 (646)	68.8 ± 6.4 (54)	29.8 ± 6.7 (47)				10.6 ± 3.8 (66)	1.8 ± 1.8 (57)	79.7 ± 4.6 (79)	0 ± 0 (37)		4.3 ± 3.0 (46)	2.3 ± 2.3 (43)	0 ± 0 (107)	
Stage III																
1	27 Jan - 3 Feb															
2	4 - 10 Feb															
3	11 - 17 Feb	100 (430)	68.3 ± 5.9 (63)		21.7 ± 5.4 (60)			8.6 ± 3.1 (81)	11.9 ± 3.5 (89)		0 ± 0 (79)					
4	18 - 24 Feb															
5	25 Feb - 2 Mar															
6	3 - 9 Mar															
7	10 - 16 Mar															
8	17 - 23 Mar	100 (332)						8.9 ± 2.8 (101)	20.0 ± 4.5 (80)		0.9 ± 0.9 (110)					
9	24 - 30 Mar															
10	31 Mar - 6 Apr															
11	7 - 13 Apr															
12	14 - 20 Apr															
13	21 - 27 Apr															
14	28 Apr - 9 May															
Average		100 (762)	68.3 ± 5.9 (63)		21.7 ± 5.4 (60)			8.8 ± 2.1 (182)	15.7 ± 2.8 (169)		0.6 ± 0.6 (189)					

Emerald 1995/6

Percentage of larvae (reared from field collected eggs) surviving the discriminating dose of various insecticides (expected survival at the discriminating dose = 0 to 2%)

									Helicoverpa armigera					*Helicoverpa punctigera*			
Week	Collection date	Average % Ha on cotton	Fenvalerate (pyrethroid) % res ± se(no. tested)	Endosulfan % res ± se(no. tested)	Fen/Pbo mix % res ± se(no. tested)	Series II % res ± se(no. tested)	Bifenthrin (Talstar®) % res ± se(no. tested)	Profenofos (Curacron®, Sabre®) % res ± se(no. tested)	Thiodicarb (Larvin®) % res ± se(no. tested)	Methomyl (as a larvicide) % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± se(no. tested)	Fenvalerate (pyrethroid) % res ± se(no. tested)	Endosulfan % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± se(no. tested)
Stage I																	
1	12 - 18 Nov																
2	19 - 25 Nov	8.6 (266)									0 ± 0 (11)		5.5 ± 2.4 (91)		0 ± 0 (79)		
3	26 Nov - 2 Dec																
4	3 - 9 Dec																
Average		8.6 (266)									0 ± 0 (11)		5.5 ± 2.4 (91)		0 ± 0 (79)		
Stage II																	
1	10 - 16 Dec	54.6 (390)	89.2 ± 3.1 (102)								0 ± 0 (97)		8.7 ± 3.4 (69)		0 ± 0 (86)		
2	17 - 23 Dec																
3	24 - 30 Dec																
4	31 Dec - 6 Jan																
5	7 - 13 Jan																
6	14 - 20 Jan																
7	21 - 26 Jan	99.5 (563)						14.9 ± 3.7 (94)	17.0 ± 3.2 (135)	80.0 ± 4.0 (100)	0 ± 0 (120)						
Average		81.1 (953)	89.2 ± 3.1 (102)					14.9 ± 3.7 (94)	17.0 ± 3.2 (135)	80.0 ± 4.0 (100)	0 ± 0 (218)		8.7 ± 3.4 (69)		0 ± 0 (86)		
Stage III																	
1	27 Jan - 3 Feb																
2	4 - 10 Feb																
3	11 - 17 Feb	97.8 (45)						15.4 ± 5.9 (39)									
4	18 - 24 Feb																
5	25 Feb - 2 Mar																
6	3 - 9 Mar																
7	10 - 16 Mar																
8	17 - 23 Mar																
9	24 - 30 Mar																
10	31 Mar - 6 Apr																
11	7 - 13 Apr																
12	14 - 20 Apr																
13	21 - 27 Apr																
14	28 Apr - 9 May																
Average		97.8 (45)						15.4 ± 5.9 (39)									

Gwydir Valley 1995/6

Percentage of larvae (reared from field collected eggs) surviving the discriminating dose of various insecticides (expected survival at the discriminating dose = 0 to 2%)

										Helicoverpa armigera						*Helicoverpa punctigera*			
Week	Collection date	Average % Ha on cotton	Fenvalerate (pyrethroid) % res ± se(no. tested)	Endosulfan % res ± se(no. tested)	Fen/Pho mix % res ± se(no. tested)	Series II % res ± se(no. tested)	Bifenthrin (Talstar ®) % res ± se(no. tested)	Profenofos (Curacron®, Sabre®) % res ± se(no. tested)	Thiodicarb (Larvin®) % res ± se(no. tested)	Methamyl (as a larvicide) % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± se(no. tested)	Fenvalerate (pyrethroid) % res ± se(no. tested)	Endosulfan % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± se(no. tested)
Stage I																
1	10 - 16 Nov															
2	17 - 23 Nov															
3	24 - 30 Nov	39.2 (51)									0 ± 0 (14)				0 ± 0 (33)	
4	1 - 7 Dec	11.8 (203)	70.7 ± 7.2 (41)										2.2 ± 1.6 (93)		0 ± 0 (103)	0 ± 0 (86)
5	8 - 14 Nov	3.7 (350)	81.8 ± 12.2 (11)										8.3 ± 3.3 (72)	0 ± 0 (64)	0 ± 0 (91)	
Average		10.4 (547)	73.1 ± 6.2 (52)										4.8 ± 1.7 (165)	0 ± 0 (64)	0 ± 0 (227)	0 ± 0 (86)
Stage II																
1	15 - 21 Dec															
2	22 - 28 Dec															
3	29 Dec - 4 Jan															
4	5 - 11 Jan															
5	12 - 18 Jan															
6	19 - 25 Jan															
7	26 Jan - 1 Feb															
Average																
Stage III																
1	2 - 8 Feb															
2	9 - 15 Feb															
3	16 - 22 Feb															
4	23 - 29 Feb	99.9 (985)	70.2 ± 4.2 (121)		28.1 ± 4.1 (121)	8.3 ± 2.4 (132)	20.3 ± 3.7 (118)	3.2 ± 1.6 (124)	11.1 ± 2.1 (225)		0 ± 0 (146)	0 ± 0 (148)				
5	1 - 7 Mar															
6	8 - 14 Mar	99.7 (318)	79.0 ± 4.6 (81)		38.7 ± 5.1 (93)			2.0 ± 1.4 (101)	4.3 ± 3.0 (47)		0 ± 0 (97)					
7	15 - 21 Mar															
8	22 - 28 Mar	96.4 (83)									1.3 ± 1.3 (79)					
9	29 Mar - 4 Apr															
10	5 - 11 Apr	100 (265)							5.8 ± 2.1 (120)		0 ± 0 (154)					
11	12 - 18 Apr	100 (128)														
Average		99.7 (1779)	73.8 ± 3.1 (202)		32.7 ± 3.2 (214)	8.3 ± 2.4 (132)	20.3 ± 3.7 (118)	2.7 ± 1.1 (225)	8.7 ± 1.4 (392)			0 ± 0 (148)				

Lockyer Valley 1995/6

Percentage of larvae (reared from field collected eggs) surviving the discriminating dose of various insecticides (expected survival at the discriminating dose = 0 to 2%)

			Helicoverpa armigera										*Helicoverpa punctigera*			
Week	Collection date	Average % Ha on cotton	Fenvalerate (pyrethroid) % res ± se(no. tested)	Endosulfan % res ± se(no. tested)	Fen/Pbu mix % res ± se(no. tested)	Series II % res ± se(no. tested)	Bifenthrin (Talstar®) % res ± se(no. tested)	Profenofos (Curacron®, Sabre®) % res ± se(no. tested)	Thiodicarb (Larvin®) % res ± se(no. tested)	Methomyl (as a larvicide) % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± se(no. tested)	Fenvalerate (pyrethroid) % res ± se(no. tested)	Endosulfan % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± se(no. tested)
Stage I																
1	10 - 16 Nov															
2	17 - 23 Nov															
3	24 - 30 Nov															
4	1 - 7 Dec															
5	8 - 14 Nov															
Average																
Stage II																
1	15 - 21 Dec															
2	22 - 28 Dec															
3	29 Dec - 4 Jan		57.4 ± 6.4 (61)								0 ± 0 (57)		0 ± 0 (52)			
4	5 - 11 Jan															
5	12 - 18 Jan		41.0 ± 5.6 (77)								0 ± 0 (34)					
6	19 - 25 Jan															
7	26 Jan - 1 Feb								15.7 ± 5.1 (51)							
Average			48.2 ± 4.3 (139)						15.7 ± 5.1 (51)		0 ± 0 (91)		0 ± 0 (52)			
Stage III																
1	2 - 8 Feb															
2	9 - 15 Feb															
3	16 - 22 Feb															
4	23 - 29 Feb															
5	1 - 7 Mar															
6	8 - 14 Mar								2.3 ± 1.3 (130)		0 ± 0 (86)					
7	15 - 21 Mar															
8	22 - 28 Mar								5.4 ± 1.8 (166)		0 ± 0 (177)	0 ± 0 (157)				
Average									4.1 ± 1.2 (296)		0 ± 0 (263)	0 ± 0 (157)				

Lower Namoi Valley 1995/6

Percentage of larvae (reared from field collected eggs) surviving the discriminating dose of various insecticides (expressed as survival at the discriminating dose = 0 to 2%)

Week	Collection date	Average % Ha on cotton	*Helicoverpa armigera*										*Helicoverpa punctigera*			
			Fenvalerate (pyrethroid) % res ± se(no. tested)	Endosulfan % res ± se(no. tested)	Fen/Pro mix % res ± se(no. tested)	Series II % res ± se(no. tested)	Bifenthrin (Talstar ®) % res ± se(no. tested)	Profenofos (Curacron®, Sabre®) % res ± se(no. tested)	Thiodicarb (Larvin®) % res ± se(no. tested)	Methomyl (as a larvicide) % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± se(no. tested)	Fenvalerate (pyrethroid) % res ± se(no. tested)	Endosulfan % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± se(no. tested)
Stage I																
1	10 - 16 Nov										0 ± 0 (96)					
2	17 - 23 Nov															
3	24 - 30 Nov	36.3 (1765)	78.8 ± 2.8 (212)	46.8 ± 3.3 (233)				0.9 ± 0.6 (217)		64.7 ± 3.1 (232)	0 ± 0 (190)	0 ± 0 (242)	4.7 ± 1.1 (379)		0 ± 0 (348)	0 ± 0 (338)
4	1 - 7 Dec	36.9 (298)	74.3 ± 3.6 (152)	50.4 ± 4.6 (117)				0.9 ± 0.9 (113)		65.8 ± 4.5 (114)	0 ± 0 (106)	0 ± 0 (102)	6.2 ± 3.0 (65)		0 ± 0 (69)	0 ± 0 (34)
5	8 - 14 Nov	16.3 (1776)	86.9 ± 3.4 (99)	38.6 ± 4.7 (109)							0 ± 0 (61)		5.9 ± 1.6 (220)	2.1 ± 1.0 (190)	0 ± 0 (251)	0 ± 0 (296)
Average		27.1 (3839)	79.0 ± 1.9 (463)	45.8 ± 2.3 (459)				0.9 ± 0.5 (330)		65.0 ± 2.6 (346)	0 ± 0 (453)	0 ± 0 (344)	5.3 ± 0.9 (664)	2.1 ± 1.0 (190)	0 ± 0 (668)	0 ± 0 (668)
Stage II																
1	15 - 21 Dec	54.6 (476)	77.9 ± 4.8 (77)	56.6 ± 6.0 (69)							0 ± 0 (126)		0 ± 0 (95)		0 ± 0 (95)	
2	22 - 28 Dec	23.7 (173)	92.2 ± 3.8 (51)										12.7 ± 3.3 (102)		0 ± 0 (67)	
3	29 Dec - 4 Jan	40.3 (694)	81.0 ± 3.8 (105)	34.1 ± 5.2 (85)							0 ± 0 (97)		4.8 ± 1.6 (189)	0.9 ± 0.9 (113)	0 ± 0 (175)	
4	5 - 11 Jan	32.7 (1357)	81.9 ± 4.0 (94)	25.8 ± 4.6 (93)				2.4 ± 1.7 (83)		70.1 ± 4.9 (87)	0 ± 0 (78)	0 ± 0 (72)	2.9 ± 1.2 (210)	0 ± 0 (246)	0 ± 0 (228)	0 ± 0 (222)
5	12 - 18 Jan	63.6 (1324)	66.4 ± 4.4 (116)	36.5 ± 4.3 (126)				9.2 ± 2.6 (130)	4.6 ± 1.7 (154)	73.9 ± 3.7 (142)	1.2 ± 0.9 (162)	0.8 ± 0.8 (130)	2.8 ± 1.4 (142)	1.3 ± 0.9 (150)		0 ± 0 (123)
6	19 - 25 Jan	51.4 (354)	77.3 ± 4.9 (75)	38.4 ± 5.7 (73)												
7	26 Jan - 1 Feb	29.2 (760)						6.7 ± 2.7 (90)	17.0 ± 4.0 (88)	67.4 ± 5.1 (86)			2.4 ± 1.4 (127)	1.4 ± 1.0 (144)		0 ± 0 (107)
Average		44.4 (5038)	78.0 ± 1.8 (518)	37.2 ± 2.3 (446)				6.6 ± 1.4 (303)	9.1 ± 1.9 (242)	71.1 ± 2.6 (315)	0.4 ± 0.3 (463)	0.5 ± 0.5 (202)	4.0 ± 0.7 (865)	0.8 ± 0.3 (653)	0 ± 0 (566)	0 ± 0 (452)
Stage III																
1	2 - 8 Feb	50.0 (694)						3.4 ± 1.7 (116)	7.8 ± 2.5 (116)	70.6 ± 4.1 (126)	0 ± 0 (94)		3.3 ± 1.6 (121)	0 ± 0 (85)	0 ± 0 (115)	
2	9 - 15 Feb	80.8(978)	74.1 ± 4.2 (112)	33.3 ± 4.4 (114)	33.9 ± 4.2 (127)			2.4 ± 1.4 (124)	4.1 ± 2.0 (97)	78.3 ± 3.9 (115)	0 ± 0 (111)	0 ± 0 (125)	0 ± 0 (74)	1.3 ± 1.3 (78)	1.2 ± 1.2 (82)	0 ± 0 (51)
3	16 - 22 Feb	94.4 (516)	81.4 ± 4.2 (86)		38.7 ± 5.7 (75)	8.1 ± 3.0 (86)		2.9 ± 1.7 (102)	5.9 ± 2.1 (125)		0 ± 0 (87)					
4	23 - 29 Feb	96.6 (654)	84.6 ± 3.6 (104)		44.0 ± 5.0 (100)	17.1 ± 3.7 (105)	27.7 ± 3.9 (130)	5.1 ± 2.0 (117)	8.0 ± 2.1 (174)		0 ± 0 (110)	0 ± 0 (113)				
5	1 - 7 Mar	93.9 (1583)	72.6 ± 3.5 (164)		38.2 ± 3.6 (191)	10.5 ± 2.2 (191)	19.4 ± 3.1 (165)	2.7 ± 1.2 (188)	7.1 ± 1.7 (240)		0 ± 0 (199)	0 ± 0 (180)				
6	8 - 14 Mar	99.6 (1731)	86.9 ± 3.4 (199)		50.8 ± 3.7 (183)	14.6 ± 2.6 (179)	44.4 ± 3.6 (198)	6.9 ± 1.9 (188)	9.7 ± 1.6 (350)		0 ± 0 (249)	0 ± 0 (246)				
7	15 - 21 Mar	99.6 (1036)	79.1 ± 3.9 (110)		45.6 ± 4.5 (123)	11.4 ± 2.6 (158)	28.4 ± 3.6 (155)	3.6 ± 1.6 (139)	12.5 ± 2.5 (176)		0 ± 0 (169)	0.7 ± 0.7 (149)				
8	22 - 28 Mar	99.8 (1263)							28.8 ± 2.8 (264)		1.2 ± 0.9 (163)	0 ± 0 (145)				
9	29 Mar - 4 Apr	100 (898)							18.1 ± 3.2 (144)		0.6 ± 0.6 (172)	0 ± 0 (147)				
10	5 - 11 Apr	99.6 (616)							5.3 ± 2.0 (132)							
11	12 - 18 Apr	100 (539)														
Average		93.3 (10508)	80.0 ± 1.4 (775)	33.3 ± 4.4 (114)	42.3 ± 1.7 (799)	12.4 ± 1.2 (719)	30.9 ± 1.8 (648)	4.0 ± 0.6 (974)		74.3 ± 2.8 (241)			2.1 ± 1.0 (195)	0.6 ± 0.6 (163)	0.5 ± 0.5 (197)	0 ± 0 (51)

Macquarie Valley 1995/6

Percentage of larvae (reared from field collected eggs) surviving the discriminating dose of various insecticides (expected survival at the discriminating dose = 0 to 2%)

												Helicoverpa armigera				*Helicoverpa punctigera*			
Week	Collection date	Average % IIa on cotton	Fenvalerate (pyrethroid) % res. (no. tested)	Endosulfan % res. ± se(no. tested)	Fen/Pbo mix % res. ± se(no. tested)	Series II % res. ± se(no. tested)	Bifenthrin (Talstar®) % res. ± se(no. tested)	Profenofos (Curacron®, Sabre®) % res ± se(no. tested)	Thiodicarb (Larvin®) % res. ± se(no. tested)	Methomyl (as a larvicide) % res. ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res. ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res. ± se(no. tested)	Fenvalerate (pyrethroid) % res. ± se(no. tested)	Endosulfan % res. ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res. ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res. ± se(no. tested)
Stage I																			
1	10 - 16 Nov																		
2	17 - 23 Nov																		
3	24 - 30 Nov																		
4	1 - 7 Dec																		
5	8 - 14 Nov																		
Average																			
Stage II																			
1	15 - 21 Dec															2.3 ± 1.1 (172)	0 ± 0 (183)	0 ± 0 (151)	0 ± 0 (151)
2	22 - 28 Dec																		
3	29 Dec - 4 Jan																		
4	5 - 11 Jan																		
5	12 - 18 Jan																		
6	19 - 25 Jan																		
7	26 Jan - 1 Feb																		
Average																			
Stage III																			
1	2 - 8 Feb																		
2	9 - 15 Feb																		
3	16 - 22 Feb																		
4	23 - 29 Feb																		
5	1 - 7 Mar																		
6	8 - 14 Mar																		
7	15 - 21 Mar																		
8	22 - 28 Mar																		
9	29 Mar - 4 Apr																		
10	5 - 11 Apr																		
11	12 - 18 Apr																		
Average																			

McIntyre Valley 1995/6

Percentage of larvae (reared from field collected eggs) surviving the discriminating dose of various insecticides (expected survival at the discriminating dose = 0 to 2%)

			Helicoverpa armigera										*Helicoverpa punctigera*			
Week	Collection date	Average % Ha on cotton	Fenvalerate (pyrethroid) % res ± se(no. tested)	Endosulfan % res ± se(no. tested)	Fen/Pbo mix % res ± se(no. tested)	Series II % res ± se(no. tested)	Bifenthrin (Talstar®) % res ± se(no. tested)	Profenofos (Curacron®, Sabre®) % res ± se(no. tested)	Thiodicarb (Larvin®) % res ± se(no. tested)	Methomyl (as a larvicide) % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± se(no. tested)	Fenvalerate (pyrethroid) % res ± se(no. tested)	Endosulfan % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± se(no. tested)
Stage I																
1	10 - 16 Nov															
2	17 - 23 Nov															
3	24 - 30 Nov															
4	1 - 7 Dec															
5	8 - 14 Nov	26.3 (19)														
Average		26.3 (19)														
Stage II																
1	15 - 21 Dec															
2	22 - 28 Dec															
3	29 Dec - 4 Jan	28.6 (84)														
4	5 - 11 Jan															
5	12 - 18 Jan															
6	19 - 25 Jan															
7	26 Jan - 1 Feb															
Average		28.6 (84)														
Stage III																
1	2 - 8 Feb															
2	9 - 15 Feb															
3	16 - 22 Feb	60.4 (508)						3.8 ± 2.1 (79)	22.1 ± 4.3 (95)		0 ± 0 (66)		0 ± 0 (102)			
4	23 - 29 Feb															
5	1 - 7 Mar	94.8 (174)							9.3 ± 4.5 (43)		0 ± 0 (88)					
6	8 - 14 Mar	100 (75)							6.8 ± 3.3 (59)		0 ± 0 (39)					
7	15 - 21 Mar															
8	22 - 28 Mar															
9	29 Mar - 4 Apr															
10	5 - 11 Apr															
11	12 - 18 Apr															
Average		72.3 (757)						3.8 ± 2.1 (79)	14.7 ± 2.6 (197)		0 ± 0 (193)		0 ± 0 (102)			

Mungindi 1995/6

Percentage of larvae (reared from field collected eggs) surviving the discriminating dose of various insecticides (expected survival at the discriminating dose = 0 to 2%)

			Helicoverpa armigera										*Helicoverpa punctigera*			
Week	Collection date	Average % Ha on cotton	Fenvalerate (pyrethroid) % res (no. tested)	Endosulfan % res. ± se(no. tested)	Fen/Pho mix % res ± se(no. tested)	Series II % res ± se(no. tested)	Bifenthrin (Talstar ®) % res ± se(no. tested)	Profenofos (Curacron®, Sabre®) % res ± se(no. tested)	Thiodicarb (Larvin®) % res ± se(no. tested)	Methomyl (as a larvicide) % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± se(no. tested)	Fenvalerate (pyrethroid) % res ± se(no. tested)	Endosulfan % res ± se(no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± se(no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± se(no. tested)
Stage I																
1	10 - 16 Nov															
2	17 - 23 Nov															
3	24 - 30 Nov															
4	1 - 7 Dec															
5	8 - 14 Nov															
Average																
Stage II																
1	15 - 21 Dec															
2	22 - 28 Dec															
3	29 Dec - 4 Jan	5.0 (120)											3.0 ± 2.1 (67)		0 ± 0 (65)	
4	5 - 11 Jan	66.6 (347)	92.0 ± 3.2 (75)	47.6 ± 5.6 (82)							0 ± 0 (75)		0 ± 0 (84)			
5	12 - 18 Jan															
6	19 - 25 Jan															
7	26 Jan - 1 Feb															
Average		50.7 (467)	92.0 ± 3.2 (75)	47.6 ± 5.6 (82)							0 ± 0 (75)		1.3 ± 0.9 (151)		0 ± 0 (65)	
Stage III																
1	2 - 8 Feb	19.7 (61)											4.0 ± 4.0 (25)			
2	9 - 15 Feb															
3	16 - 22 Feb	100 (22)														
4	23 - 29 Feb															
5	1 - 7 Mar															
6	8 - 14 Mar															
7	15 - 21 Mar															
8	22 - 28 Mar															
Average		41.0 (83)											4.0 ± 4.0 (25)			

South Burnett 1995/6

Percentage of larvae (reared from field collected eggs) surviving the discriminating dose of various insecticides (expected survival at the discriminating dose = 0 to 2%)

			Helicoverpa armigera										*Helicoverpa punctigera*			
Week	Collection date	Average % Ha on cotton	Fenvalerate (pyrethroid) % res (no. tested)	Endosulfan % res ± s.e.m. (no. tested)	Fen/Pbo mix % res ± s.e.m. (no. tested)	Series II % res ± s.e.m. (no. tested)	Bifenthrin (Talstar®) % res ± s.e.m. (no. tested)	Profenofos (Curacron®, Sabre®) % res ± s.e.m. (no. tested)	Thiodicarb (Larvin®) % res ± s.e.m. (no. tested)	Methomyl (as a larvicide) % res ± s.e.m. (no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± s.e.m. (no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± s.e.m. (no. tested)	Fenvalerate (pyrethroid) % res ± s.e.m. (no. tested)	Endosulfan % res ± s.e.m. (no. tested)	*Bacillus thuringiensis* var. *kurstaki* (Dipel 2x®) % res ± s.e.m. (no. tested)	*Bacillus thuringiensis* var. *aizawai* (Xentari®) % res ± s.e.m. (no. tested)
Stage I																
1	10 - 16 Nov															
2	17 - 23 Nov															
3	24 - 30 Nov															
4	1 - 7 Dec															
5	8 - 14 Nov															
Average																
Stage II																
1	15 - 21 Dec															
2	22 - 28 Dec															
3	29 Dec - 4 Jan															
4	5 - 11 Jan															
5	12 - 18 Jan		50.6 ± 4.9 (107)								2.2 ± 2.2 (45)					
6	19 - 25 Jan															
7	26 Jan - 1 Feb															
Average			50.6 ± 4.9 (107)								2.2 ± 2.2 (45)					
Stage III																
1	2 - 8 Feb								8.6 ± 2.6 (124)							
2	9 - 15 Feb															
3	16 - 22 Feb															
4	23 - 29 Feb							1.6 ± 1.6 (66)	2.6 ± 1.8 (77)		0 ± 0 (102)					
5	1 - 7 Mar															
6	8 - 14 Mar								3.0 ± 2.1 (67)		0 ± 0 (64)					
7	15 - 21 Mar								27.5 ± 6.3 (51)							
8	22 - 28 Mar								5.8 ± 3.3 (52)		0.9 ± 0.9 (106)					
Average								1.6 ± 1.6 (66)	8.6 ± 1.5 (371)		0.4 ± 0.4 (272)					

St George 1995/6

Percentage of larvae (reared from field collected eggs) surviving the discriminating dose of various insecticides (expected survival at the discriminating dose = 0 to 2%)

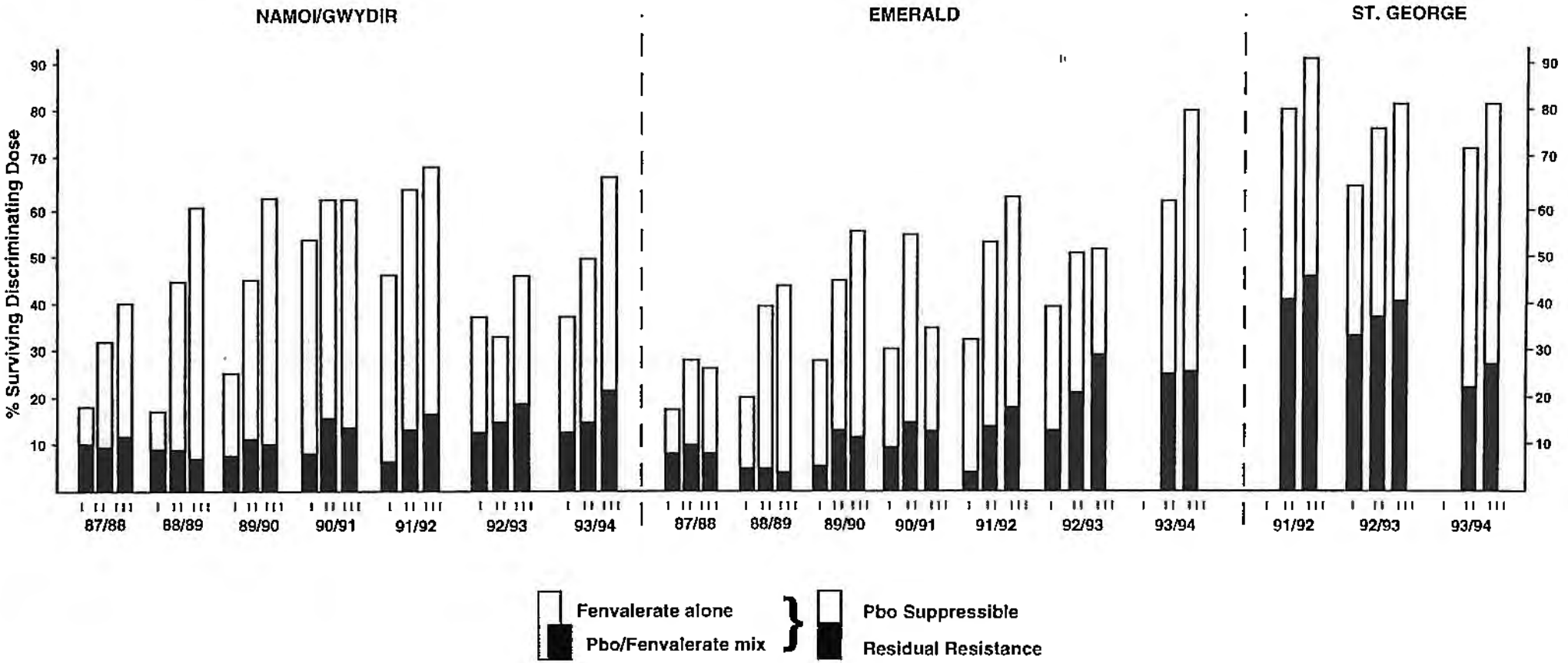
			Helicoverpa armigera										*Helicoverpa punctigera*			
Week	Collection date	Average % Ha on cotton	Fenvalerate (pyrethroid) % res ± se (no. tested)	Endosulfan % res ± se (no. tested)	Fen/Pho mix % res ± se (no. tested)	Series II % res ± se (no. tested)	Bifenthrin (Talstar ®) % res ± se (no. tested)	Profenofos (Curacron®, Sabre®) % res ± se (no. tested)	Thiodicarb (Larvin®) % res ± se (no. tested)	Methomyl (as a larvicide) % res ± se (no. tested)	Bacillus thuringiensis var. kurstaki (Dipel 2x®) % res ± se (no. tested)	Bacillus thuringiensis var. aizawai (Xentari®) % res ± se (no. tested)	Fenvalerate (pyrethroid) % res ± se (no. tested)	Endosulfan % res ± se (no. tested)	Bacillus thuringiensis var. kurstaki (Dipel 2x®) % res ± se (no. tested)	Bacillus thuringiensis var. aizawai (Xentari®) % res ± se (no. tested)
Stage I																
1	10 - 16 Nov															
2	17 - 23 Nov															
3	24 - 30 Nov	0 (130)											7.8 ± 2.7 (103)			
4	1 - 7 Dec	7.1 (575)	91.7 ± 4.7 (36)										9.0 ± 3.6 (67)	0 ± 0 (91)	0 ± 0 (102)	0 ± 0 (98)
5	8 - 14 Nov	3.3 (488)	69.6 ± 9.8 (23)										3.7 ± 1.8 (107)	3.4 ± 1.9 (88)	0 ± 0 (130)	
Average		4.8 (1193)	83.1 ± 4.9 (59)										6.5 ± 1.5 (277)	1.7 ± 1.0 (179)	0 ± 0 (232)	0 ± 0 (98)
Stage II																
1	15 - 21 Dec	1.0 (480)											2.2 ± 1.6 (92)	3.8 ± 1.9 (105)	0 ± 0 (89)	0 ± 0 (64)
2	22 - 28 Dec															
3	29 Dec - 4 Jan															
4	5 - 11 Jan	41.7 (271)	87.4 ± 3.0 (127)	43.1 ± 4.9 (102)					0 ± 0 (58)		0 ± 0 (58)		2.6 ± 1.1 (194)	0 ± 0 (137)	0 ± 0 (162)	0 ± 0 (130)
5	12 - 18 Jan	37.2 (752)														
6	19 - 25 Jan	20.2 (84)	93.9 ± 4.2 (33)										0 ± 0 (36)			
7	26 Jan - 1 Feb	36.0 (164)														
Average		26.1 (1751)	88.8 ± 2.5 (160)	43.1 ± 4.9 (102)					0 ± 0 (58)		0 ± 0 (58)		2.3 ± 0.8 (322)	1.7 ± 0.8 (242)	0 ± 0 (251)	0 ± 0 (194)
Stage III																
1	2 - 8 Feb	49.0 (1207)						5.6 ± 2.0 (127)	30.5 ± 3.9 (141)	71.4 ± 4.8 (91)	0 ± 0 (127)		0.6 ± 0.6 (180)	0 ± 0 (172)	0 ± 0 (150)	
2	9 - 15 Feb	93.0 (71)						2.4 ± 2.4 (41)								
3	16 - 22 Feb	88.0 (440)						4.6 ± 1.7 (153)	27.1 ± 3.9 (129)		0 ± 0 (68)		3.6 ± 3.6 (28)			
4	23 - 29 Feb	75.3 (239)						2.8 ± 2.0 (72)	3.8 ± 2.2 (79)		0 ± 0 (63)				0 ± 0 (88)	
5	1 - 7 Mar	66.9 (444)						0 ± 0 (82)	7.6 ± 2.4 (119)		0 ± 0 (102)				0 ± 0 (139)	
6	8 - 14 Mar	95.1 (346)						0.9 ± 0.9 (116)	12.2 ± 3.6 (82)		1.1 ± 1.1 (93)					
7	15 - 21 Mar															
8	22 - 28 Mar	976.2 (72)						5.0 ± 2.8 (60)								
Average		73.3 (2819)						3.2 ± 0.7 (651)	18.2 ± 1.6 (550)	71.4 ± 4.8 (91)	0.2 ± 0.2 (453)		1.0 ± 0.7 (208)	0 ± 0 (172)	0 ± 0 (628)	

Upper Nammi Valley 1995/6

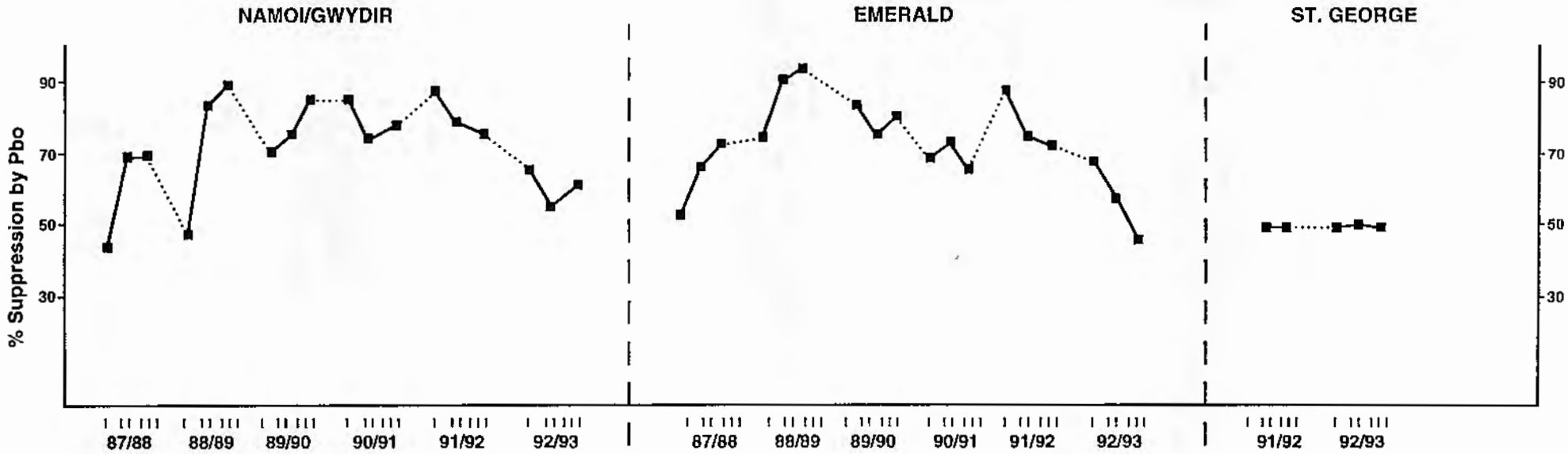
Percentage of larvae (reared from field collected eggs) surviving the discriminating dose of various insecticides (expected survival at the discriminating dose = 0 to 2%)

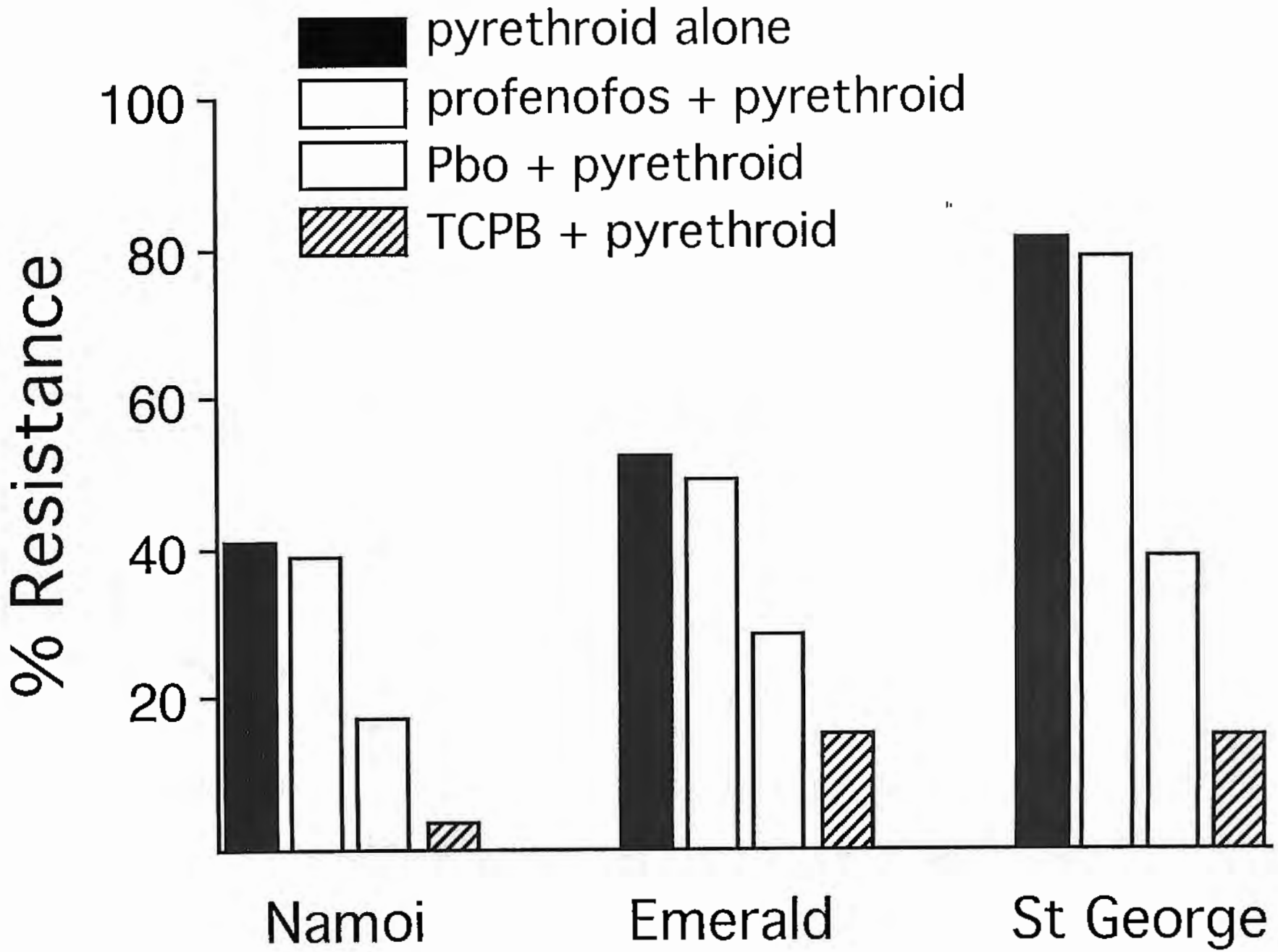
			Helicoverpa armigera									*Helicoverpa punctigera*			
Week	Collection date	Average % Ha on cotton	Fenvalerate (pyrethroid) % res (no. tested)	Endosulfan % res ± s.e.m. (no. tested)	Fen/Pbo mix % res ± s.e.m. (no. tested)	Series II % res ± s.e.m. (no. tested)	Bifenthrin (Talstar®) % res ± s.e.m. (no. tested)	Profenofos (Curacron®, Sabre®) % res ± s.e.m. (no. tested)	Thiodicarb (Larvin®) % res ± s.e.m. (no. tested)	Methomyl (as a larvicide) % res ± s.e.m. (no. tested)	*Bacillus thuringiensis var. kurstaki* (Dipel 2x®) % res ± s.e.m. (no. tested)	*Bacillus thuringiensis var. aizawai* (Xentari®) % res ± s.e.m. (no. tested)	Fenvalerate (pyrethroid) % res ± s.e.m. (no. tested)	Endosulfan % res ± s.e.m. (no. tested)	*Bacillus thuringiensis var. kurstaki* (Dipel 2x®) % res ± s.e.m. (no. tested)	*Bacillus thuringiensis var. aizawai* (Xentari®) % res ± s.e.m. (no. tested)
Stage I																
1	10 - 16 Nov															
2	17 - 23 Nov															
3	24 - 30 Nov															
4	1 - 7 Dec		60.2 ± 4.4 (123)	33.9 ± 4.3 (121)					0 ± 0 (152)		0 ± 0 (106)					
5	8 - 14 Nov															
Average			60.2 ± 4.4 (123)	33.9 ± 4.3 (121)					0 ± 0 (152)		0 ± 0 (106)					
Stage II																
1	15 - 21 Dec															
2	22 - 28 Dec															
3	29 Dec - 4 Jan															
4	5 - 11 Jan															
5	12 - 18 Jan	14.1 (469)	74.1 ± 4.8 (85)										0 ± 0 (163)	2.2 ± 1.3 (136)	0 ± 0 (65)	0 ± 0 (91)
6	19 - 25 Jan															
7	26 Jan - 1 Feb															
Average		14.1 (469)	74.1 ± 4.8 (85)										0 ± 0 (163)	2.2 ± 1.3 (136)	0 ± 0 (65)	0 ± 0 (91)
Stage III																
1	2 - 8 Feb															
2	9 - 15 Feb															
3	16 - 22 Feb															
4	23 - 29 Feb															
5	1 - 7 Mar															
6	8 - 14 Mar															
7	15 - 21 Mar															
8	22 - 28 Mar															
9	29 Mar - 4 Apr															
10	5 - 11 Apr															
11	12 - 18 Apr															
Average																

SUPPRESSION OF FIELD PYRETHROID RESISTANCE BY PBO



% SUPPRESSION OF FIELD PYRETHROID RESISTANCE BY PBO




pyrethroid alone
profenofos + pyrethroid
Pbo + pyrethroid
TCPB + pyrethroid
% Resistance
100
80
60
40
20
Namoi
Emerald
St George

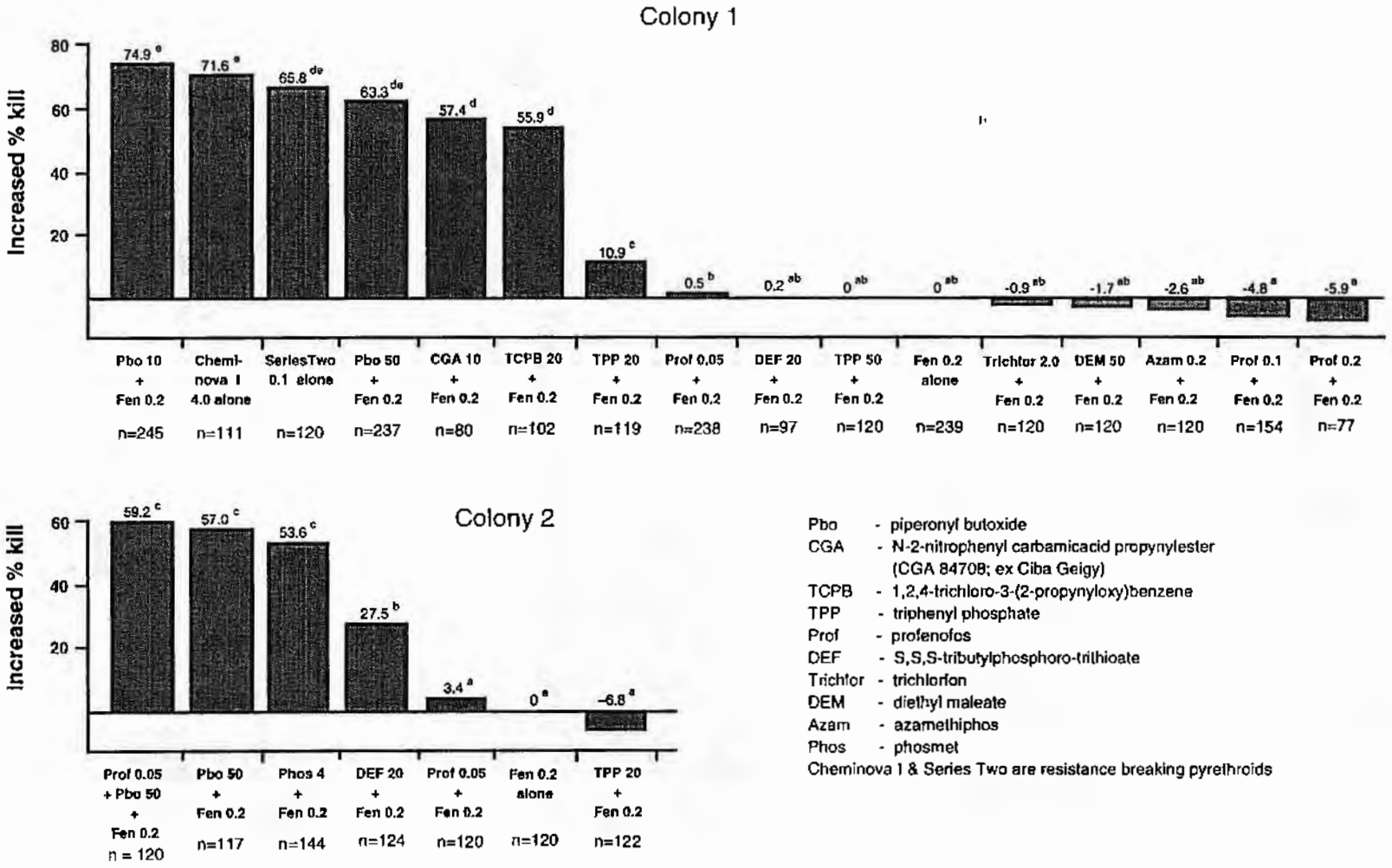
Average % suppression of pyrethroid resistance by :

profenofos	< 10 %
Pbo	40 - 60 %
TCPB	70 - 90 %
PP	70 - 80 %

Table 1 The number of occasions where various synergists or two resistance breaking pyrethroids (the simple benzyl alcohol and piperonyl acid pyrethroids Series Two and Cheminova I, respectively) (doses all expressed in µg/30-40 mg larva) were effective in significantly suppressing pyrethroid resistance in the F_1 *Helicoverpa armigera* populations described in figures 1-4. Ineffective compounds not significantly different from fenvalerate 0.2 (µg/30-40 mg larva) alone. Effective compounds, all of which significantly improved the kill over fenvalerate 0.2 alone, were then classed as either equivalent in activity to, or better than, or less active than Pbo (at either 10 or 50 µg/30-40mg larva), as determined by the Chi-squared tests in figures 1-4. Full chemical names given in the captions of figures 1-4.

Chemical group	Ineffective	Effective		
		less than Pbo	equivalent to Pbo	better than Pbo
Organophosphates				
profenofos 0.05	6 out of 6			
profenofos 0.1	4 out of 4			
profenofos 0.2	4 out of 4			
trichlorfon 2.0	2 out of 2			
azamethiphos 0.2	2 out of 2			
phosmet 4.0		1 out of 3	2 out of 3	
Esterase, Glutathione transferase inhibitors				
TPP 20	6 out of 7	1 out of 7		
TPP 50	3 out of 3			
DEM 50	3 out of 3			
DEF 20	5 out of 9	4 out of 9		
Propynyl compounds				
CGA 10			2 out of 2	
PP 20			1 out of 1	
PP 50		1 out of 1		
TCPB 20			3 out of 6	3 out of 6
Resistance breaking pyrethroids				
Series Two 0.1 alone			3 out of 5	2 out of 5
Cheminova I 4.0 alone			2 out of 5	3 out of 5
Others				
profenofos 0.05 + Pbo 50			2 out of 3	1 out of 3

St. George - fenvalerate & endosulfan survivors



Pbo - piperonyl butoxide
CGA - N-2-nitrophenyl carbamicacid propynylester (CGA 84708; ex Ciba Geigy)
TCPB - 1,2,4-trichloro-3-(2-propynyloxy)benzene
TPP - triphenyl phosphate
Prof - profenofos
DEF - S,S,S-tributylphosphoro-trithioate
Trichlor - trichlorfon
DEM - diethyl maleate
Azam - azamethiphos
Phos - phosmet
Cheminova I & Series Two are resistance breaking pyrethroids

Fig. 1 Bioassay of various synergists (and two resistance breaking pyrethroids) on the progeny of two colonies of randomly mated St. George *Helicoverpa armigera* moths (collected as eggs from December 1992 to February 1993) which had survived either a fenvalerate or an endosulfan discriminating dose larval screen (0.2 & 10 µg / 30-40 mg larva, respectively). Results expressed as the increased kill (adjusted for any control mortality with the synergists alone) over the base kill with fenvalerate alone (5.9% & 20.8% in the top & bottom graphs, respectively). Synergists (µg/larva) applied topically in acetone, 5-15 minutes prior to fenvalerate. Treatments with the same letter are not significantly different at the 5% level (Chi-squared test). n = number of larvae tested.

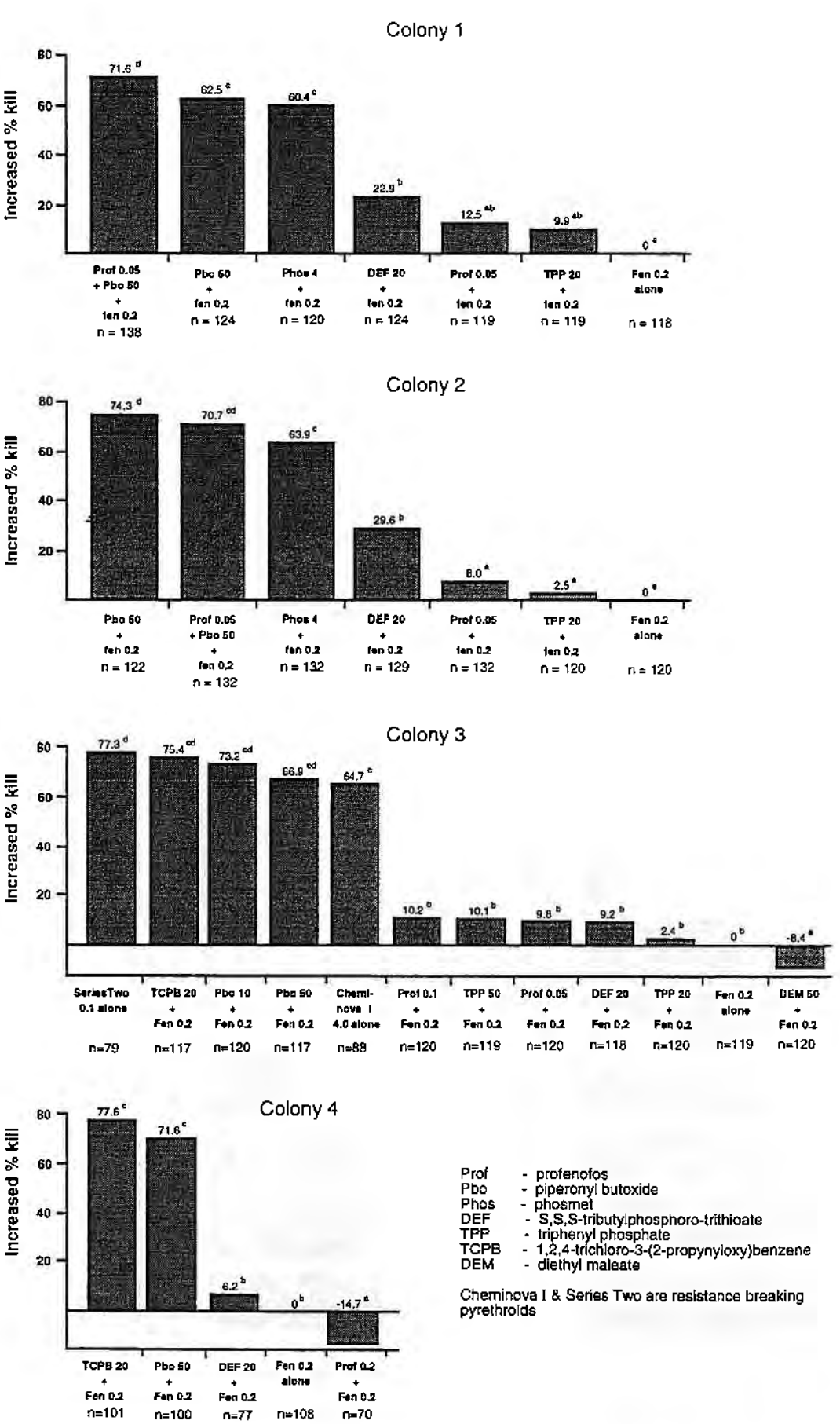


Fig. 2 Bioassay of various synergists (and two resistance breaking pyrethroids) on the progeny of four colonies of randomly mated Namoi/Gwydir & Emerald *Helicoverpa armigera* moths (collected as eggs from December 1992 to February 1993) which had survived either a fenvalerate or an endosulfan discriminating dose larval screen (0.2 & 10 µg / 30-40 mg larva, respectively). Results expressed as the increased kill (adjusted for any control mortality with the synergists alone) over the base kill with fenvalerate alone (25.4%, 16.7%, 12.6% & 19.4% in the top to bottom graphs, respectively). Synergists (µg/larva) applied topically in acetone, 5-15 minutes prior to fenvalerate. Treatments with the same letter are not significantly different at the 5% level (Chi-squared test). n = number of larvae tested.

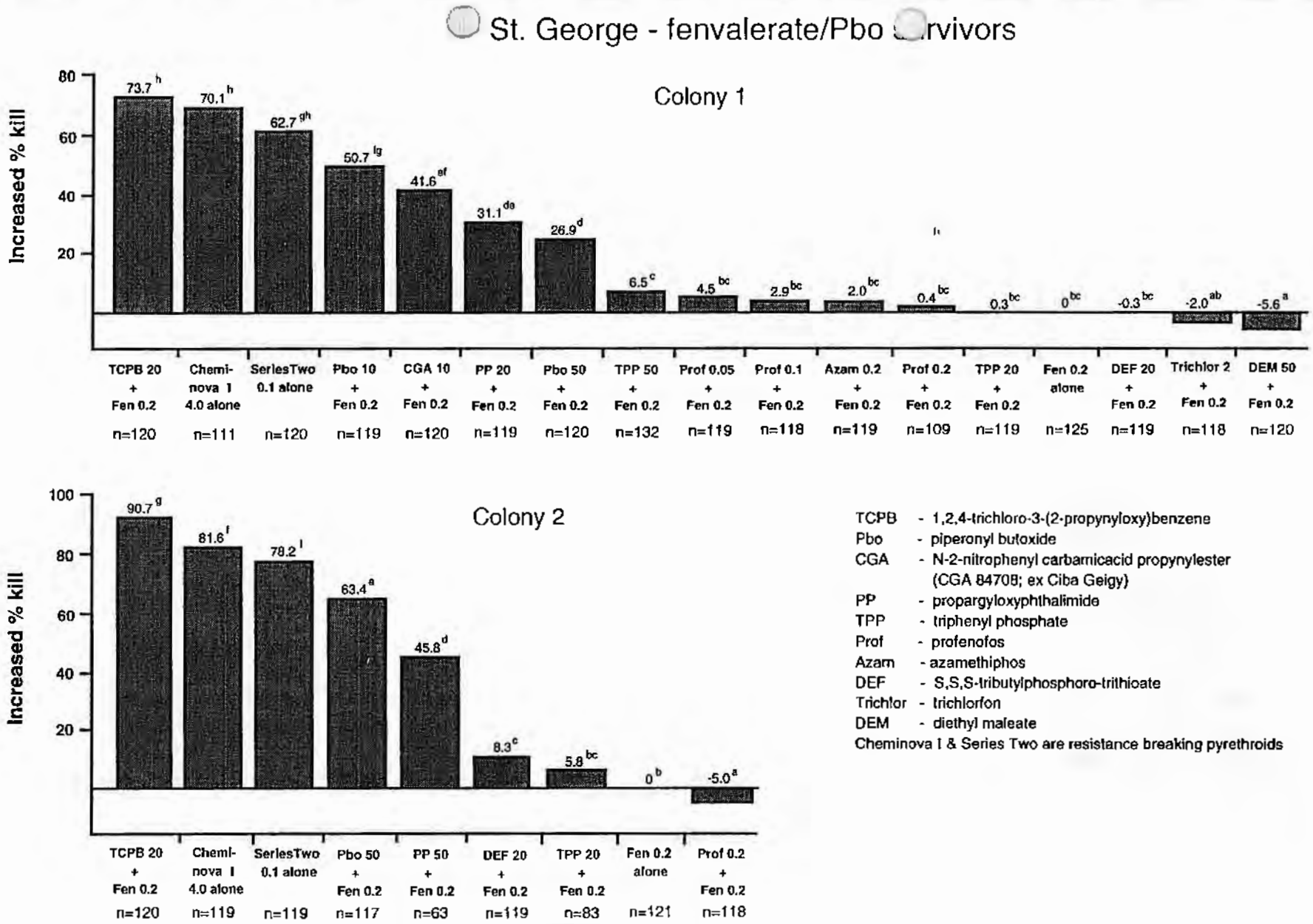


Fig. 3 Bioassay of various synergists (and two resistance breaking pyrethroids) on the progeny of two colonies of randomly mated St. George *Helicoverpa armigera* moths (collected as eggs in January/February 1993) which had survived a fenvalerate/piperonyl butoxide discriminating dose larval screen (0.2/50 µg / 30-40 mg larva, respectively). Results expressed as the increased kill (adjusted for any control mortality with the synergists alone) over the base kill with fenvalerate alone (5.6% & 5.0% in the top & bottom graphs, respectively). Synergists (µg/larva) applied topically in acetone, 5-15 minutes prior to fenvalarate. Treatments with the same letter are not significantly different at the 5% level (Chi-squared test). n = number of larvae tested.

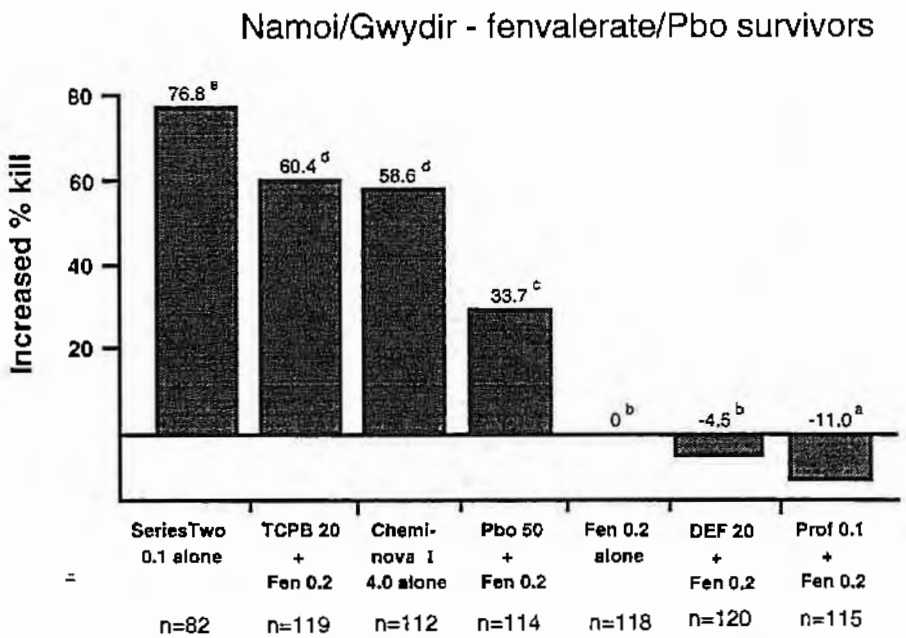
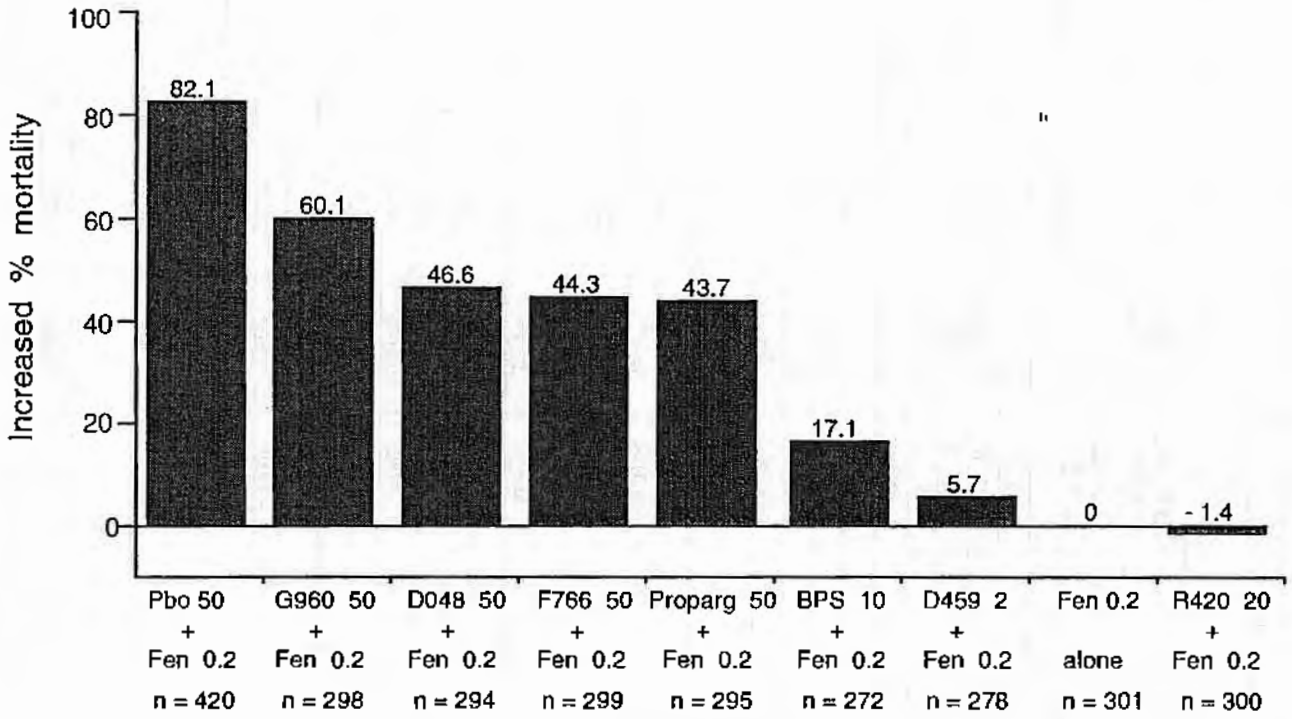


Fig. 4 Bioassay of various synergists (and two resistance breaking pyrethroids) on the progeny of randomly mated Namoi/Gwydir *Helicoverpa armigera* moths (collected as eggs in February 1993) which had survived a fenvalerate/piperonyl butoxide discriminating dose larval screen (0.2/50 µg / 30-40 mg larva, respectively). Results expressed as the increased kill (adjusted for any control mortality with the synergists alone) over the base kill with fenvalerate alone (11.0%). Synergists (µg/larva) applied topically in acetone, 5-15 minutes prior to fenvalerate. Treatments with the same letter are not significantly different at the 5% level (Chi-squared test). n = number of larvae tested.

TCPB - 1,2,4-trichloro-3-(2-propynyloxy)benzene
Pbo - piperonyl butoxide
DEF - S,S,S-tributylphosphoro-trithioate
Prof - profenofos
Cheminova I & Series Two are resistance breaking pyrethroids



Impact of various synergists on mortality at the fenvalerate discriminating dose (0.2 µg/larva) on 30-40 mg fourth instar mixed function oxidase pyrethroid resistant *Helicoverpa armigera*. Results expressed as the increased mortality (adjusted for any control mortality) over the base mortality with fenvalerate alone (17.9%). Synergists (µg/larva) applied topically in acetone, 5 -15 minutes prior to fenvalerate (premix applied simultaneously). n=number of larvae tested. Pbo - piperonyl butoxide, Proparg - propargite, other codes from Uniroyal.

ENDO R SELECTION EXPERIMENT

Treatment	Base Line Susceptible	F1 (Staning point)	F2	F3	F4	F5	F6	F7
Selection pressure on previous larval generation (mg/30-40mg larva)	-	Endo 10	Endo ≥ 20 i	Endo ≥ 40 i	Endo ≥ 80 i	Endo ≥ 80 •	Endo ≥ 160 =	Endo ≥ 240 =
Endosulfan								
LD50	0.7245	50.5672	25.3390	63.1958	43.3384	91.2551	137.8322	193.9387
Lower 95% C.I.	0.6475	41.8432	19.6430	55.6134	35.8849	72.6016	106.4821	147.3027
Upper 95% C.I.	0.8107	63.0229	31.8210	71.2185	51.6545	115.7272	178.4124	255.3396
Slope	5.9	2.0	1.2	2.3	2.1	1.6	1.6	2.0
Resistance factor	-	69.8 *	34.0 *	87.2 *	59.8 *	126.0 *	190.2 *	267.7 *
Endosulfan a								
LD50	0.6098	49.4017		74.4185	37.3764	110.9289	73.3219	147.5788
Lower 95% C.I.	0.5406	40.9701		65.1719	28.2109	87.8473	58.5629	103.0059
Upper 95% C.I.	0.6878	60.6301		84.5456	47.3625	141.6184	91.8004	211.4393
Slope	5.4	2.2		2.3	1.4	1.5	2.0	1.5
Resistance factor	-	81.0 *		122.0 *	61.3 *	181.9 *	120.2 *	242.0 *
Endosulfan b								
LD50	0.5747	54.7282		66.8511	51.6607	153.0112	72.5890	160.9176
Lower 95% C.I.	0.4791	47.3819		60.7632	43.0587	129.7413	59.2742	112.2474
Upper 95% C.I.	0.6893	63.7044		72.6843	61.8695	180.9965	88.8947	230.6911
Slope	2.7	3.0		3.0	2.4	2.8	2.5	1.5
Resistance factor	-	95.2 *		116.3 *	89.9 *	266.2 *	126.3 *	280.0 *
Endosulfan SO_4								
LD50	0.6152	87.1798		126.4612	92.0567	218.8091	183.3696	833.6459
Lower 95% C.I.	0.5210	71.9970		113.1880	75.3112	184.8631	144.9004	308.4526
Upper 95% C.I.	0.7266	106.2236		145.7926	113.4496	261.0356	232.0518	2253.0706
Slope	3.1	1.9		2.7	2.1	2.7	2.0	1.8
Resistance factor	-	141.7 *		205.6 *	149.6 *	355.7 *	198.1 *	1355.1z *
Dieldrin								
LD50	2.8916	61.6664	241.9944	128.3708	60.3191	194.9881	81.6381	119.8554
Lower 95% C.I.	2.0067	41.8391	183.4759	102.4545	48.5354	160.5748	51.4376	71.9536
Upper 95% C.I.	4.1668	91.6643	376.3974	163.4100	75.0877	240.7073	129.5705	199.6473
Slope	2.4	0.8	1.8	1.6	1.8	2.1	1.5	1.6
Resistance factor	-	21.3 *	83.7 *	44.4 *	20.9 *	67.4 *	28.2 *	41.4 *
Fenvalerate								
LD50	0.0445	1.1476	0.6801	0.8663	0.4454	1.6473	2.9218	1.7452
Lower 95% C.I.	0.0366	0.9348	0.5601	0.7026	0.3601	1.3620	2.1817	1.3409
Upper 95% C.I.	0.0543	1.3984	0.8140	1.0738	0.5490	1.9858	3.9128	2.2715
Slope	2.1	2.1	2.5	1.9	2.1	2.2	1.3	1.8
Resistance factor	-	25.8 *	15.3 *	19.5 *	10.0 *	37.0 *	65.7 *	39.2 *
Deltamethrin								
LD50	0.0096	0.1707	0.1794	0.2946	0.2291	0.3179	0.4240	0.9301
Lower 95% C.I.	0.0069	0.1389	0.1522	0.2430	0.1865	0.2587	0.3276	0.6839
Upper 95% C.I.	0.0134	0.2119	0.2139	0.3608	0.2824	0.3856	0.5487	1.2650
Slope	3.1	1.9	3.1	2.3	2.1	2.3	1.8	1.9
Resistance factor	-	17.8 *	18.7 *	30.7 *	23.9 *	33.1 *	44.2 *	96.9 *
Epimethyl amino abamectin								
LD50	0.0056	0.0058	0.0064	0.0078	0.0060	0.0092	0.0073	0.0055
Lower 95% C.I.	0.0049	0.0045	0.0053	0.0065	0.0051	0.0080	0.0045	0.0045
Upper 95% C.I.	0.0064	0.0073	0.0077	0.0094	0.0071	0.0107	0.0117	0.0068
Slope	4.1	1.7	2.3	2.3	2.8	3.5	2.1	5.1
Resistance factor	-	1.0 ns	1.1 ns	1.4 *	1.1 ns	1.7 *	1.3 ns	1.0 ns
Bt								
LC50	0.09			0.10				
Lower 95% C.I.				0.079				
Upper 95% C.I.				0.115				
Slope	2.7			2.4				
Resistance factor	-			1.1 ns				

ENDO R SELECTION EXPERIMENT

Treatment	Base Line Susceptible	F1 (Starting point)	F2	F3	F4	F5	F6	F7
Selection pressure on previous larval generation (mg/30-40mg larva)	-	Endo 10	Endo ≥ 20 i	Endo ≥ 40 i	Endo ≥ 80 i	Endo ≥ 80 •	Endo ≥ 160 =	Endo ≥ 240 =
Chlorpyrifos								
LD50	0.3268	0.6663	0.3029	0.4985	0.4694	0.6021	0.8688	0.6689
Lower 95% C.I.	0.2847	0.5774	0.2543	0.4103	0.3804	0.5053	0.7292	0.5056
Upper 95% C.I.	0.3751	0.7617	0.3585	0.5945	0.5784	0.7187	1.0351	0.8859
Slope	4.6	4.0	3.0	2.8	2.1	2.7	3.5	2.3
Resistance factor	-	2.0 *	0.9 ns	1.5 *	1.4 *	1.8 *	2.7 *	2.0 *
Fenitrothion								
LD50	0.6111	26.9177	12.4162	17.1112	11.7292	20.1837	16.4621	
Lower 95% C.I.	0.4600	21.6942	9.5479	13.4092	9.0758	15.6407	12.8016	
Upper 95% C.I.	0.8123	33.2553	16.5398	21.6737	15.1966	26.4442	21.1692	
Slope	3.4	1.8	1.3	1.4	1.5	1.4	1.7	
Resistance factor	-	44.0 *	20.3 *	28.0 *	19.2 *	33.0 *	26.9 *	
Malathion								
LD50	= 1.8683				10.7610	45.3204	42.2703	87.6061
Lower 95% C.I.	1.5271				8.4391	34.7096	33.5127	63.8950
Upper 95% C.I.	2.2856				13.8989	61.0981	53.3165	120.1163
Slope	2.1				1.5	1.3	2.1	1.9
Resistance factor	-				5.8 *	24.3 *	22.6 *	46.9 *
Methyl parathion								
LD50	0.1463	0.6170	0.3889	0.5736	1.0231	0.5797	0.8485	1.7650
Lower 95% C.I.	0.1286	0.5115	0.3305	0.4684	0.8213	0.4709	0.5717	1.3240
Upper 95% C.I.	0.1663	0.7334	0.4560	0.6984	1.2751	0.6986	1.2592	2.3529
Slope	3.6	2.7	3.3	2.1	1.9	2.4	2.9	1.9
Resistance factor	-	4.2 *	2.7 *	3.9 *	7.0 *	4.0 *	5.8 *	12.0 *
Monocrotophos								
LD50	1.0482	12.6787	10.3821	14.3800	8.1890	22.6871	14.5762	19.4325
Lower 95% C.I.	0.9046	10.3336	8.2209	11.7488	6.4130	17.7609	11.1908	14.1260
Upper 95% C.I.	1.2145	15.3859	13.2388	17.7443	10.4659	28.9941	18.9858	26.7325
Slope	3.5	2.2	1.5	2.0	1.5	1.4	1.5	1.6
Resistance factor	-	12.1 *	9.9 *	13.7 *	7.8 *	21.6 *	13.9 *	18.5 *
Profenofos								
LD50	0.0956	0.2682	0.2121	0.3164	0.2220	0.5165	0.3621	0.6864
Lower 95% C.I.	0.0855	0.2255	0.1794	0.2722	0.1881	0.4401	0.3061	0.5952
Upper 95% C.I.	0.1069	0.3180	0.2490	0.3679	0.2671	0.6022	0.4283	0.7916
Slope	3.1	3.1	3.4	3.9	3.1	3.4	4.0	7.2
Resistance factor	-	2.8 *	2.2 *	3.3 *	2.3 *	5.4 *	3.8 *	7.2 *
Quinalphos								
LC50	0.1134				0.6271	1.8201	2.4695	3.3038
Lower 95% C.I.	0.1022				0.4599	1.4670	2.0441	2.4469
Upper 95% C.I.	0.1258				0.8523	2.2476	2.9833	4.4606
Slope	6.7				1.1	1.8	2.7	1.8
Resistance factor	-				5.5 *	16.0 *	21.8 *	29.1 *
Sulprofos								
LD50	0.3892	1.3382	0.8946	1.3574	0.8535	1.1632	1.6883	2.1433
Lower 95% C.I.	0.3892	1.1129	0.7443	1.1115	0.6831	0.9601	1.3708	1.7483
Upper 95% C.I.	0.3442	1.6041	1.0687	1.6451	1.0612	1.4002	2.0794	2.6277
Slope	6.3	2.4	2.6	2.1	1.7	2.3	2.3	3.6
Resistance factor	-	3.4 *	2.3 *	3.5 *	2.2 *	3.0 *	4.3 *	5.5 *

i Includes the a and b endosulfan isomers and endosulfan sulfate.

• Includes the a endosulfan isomer only.

= Includes endosulfan only.

Table 1. Calibration of spinosad bioassays and potential discriminating doses on 13 strains of *Helicoverpa armigera* and 7 strains of *Helicoverpa punctigera* collected as eggs or larvae on a range of hosts from 1990 to 1997 and tested in the F_1 (or F_2/F_3 where indicated). All mortality assessments made at day 6 after treatment. *H. armigera* and *H. punctigera* both tested as 30-40 mg third or fourth instar larvae . n= total number of larvae tested at each candidate discriminating dose.

Strain data		LD_{50}	95% Conf. interval		Slope	% Mortality at µg/larva		
Collection site	Host	(µg/larva)	Lower	Upper		0.5	1.0	2.0
Helicoverpa armigera								
Long term laboratory susceptible strain								
tested 1990		0.08	0.070	0.096	2.5	96.5	99.3	99.6
tested 1994		0.08	0.069	0.096	2.5	97.9	100	
tested 1995		0.17	0.060	0.499	2.0	88.1	96.4	100
tested 1996		0.04	0.036	0.049	3.4	89.0	98.6	100
Laboratory resistant strains								
MFO strain*		0.06	0.052	0.075	1.9	91.7	100	
EndoR strain¶		0.11	0.087	0.133	1.8	87.2	89.6	
Field strains (1990-1997)								
Bourke, NSW	cotton	0.06	0.037	0.085	3.1	100		
Breeza, NSW	sunflower	0.06	0.035	0.111	2.3	97.9		
Kununurra, WA	chickpea	0.07	0.053	0.089	3.4	97.9	98.0	100
Myall Vale, NSW F_3	cotton	0.12	0.086	0.166	2.4	100	100	100
Narrabri, NSW F_3	cotton	0.12	0.095	0.145	1.8	77.1	100	
Wee Waa, NSW	cotton	0.14	0.113	0.185	2.2	91.5	93.3	98.3
Spring Plains, NSW F_3	cotton	0.16	0.130	0.199	1.8	87.5	89.6	97.9
Bairnsdale, VIC F_2	maize	0.17	0.139	0.200	2.4	89.4	95.8	100
Moree, NSW	cotton					93.8	97.9	100
Emerald, QLD	navy beans					90.3	97.2	99.6
Average		**0.10**			**2.4**	**92.2**	**96.8**	**99.5**
± standard error		± 0.012			± 0.15	± 1.52	± 0.97	± 0.25
						n=1,809	n=1,757	n=1,448
Helicoverpa punctigera								
Long term laboratory susceptible strain								
tested 1990		0.02	0.019	0.026	2.5			
tested 1996		0.02	0.015	0.022	4.3			
Laboratory resistant strain								
MFO strain*		0.02	0.017	0.026	2.0			
Field strains (1995-1997)								
Dalby, QLD	cotton	0.01	0.013	0.017	4.1			
Wee Waa, NSW	cotton	0.02	0.014	0.018	4.9			
Narrabri, NSW F_3	cotton	0.02	0.019	0.027	3.5			
Moree, NSW	cotton	0.03	0.023	0.029	5.5			
Breeza, NSW	cotton	0.03	0.023	0.029	5.5			
Average		**0.02**			**4.0**			
± standard error		± 0.002			± 0.46			

* Pyrethroid resistant (mixed function oxidases only)

¶ Endosulfan resistant

Table 1. Calibration of chlorfenapyr bioassays and potential discriminating doses on 13 strains of *Helicoverpa armigera* and 11 strains of *Helicoverpa punctigera* collected as eggs or larvae on a range of hosts from 1996 to 1997 and tested in the F_1 (or F_2/F_3 where indicated). All mortality assessments made at day 4 after treatment. *H. armigera* and *H. punctigera* both tested as 30-40 mg third or fourth instar larvae (except for the Bairnsdale *H. armigera* colony which was tested either as third instars only or fourth instars only, as indicated). n= total number of larvae tested at each candidate discriminating dose.

Strain data		LD50	95% Conf. interval		Slope	% Mortality at µg/larva		
Collection site	Host	(µg/larva)	Lower	Upper		0.5	1.0	2.0
Helicoverpa armigera								
Long term laboratory susceptible		0.10	0.095	0.114	7.8	100	100	100
Narrabri, NSW F_3	cotton	0.15	0.119	0.188	5.0	97.9		
Bairnsdale, VIC F_2, 3rds	maize	0.16	0.107	0.247	4.5	91.7	100	100
Boggabri, NSW	sorghum	0.16	0.146	0.176	8.6	100	97.9	
Armidale, NSW	triticale	0.17	0.133	0.224	4.6	93.8	100	
Narrabri, NSW F_3	cotton	0.18	0.158	0.212	5.0	97.2	100	100
Darlington Point, NSW	maize	0.19	0.112	0.315	4.1	93.8	97.9	
Rocky Creek, NSW	*Verbascum virgatum*	0.21	0.161	0.236	4.7	93.8	100	
Bairnsdale, VIC F_2, 4ths	maize	0.23	0.131	0.409	2.3	87.5	93.8	97.9
Spring Plains, NSW F_3	cotton	0.29	0.178	0.471	2.1	77.1	95.8	91.7
Kununurra, WA	chickpeas	0.32	0.227	0.439	2.1	79.2	75.0	93.8
Gympie, QLD	beans					96.3	100	99.1
Devonport, TAS	maiza					97.3	97.2	98.6
?????	?????					xxxx	xxxx	xxxx
?????	?????					xxxx	xxxx	xxxx
Average		**0.20**			**4.6**	**92.7**	**96.5**	**97.6**
± standard error		± 0.019			± 0.64	± 2.03	± 2.04	± 1.12
						n=885	n=761	n=592
Helicoverpa punctigera								
Bourke, NSW	cotton	0.08	0.045	0.143	7.6	100		
Pinery, SA	field pea	0.09	0.072	0.108	6.5	100		
Long term laboratory susceptible		0.09	0.074	0.117	6.4	100		
Wee Waa, NSW	cotton	0.10	0.087	0.105	7.7	100		
Breeza, NSW	cotton	0.11	0.098	0.123	5.7	100		
Warren, NSW	cotton	0.11	0.085	0.143	16.6	100		
Goondiwindi, QLD	cotton	0.12	0.104	0.131	5.5	100		
Narrabri, NSW F_3	cotton	0.12	0.081	0.175	5.0	97.2		
St. George, QLD	cotton	0.13	0.092	0.191	4.4	95.8		
Theodore/Biloela, QLD	cotton	0.15	0.133	0.164	7.0	100		
Moree, NSW	cotton	0.18	0.138	0.226	5.1	95.8		
?????	?????					xxxx		
?????	?????					xxxx		
Average		**0.12**			**7.0**	**99.0**		
± standard error		± 0.009			± 1.01	± 0.54		
						n=492		

Table 1. Calibration of abamectin and emamectin benzoate bioassays and potential discriminating doses on 10 strains each of *Helicoverpa armigera* and *Helicoverpa punctigera* collected as eggs or larvae on a range of hosts from 1996 to 1997 and tested in the F_1 (or F_3 where indicated). All mortality assessments made at day 10 after treatment. *H. armigera* tested as 30-40 mg third instar larvae only; *H. punctigera* tested as 30-40 mg third or fourth instar larvae. n= total number of larvae tested at each candidate discriminating dose.

Strain data		LD50	95% Conf. interval		Slope	% Mortality at µg/larva			
Collection site	Host	(µg/larva)	Lower	Upper		0.003	0.006	0.012	0.024
ABAMECTIN on *Helicoverpa armigera*									
Long term laboratory susceptible		0.03	0.018	0.060	1.4				
Wee Waa, NSW F_3	cotton	0.04	0.025	0.069	1.6				
Boggabri, NSW	sunflower	0.04	0.027	0.058	2.4				
Darlington Point, NSW	maize	0.04	0.009	0.204	2.0				
Bairnsdale, VIC F_3	maize	0.05	0.028	0.083	1.7				
Narrabri, NSW F_3	cotton	0.06	0.038	0.095	2.2				
Armidale, NSW	triticale	0.07	0.036	0.128	1.8				
Rocky Creek, NSW	*Verbascum virgatum*	0.07	0.039	0.134	1.5				
Kununurra, WA	chickpea	0.08	0.046	0.132	2.0				
Spring Plains, NSW F_3	cotton	0.09	0.054	0.150	1.7				
Average ± standard error		0.06 ± 0.006			1.8 ± 0.10				
ABAMECTIN on *Helicoverpa punctigera*									
Long term laboratory susceptible		0.002	0.0011	0.0031	3.1				
Warren, NSW	cotton	0.004	0.0021	0.0058	3.6				
Bourke, NSW	cotton	0.004	0.0035	0.0047	3.3				
Goondiwindi, QLD	cotton	0.004	0.0035	0.0047	3.3				
Quambone, NSW	cotton	0.004	0.0035	0.0051	3.0				
St. George, QLD	cotton	0.005	0.0044	0.0061	2.5				
Mareeba, QLD	tobacco	0.005	0.0045	0.0064	3.0				
Narrabri, NSW F_3	cotton	0.005	0.0039	0.0058	3.2				
Theodore/Biloela, QLD	cotton	0.006	0.0053	0.0072	3.9				
Wee Waa, NSW	cotton	0.006	0.0054	0.0071	3.6				
Average ± standard error		0.005 ± 0.0004			3.3 ± 0.12				
EMAMECTIN BENZOATE on *Helicoverpa armigera*									
Long term laboratory susceptible		0.001	0.0006	0.0026	3.4	100	93.8	97.9	100
Kununurra, WA	chickpea	0.002	0.0012	0.0039	3.3	81.3	95.6	95.8	97.8
Bairnsdale, VIC F_3	maize	0.002	0.0015	0.0020	5.0	80.6	100	100	100
Wee Waa, NSW F_3	cotton	0.002	0.0017	0.0022	5.3	77.1	100	100	100
Narrabri, NSW F_3	cotton	0.002	0.0015	0.0019	6.1	89.6	100	100	
Boggabri, NSW	sunflower	0.002	0.0015	0.0019	5.2	85.4	100	97.9	95.8
Rocky Creek, NSW	*Verbascum virgatum*	0.002	0.0018	0.0022	7.8	87.5	100	100	100
Darlington Point, NSW	maize	0.002	0.0016	0.0026	4.9	87.5	93.8	100	100
Armidale, NSW	triticale	0.003	0.0017	0.0053	3.3	41.7	100	95.8	95.8
Spring Plains, NSW F_3	cotton	0.003	0.0023	0.0030	6.9	54.2	100	95.8	91.7
Average ± standerd error		0.002 ± 0.0002			5.1 ± 0.48	78.5 ± 5.53 n=444	98.3 ± 0.87 n=441	98.3 ± 0.61 n=444	97.9 ± 0.98 n=364
EMAMECTIN BENZOATE on *Helicoverpa punctigera*									
Mareeba, QLD	tobacco	0.002	0.0013	0.0022	3.6		90.9	100	100
Quambone, NSW	cotton	0.002	0.0015	0.0028	3.4		97.9	95.8	100
Bourke, NSW	cotton	0.002	0.0016	0.0028	3.0		95.8	95.8	100
Goondiwindi, QLD	cotton	0.002	0.0021	0.0029	2.8		77.1	97.9	97.9
Warren, NSW	cotton	0.003	0.0023	0.0045	3.6		85.4	100	97.9
Theodore/Biloela, QLD	cotton	0.003	0.0022	0.0049	3.1		89.6	97.9	95.8
Long term laboratory susceptible		0.003	0.0023	0.0031	5.0		91.7	100	100
St. George, QLD	cotton	0.004	0.0032	0.0043	4.4		83.3	97.9	100
Waa Waa, NSW	cotton	0.004	0.0034	0.0042	6.6		89.6	100	100
Narrabri, NSW F_3	cotton	0.006	0.0048	0.0068	3.4		66.7	80.6	97.2
Average ± standard error		0.003 ± 0.0004			3.9 ± 0.37		86.8 ± 2.93 n=440	96.6 ± 1.85 n=440	98.9 ± 0.49 n=464

Table 2. Average bioassay data for abamectin and emamectin benzoate tested on 10 strains each of *Helicoverpa armigera* and *Helicoverpa punctigera* (data taken from Table 1). Means in the same row or column, followed by the same letter, are not significantly different ($p<0.01$, paired t test and unpaired t test, respectively).

Species	Abamectin		Emamectin benzoate		Increased activity of emamectin over abamectin
	Average LD50 (µg/larva) and range of LD50s	Average slope	Average LD50 (µg/larva) and range of LD50s	Average slope	
Helicoverpa armigera	0.06 [a] (0.03 - 0.09)	1.8	0.002 [b] (0.001 - 0.003)	5.1	30x
Helicoverpa punctigera	0.005 [b] (0.002 - 0.006)	3.3	0.003 [b] (0.002 - 0.006)	3.9	nil
Increased susceptibility of *H. punctigera* compared to *H. armigera*	12.0x		nil		

	Abamectin LC50 (µg / 30-40 mg 3rd or 4th instar larva) 95% confidence limits in brackets			Epimethylamino abamectin LC50 (µg / 30-40 mg 3rd or 4th instar larva) 95% confidence limits in brackets			
	Alone	Pbo 50 µg per larva pre-treatment	Syn. ratio	Alone	Pbo 50 µg per larva pre-treatment	Syn. ratio	Increased toxicity of epimethylamino abamectin alone over abamectin alone
Helicoverpa armigera							
Pyrethroid susceptible colony				0.007 (0.0059, 0.0085) Slope = 2.3	0.012 (0.0099, 0.0149) Slope = 1.9	0.6 *	-
Pyrethroid resistant colony	0.098 (0.0746, 0.1324) Slope = 1.3	0.231 (0.1487, 0.3532) Slope = 0.6	0.4 *	0.008 (0.0059, 0.0099) Slope = 1.4	0.014 (0.0109, 0.0177) Slope = 1.5	0.6 *	12.3 *
Helicoverpa punctigera							
Emerald, Qld.	0.011 (0.0087, 0.0134) Slope = 1.7			0.005 (0.0040, 0.0054) Slope = 3.4			2.2 *
St. George, Qld.	0.005 (0.0038, 0.0059) Slope = 2.0			0.004 (0.0035, 0.0046) Slope = 3.6			1.3 ns
Narrabri, NSW.	0.006 (0.0048, 0.0078) Slope = 1.6	0.019 (0.0163, 0.0231) Slope = 2.5	0.3 *	0.004 (0.0039, 0.0050) Slope = 4.6	0.006 (0.0046, 0.0066) Slope = 2.6	0.7 ns	1.5 ns

*, ns indicate non-overlap or overlap of 95% confidence limits, respectively. Synergistic ratio = LC50 alone ÷ LC50 after Pbo pre-treatment. Increased toxicity of epimethylamino abamectin over abamectin = LC50 abamectin alone ÷ LC50 epimethylamino abamectin alone.

yrethroid Resistance in *Helicoverpa punc ra*
(collected as larvae in the field and tested in the following F_1 generation)

LAB SUSCEPTIBLE COLONIES

Collection source	Date tested	Lab generation tested	No. tested	No. dead	% survival @ Fen 0.05µg/larva
Narrabri NSW	May '94	F_{10}	168	167	0.6
Bundaberg QLD	May '94	F_3	546	542	0.7
Narrabri NSW	March '95	F9	244	237	2.9

FIELD COLONIES (all tested in the F_1)

Collection site	Month collected	Host	No. tested	No. dead	% survival @ Fen 0.05µg/larva
1993/94 season					
Myall Vale NSW	April	cotton	167	166	0.6
Moree NSW	April	cotton	184	184	0
Kununurra WA	May	cotton	84	83	1.2
Durham Downs via Roma QLD	June	weeds	56	56	0
Bourke NSW	Dec	cotton	126	125	0.8
1994/95 season					
Burren Junction NSW	Sept	faba bean	212	201	5.2
Merah North NSW	Sept	faba bean	226	204	9.7
Wee Waa NSW	Sept	faba bean	225	220	2.2
Narrabri NSW	Sept	faba bean	210	202	3.8
Walgett NSW	Sept	chickpea	236	228	3.4
Wee Waa NSW	Sept	potato	188	183	2.7
Wee Waa NSW	Sept	lupins	225	224	0.4
Narrabri NSW	Sept	chickpea	279	270	3.2
Boggabri NSW	Sept	faba bean	294	290	1.4
Boggabri NSW	Sept	lucerne	221	221	0
Boggabri NSW	Sept	chickpea	262	262	0
Edgeroi NSW	Sept	lucerne	259	258	0.4
Narrabri NSW	Sept	lucerne	245	235	4.1
Goondiwindi QLD	Oct	chickpea	243	240	1.2
Bundaberg QLD	Nov	tomatoes	244	243	0.4
Warren NSW	Nov	lucerne	211	204	3.3
Dubbo NSW	Nov	lucerne	254	230	9.4
Dubbo NSW	Nov	linseed	134	131	2.2
Esperance WA	Nov	lupins	222	218	1.8

Collection site	Month collected	Host	No. tested	No. dead	% survival @ Fen 0.05µg/larva
Mareeba QLD	Nov	tobacco	219	212	3.2
Waroo via Forbes NSW	Nov	lucerne	229	226	1.3
Hopetoun WA	Nov	lupins	226	219	3.1
Albany WA	Nov	linseed	175	161	8.0
Spring Ridge NSW	Nov	field pea	268	255	4.9
Quandialla NSW	Nov	field pea	154	150	2.6
Forbes NSW	Nov	lucerne	207	200	3.4
Coonabarabran NSW	Nov	lucerne	259	246	5.0
Manilla NSW	Nov	lucerne	365	310	15.0
Attunga NSW	Nov	lucerne	233	231	1.0
Breeza NSW	Nov	lucerne	210	204	2.9
Devonport TAS	Nov	peas	272	260	4.4
Knoxfield VIC	Nov	tomatoes	119	115	3.4
Warren NSW	Nov	cotton	442	392	11.3
Urrbrae SA	Nov	daisys	237	225	5.1
Murgon QLD	Dec	lucerne	250	239	4.4
Trangie NSW	Dec	tomatoes	312	308	1.3
Bourke NSW	Jan	cotton	272	271	0.4
Narrabri NSW	Jan	cotton	272	254	6.6
Devonport TAS	Feb	sweet corn	203	199	2.0
Gurley NSW	Feb	marshmallow	218	210	3.7
St George QLD	Feb	cotton	229	218	4.8
Bald Hill Rd NSW	Feb	tribulus	253	244	3.6
Broken Note via Moree NSW		chenopoda	226	221	2.2
Coolabah NSW		malvastrum	191	185	3.1
Come-by-Chance NSW			223	221	1.0
Brewarrina NSW		malvastrum	218	208	4.6
Cassilis NSW		lucerne	212	220	3.6
Bourke NSW		verbesina	228	220	3.6
Edgeroi NSW		sunflower	122	122	0
Delungra NSW		sunflower	186	178	4.3

N.B. The expected levels of pyrethroid resistance would be in the range of 1-5% for the discriminating dose of Fenvalerate 0.05.

$\lambda = 55 \left(\omega = 3.3 \pm 0.40 \right)$