RESISTANT PEST MANAGEMENT

A Biannual Newsletter of the Pesticide Research Center (PRC) in Cooperation with the Western Regional Coordinating Committee (WRCC-60), the International Organization for Resistant Pest Management (IOPRM) and the Insecticide Resistance Action Committee (IRAC)

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Pyrethroid and endosulfan resistance in *Helicoverpa armigera* in India.

In 1987, cotton crops in Guntur and Krishna District, Andhra Pradesh, India, were badly damaged by severe infestations of *Helicoverpa armigera* (Hübner). Some farmers applied over 30 sprays of insecticide but were unable to control the problem. In some areas complete crop loss resulted and many farmers abandoned their fields because they ran out of funds (both cash and credit) to purchase pesticides. Andrew King (Natural Resources Institute entomologist) visited some of the worst affected areas and collected samples of larvae for resistance testing at the Indian Agricultural Research Institute, New Delhi and Reading University, UK. High order resistance to pyrethroids and moderate resistance to endosulfan was subsequently confirmed independently by Dhingra *et al.* (1988) and McCaffery *et al.* (1989). Limited scale monitoring of insecticide resistance in the Guntur / Krishna cotton belt and at ICRISAT center continued up to 1990 (King & Sawicki 1990, Armes *et al.* 1992) through a NRI funded collaborative programme with ICRISAT and Reading University. As this early data indicated that resistance was spreading throughout India and tolerance to organophosphate and carbamate insecticides was increasing, a collaborative project between NRI and ICRISAT was drawn up to intensively monitor insecticide resistance, study its dynamics and in collaboration with national agricultural research institutes, develop management strategies appropriate to India. An additional important component of the research was to identify the insecticide resistance mechanisms present in Indian *H. armigera* and to this end NRI are funding Alan McCaffery's research group at Reading University to undertake these studies. Nigel Armes was seconded to ICRISAT in the latter part of 1990 to establish an insecticide resistance monitoring program at ICRISAT Center. It was realized early on in the project that a simple, rapid assay technique was required for monitoring resistance in *H. armigera* populations at selected locations over the whole cropping season, in order to investigate seasonal dynamics of resistance. The discriminating dose test method successfully used by Neil Forrester in Australia was identified as the most appropriate technique for India and the method was successfully evaluated during the 1991-92 cropping season using a cypermethrin discriminating dose (Armes *et al.* in press a & b). Nigel Armes visited Neil Forrester's laboratory in early 1992 for a three day update on the Australian Strategy and a full scale monitoring program based at ICRISAT was implemented for the 1992-93 season. The agrochemical industry organization, the Insecticide Resistance Action Committee (IRAC) made funds available for Peter Lonergan (former Technical Officer with Neil Forrester) to work with the NRI / ICRISAT collaborative project for 10 months. This additional support, backed by extra logistical support from ICRISAT has allowed us to monitor resistance at two extra locations remote from the ICRISAT Center. A much larger scale IRM project is planned for the future whereby the technologies developed in this pilot study will be extended to a wider monitoring network to be coordinated by national scientists. This expanded project will be presented at the November IOPRM Congress for consideration by international funding organizations. Currently pyrethroid and endosulfan resistance is being monitored at four locations in Andhra Pradesh:-

- ICRISAT Centre, Medak District (cereal and legumes cropping system, moderate insecticide use)
- Rangareddi District (traditionally cereals and legumes but an increasing area to cash crops, cotton in particular; increasing dependence on insecticides)
- Krishna District (cotton-pigeon pea strip cropping, moderate insecticide use)
- Guntur District (predominantly monocrop cotton, traditional cash crop area, heavy use of insecticides)

This last location has been the area which has experienced the worst resistance problems, with extensive crop losses in some seasons. The monitoring program commenced in June at ICRISAT but was delayed in the other areas due to the late arrival of the monsoon.

Monitoring Techniques

Eggs are collected from host crops in the field. The crops sampled at the different locations in chronological order of appearance are:-

- **ICRISAT Center** -- weeds, volunteer chickpea, mung bean, sorghum, cotton, pigeonpea, chickpea)
- **Rangareddi District** -- weeds, tomato, cotton, sunflower, pigeonpea, chickpea, tomato
- **Krishna District** -- cotton, pigeonpea, chickpea
- **Guntur District** -- cotton, pigeonpea, chillies, groundnut

They are reared through on a chickpea flour based artificial diet to 30-40 milligram 3rd or 4th instar larvae and are randomly assigned to a number of topically applied discriminating dose screens (usually five treatments but occasionally less if numbers are low). These are:-

- **cypermethrin 0.1 µg / 30-40mg larva** (this is the LD_{99} for susceptibles, calibrated on Indian *Heliothis armigera)*
- **fenvalerate 0.2 µg / 30-40mg larva** (this is the LD99 for susceptibles, calibrated on Australian *Heliothis armigera.*)
- **cypermethrin 1.0 µg / 30-40mg larva** (1 0 times LD_{99} for susceptibles, precise kill of heterozygotes or homozygotes unknown at this stage but introduced as a "twin" discriminating dose because of the very high survival at the normal susceptible discriminating dose).
- **cypermethrin 0.1 µg + Pbo 50g / 30-40mg larva** (to determine the extent of monooxygenase mediated pyrethroid resistance).
- **endosulfan 10 µg / 30-40mg larva** (same screening dose as used in Australia).

In light of the results so far, it is planned to introduce a sixth screen as soon as possible:-

- **cypermethrin 0.1 µg + profenofos 0.1 g to determine the extent of esterase 30-40mg larva mediated pyrethroid resistance.** (to determine the extent of esterase mediated pyrethroid resistance).

Data for each week of samples (beginning 8-14th June) are pooled for each area and are presented as the percentage of larvae screened which survive the relevant discriminating dose.

Results so far

- Early season pyrethroid resistance levels are high at ICRISAT (usually 70-80% survival at the cypermethrin 0.1 discriminating dose). The fenvalerate 0.2 dose gives on average an 8.9% lower level of resistance (usually 60-70% survival) which indicates that this dose may be slightly high for Indian *Heliothis armigera.* The early results from the more intensively sprayed Guntur and Rangareddi districts indicate even higher resistance levels in those areas.
- Survival at the fenvalerate 0.2 discriminating dose generally ranged from 60-70% in Australia late last season, after the pyrethroid use period. This is comparable to the early season pre-pyrethroid use resistance levels at ICRISAT.
- Piperonyl butoxide (Pbo) suppresses pyrethroid resistance 46% on average at ICRISAT. This is low compared to the situation in Australia (70-90% suppression by Pbo in most areas). The reason for this high residual Pbo insensitive pyrethroid resistance is unknown at this stage. It could be due to either nerve insensitivity or esterase mediated pyrethroid resistance. The proposed profenofos pyrethroid screen should help shed some light on this problem.
- Early season endosulfan resistance levels were low at ICRISAT (generally less than 20%). However, there was a trend to higher levels as the season progressed and the levels in the intensively sprayed areas were somewhat higher (up to 40-50% resistance). These more recent levels are just slightly below those recorded at the end of last season in Australia.

Conclusions

The early season pre-pyrethroid use resistance situation in India is at least as serious as the post-pyrethroid use resistance situation in Australia. It can be expected that, as in previous seasons in south India, pyrethroid resistance levels will rise sharply once spraying commences, indicating a much worse resistance problem than for the managed situation in Australia. Pbo would seem to offer little advantage in India because of either significant nerve insensitivity or esterase mediated pyrethroid resistance. If the latter is found to be the case, then organophosphate / pyrethroid mixes could be useful (in a managed system) but this has yet to be researched. If the former mechanism is responsible for the residual Pbo insensitive pyrethroid resistance, then little can be done except to establish a rotation type Insecticide Resistance Management Strategy which favors selection of the more amenable metabolic (monooxygenase or esterase mediated) resistance mechanisms. Such a scheme should aim to incorporate non-chemical control measures into a workable IRM / IPM Strategy to relieve selection pressure on all the chemical groups involved in the strategy.

Early results from the intensively sprayed areas indicate that endosulfan resistance is also a potentially serious problem in India. Where numbers permit, we will also endeavor to incorporate alternative chemistry into the monitoring program, particularly the organophosphate compounds monocrotophos and quinalphos.

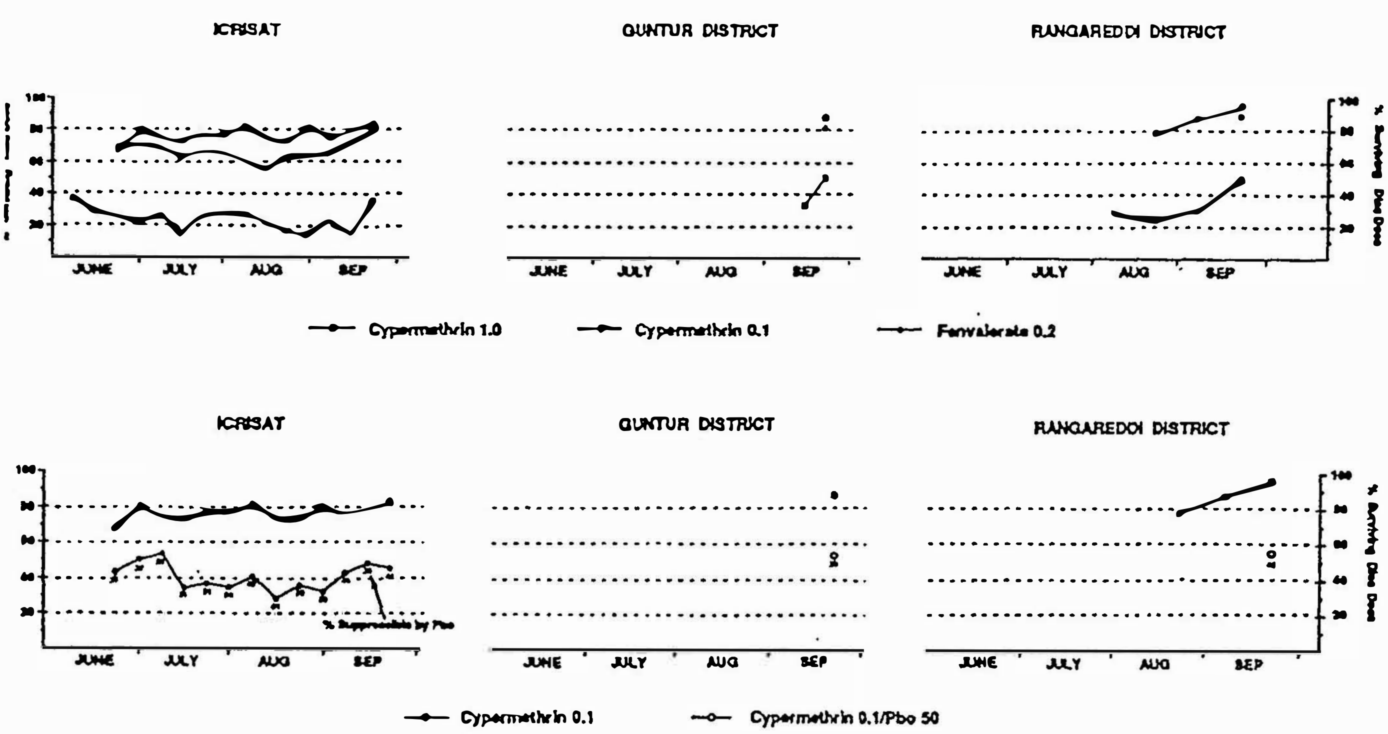
Acknowledgments

We wish to thank ICRISAT for their support to our research program, in particular Dr. Duncan McDonald for providing additional funds for accommodation and transport and to Dr. John Wightman for use of his facilities. We wish also to thank the Insecticide Resistance Action Committee for their financial support, in particular Dr. Claude Le Rumeur and Dr. Geoff Jackson for their enthusi

this project. Invaluable technical assistance was provided by Mr. K. V. S. Satyanarayana and M. Satyanarayana (ICRISAT).

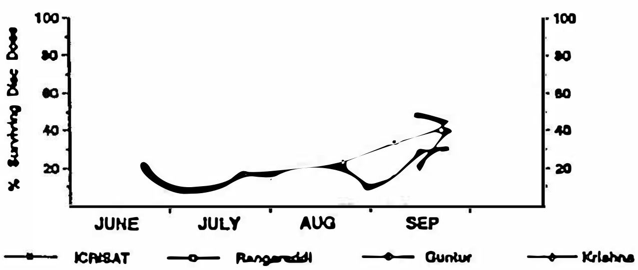
INDIA 1992

% ***Heliothis armigera*** **larvae (reared from field collected eggs) surviving the Discriminating Dose (µg / 30 - 40 mg larva).**



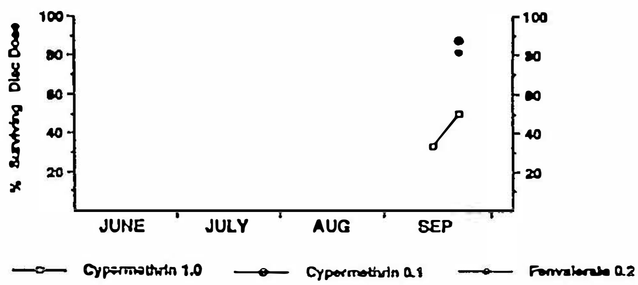
ENDOSULFAN SCREENS, INDIA 1992

% *Heliothis armigera* larvae (reared from field collected eggs) surviving the Discriminating Dose (10μg / 30 - 40 mg larva).



GUNTUR DISTRICT, INDIA 1992

% *Heliothis armigera* larvae (reared from field collected eggs) surviving the Discriminating Dose (μg / 30 - 40 mg larva).



GUNTUR DISTRICT, INDIA 1992

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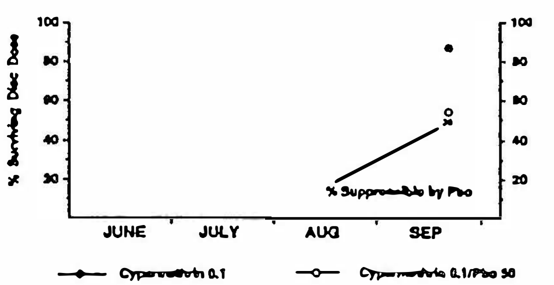
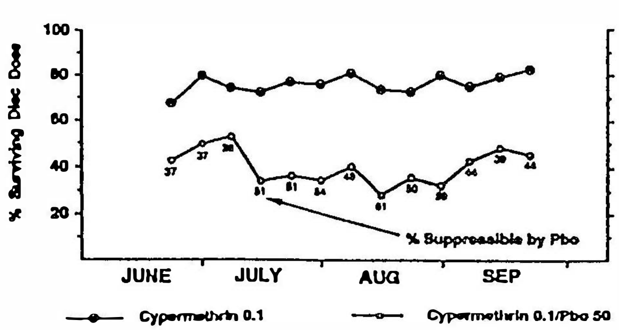


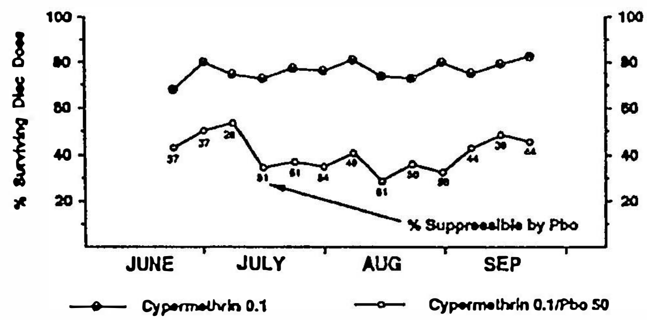
ICRISAT, HYDERABAD, INDIA 1992

% *Heliothis armigera* larvae (reared from field collected eggs) surviving the Discriminating Dose (μg / 30 - 40 mg larva).



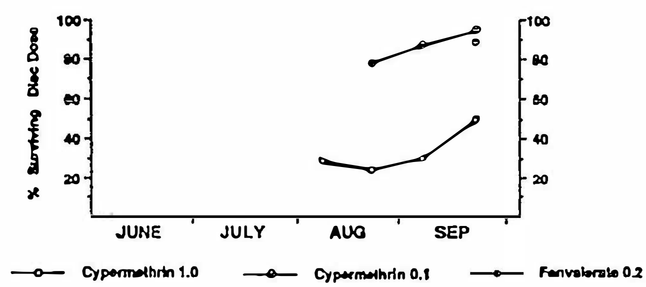
ICRISAT, HYDERABAD, INDIA 1992

% *Heliothis armigera* larvae (reared from field collected eggs) surviving the Discriminating Dose (μg / 30 - 40 mg larva).



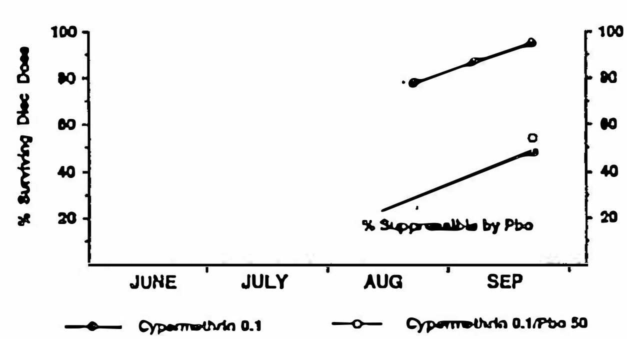
RANGAREDDI DISTRICT, INDIA 1992

% *Heliothis armigera* larvae (reared from field collected eggs) surviving the Discriminating Dose (μg / 30 - 40 mg larva).



RANGAREDDI DISTRICT, INDIA 1992

% *Heliothis armigera* larvae (reared from field collected eggs) surviving the Discriminating Dose (μg / 30 - 40 mg larva).



ICRISAT, HYDERABAD 1992

WEEK	DATE	CYPERMETHRIN 1.0		CYPERMETHRIN 0.1		CYPER 0.1 / PBO 50		FENVALERATE 0.2		ENDOSULFAN 10	
		No Dead / No. Tested	Cyper 1.0 % Res ± s.e	No Dead / No. Tested	Cyper 0.1 % Res ± s.e	No Dead / No. Tested	Cyper/ PBO % Res ± s.e	No Dead / No. Tested	Fen 0.2 % Res ± s.e	No Dead / No. Tested	Endo 10 % Res ± s.e
1	8/6 - 14/6	31/48	35.4 ± 7.0								
2	15/6 - 21/6	82/114	28.1 ± 4.2								
3	22/6 - 28/6	208/282	26.2 ± 2.6	42/132	68.2 ± 4.1	76/134	43.3 ± 4.3	24/81	70.4 ± 5.1	88/113	22.1 ± 3.9
4	29/6 - 5/7	173/220	20.9 ± 2.7	26/129	79.8 ± 3.5	53/107	50.5 ± 4.9	28/96	71.4 ± 4.6	95/104	8.7 ± 2.6
5	6/7 - 12/7	194/264	.26.5 ± 2.7	69/273	74.7 ± 2.6	130/281	53.7 ± 3.0	85/279	69.5 ± 2.8	254/282	9.9 ± 1.8
6	13/7 - 19/7	40/47	14.9 ± 5.3	12/44	72.7 ± 6.8	31/48	35.4 ± 7.0	18/47	61.7 ± 7.2	49/54	9.3 ± 4.0
7	20/7 - 26/7	65/90	28.7 ± 4.7	20/89	77.6 ± 4.4	54/87	37.9 ± 5.2	31/93	66.7 ± 4.9	75/92	18.5 ± 4.1
8	27/7 - 2/8	128/181	29.3 ± 3.4	42/182	76.9 ± 3.1	111/171	35.1 ± 3.7	60/184	67.4 ± 3.5	155/183	15.3 ± 2.7
9	3/8 - 9/8	50/70	28.6 ± 5.4	14/72	80.6 ± 4.7	39/66	40.9 ± 6.1			59/75	21.3 ± 4.8
10	10/8 - 16/8	139/180	22.8 ± 3.1	46/174	73.6 ± 3.4	126/176	29.0 ± 3.4	75/172	56.4 ± 3.8	141/182	22.6 ± 3.1
11	17/8 - 23/8	136/166	18.1 ± 3.0	36/134	73.1 ± 3.8	106/167	36.6 ± 3.7	48/131	63.4 ± 4.2	141/176	19.9 ± 3.0
12	24/8 - 30/8	130/156	16.7 ± 3.0	29/148	80.4 ± 3.3	111/166	33.1 ± 3.7	50/136 .	63.2 ± 4.2	139/155	10.3 ± 2.4
13	31/8 - 6/9		22.7		75.4		42.6		63.6		14.6
14	7/9 - 13/9		16.0		79.3		48.3		71.2		29.4
15	14/9 - 20/9		37.3		81.9		46.1		81.6		31.1

Krishna District 1992

WEEK	DATE	CYPERMETHRIN 1.0		CYPERMETHRIN 0.1		CYPER 0.1 / PBO 50		FENVALERATE 0.2		ENDOSULFAN 10	
		No Dead / No. Tested	Cyper 1.0 % Res ± s.e	No Dead / No. Tested	Cyper 0.1 % Res ± s.e	No Dead / No. Tested	Cyper/ PBO % Res ± s.e	No Dead / No. Tested	Fen 0.2 % Res ± s.e	No Dead / No. Tested	Endo 10 % Res ± s.e
14	7/9 - 13/9		15.9								23.3
15	14/9 - 20/9		22.2								40.0

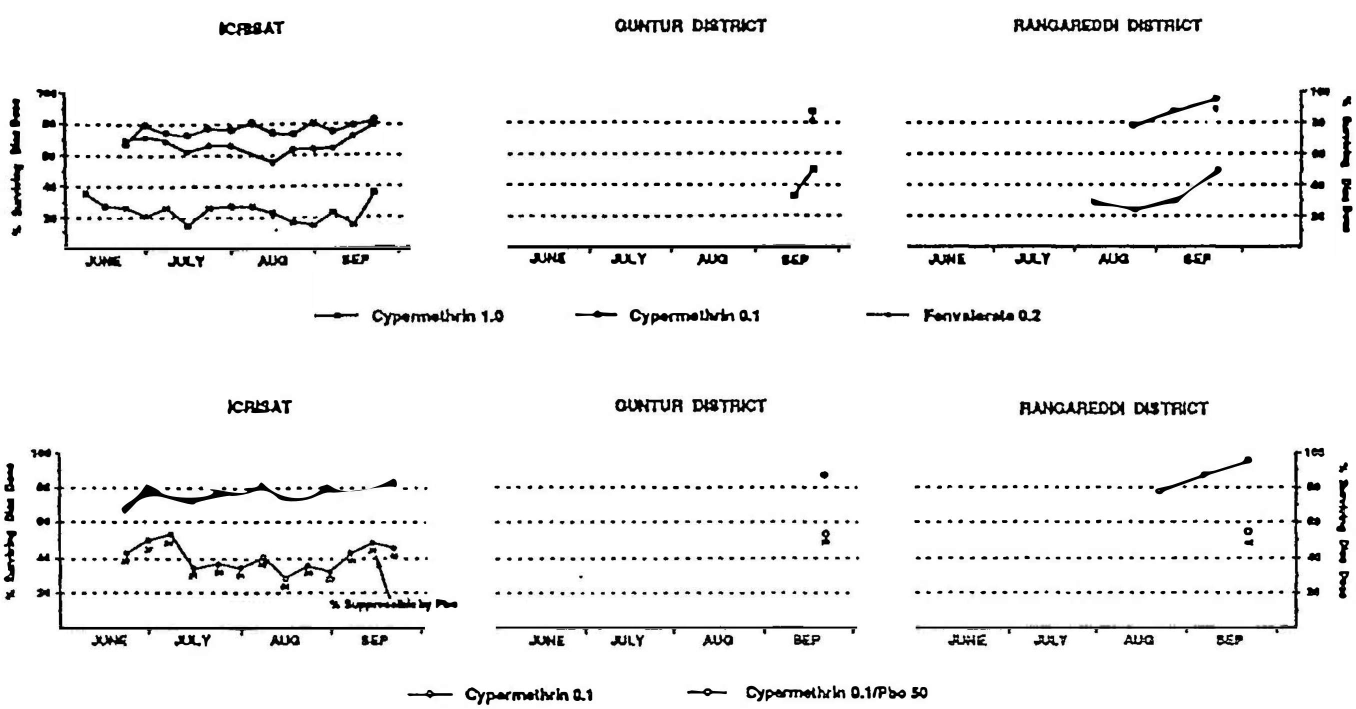
Guntur District 1992

WEEK	DATE	CYPERMETHRIN 1.0		CYPERMETHRIN 0.1		CYPER 0.1 / PBO 50		FENVALERATE 0.2		ENDOSULFAN 10	
		No Dead / No. Tested	Cyper 1.0 % Res ± s.e	No Dead / No. Tested	Cyper 0.1 % Res ± s.e	No Dead / No. Tested	Cyper/ PBO % Res ± s.e	No Dead / No. Tested	Fen 0.2 % Res ± s.e	No Dead / No. Tested	Endo 10 % Res ± s.e
14	7/9 - 13/9		32.4								48.3
15	14/9 - 20/9		50.8		87.1		53.5		81.4		46.3

Rangareddi District 1992

WEEK	DATE	CYPERMETHRIN 1.0		CYPERMETHRIN 0.1		CYPER 0.1 / PBO 50		FENVALERATE 0.2		ENDOSULFAN 10	
		No Dead / No. Tested	Cyper 1.0 % Res ± s.e	No Dead / No. Tested	Cyper 0.1 % Res ± s.e	No Dead / No. Tested	Cyper/ PBO % Res ± s.e	No Dead / No. Tested	Fen 0.2 % Res ± s.e	No Dead / No. Tested	Endo 10 % Res ± s.e
9	3/8 - 9/8	77/109	29.4 ± 4.4								
11	17/8 - 23/8	235/310	24.2 ± 4.4	70/311	77.5 ±2.4					241/313	23.0 ± 2.4
13			30.3		88.6						34.4
15	14/9 - 20/9		50.3		94.6		54.9		88.3		39.9

% *Heliothis armigera* larvae (reared from field collected eggs) surviving the Discriminating Dose (µg / 30 - 40 mg larva).



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