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MONITORING OF INSECTICIDE RESISTANCE AGAINST *HELICOVERPA ARMIGERA* ON COTTON

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ABSTRACT

The resistance to five insecticides *viz.*, endosulfan, quinalphos, methomyl, spinoad and cypermethrin was monitored in *H. armigera*. The field population of *H. armigera* from various locations of five districts *viz.*, Sirsa, Hisar, Fatehabad, Jind and Bhiwani of Haryana state developed 1.080- to 130.978- fold mean resistance against different insecticides. However, the population of Hisar was found highly resistant to all the insecticides tested except endosulfan, quinalphos and spinosad. The highest mean resistance against cypermethrin (130.978- folds) was observed in Fatehabad population. The populations collected from Jind and Bhiwani areas were comparatively susceptible to all the insecticides except cypermethrin. However, population of Hisar and Sirsa were comparatively more susceptible to cypermethrin. Bhiwani population showed low level of resistance (1.080- to 26.916- folds) to most of the insecticides under test except cypermethrin.

Key words: Insecticide resistance, *Helicoverpa armigera*, cotton.

Resistance to conventional insecticides is recognized as one of the most important challenges facing the future of agriculture. *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) has assumed the status of national pest in India due to detection of very high degree of resistance to a range of insecticides including synthethc pyrethroids, organophosphates, endosulfan and carbamates commonly used by farmers in India (Gowda, 1996 and Rajashekar *et al.*, 1996). This pest has developed resistance to all the major insecticide classes and it has become increasingly difficult to control its population not only in India (Armes *et al.*, 1992 and Dhingra *et al.*, 1988), but also in Thailand (Ahmad *et al.*, 1989). The resistance to insecticide in *H. armigera* is widely recognized and documented for the different cotton growing areas of India and other leading cotton growing countries of the world. Kranthi (2005) reported low to moderate level of resistance in Maharashtra, moderate to high in Tamil Nadu, U.P., Gujarat and Punjab and high in Andhra Pradesh and Madhya Pradesh. The present research is aimed at monitoring resistance to certain commonly used insecticides in *H. armigera* population.

MATERIALS AND METHODS

The experiment was conducted at Insecticide Resistance Management Laboratory of Central Institute for Cotton Research, Regional Station-Sirsa (Haryana) during 2005-06 and 2006-07. Five serial dilutions of endosulfan, cypermethrin, quinalphos, methomyl and spinosad were prepared from stock solutions of 10.0, 0.1, 0.75, 0.1 and 1.0 ug/ul. Technical formulations of different insecticides of known purity were used in the preparation of solutions. Acetone was used as a solvent for the preparation of different concentrations.

Larvae collected from selected locations in five districts namely Sirsa, Hisar, Fatehabad, Jind and Bhiwani of Haryana state were reared in laboratory on artificial diet. The third instar larvae weighing 30-40 mg each were used for testing of different doses. Fifteen to forty five larvae were used per concentration according to availability. The insecticides were used for bioassay using probit analysis (Finney, 1971). Technical grade insecticides i.e., cypermethrin, endosulfan, quinalphos, methomyl and spinosad were dissolved in acetone to obtain different concentrations of the insecticides, respectively. Hamilton micro-applicator was used to apply one ml of insecticide solution to dorsal meso-thorax of third instar larvae on the dorsum of meso-thorax. In control treatment one ml of acetone was used. It was ensured that acetone did not drip to the lateral sides of the larvae. Once all the larvae in the tray were treated, the lid was closed and labelled. The tubes were transferred to bioassay chambers or to BOD incubators at 25±2°C, 75±5% RH. The artificial diet was changed after three days.

The resistance profile of these resistant populations was also worked out to endosulfan, cypermethrin, quinalphos, methomyl and spinosad by using discriminating dosages *i.e.*, 10.0, 0.1, 0.75, 0.1 and 1.0 ug/

ul, respectively. Mortality assessments were made according to Armes *et al.* (1996) based on the number of moribund and dead larvae. Mortality of *H. armigera* in different treatments was recorded upto 72 hrs after the application. Data were subjected to log probit technique (Finney, 1971) using the computer program PC-POLO software Resistant Index (Busvine, 1971) was computed using the following formula (FAO, 1979):

$$\text{Resistant Index} = \frac{LD_{50} \text{ of resistant strain}}{LD_{50} \text{ of susceptible strain}}$$

For the purpose of computing resistance index, the values of susceptible strains of different tested insecticides as given by CICR, Nagpur were used in present studies (Kranthi, 2005).

RESULTS AND DISCUSSION

The studies on determination of resistance to insecticides in *H. armigera* populations collected from various locations of Haryana state revealed that different populations developed resistance to the insecticides under test. The mean resistances at different locations were recorded 10.80- folds (Spinosad) to 130.978- folds (Cypermethrin), when compared with the LD_{50} of most susceptible population. Among the different populations, Hisar district population showed the highest level of resistance against all the insecticides except spinosad. Fatehabad, Hisar and Sirsa population showed maximum mean resistance to cypermethrin 130.978-, 126.495- and 77.496-folds, respectively. Hisar and Fatehabad population was susceptible to all the insecticides except spinosad but Sirsa population susceptible to cypermethrin and endosulfan.

It has been observed that Jind and Bhiwani populations showed low level of resistance to most of the insecticides under test except cypermethrin. The remaining populations also showed low level of resistance to the insecticides except cypermethrin in Fatehabad, Hisar, Sirsa and methomyl in Fatehabad and Hisar, respectively. However, Sirsa and Hisar populations exhibited 77.496-folds (cypermethrin), 7.285-folds (endosulfan) and 126.495-folds (cypermethrin) and 18.345-folds (methomyl) resistance, respectively. Similarly, 32.33-, 3.400- and 2.290-folds resistance to cypermethrin, quinalphos and endosulfan and 26.91-, 3.83- and 2.40-folds resistance to cypermethrin, endosulfan and quinalphos were recorded in the populations of Jind and Bhiwani, respectively. The data on dosage-mortality response of third instar larvae of different populations collected from five areas revealed that the χ^2 values indicated a good fit of probit response in all bioassays. This showed that there was no heterogeneity between observed and expected responses.

In the present study, resistance level ranged from 2.290- to 7.47- folds to endosulfan. Kranthi (2005) reported low level of resistance in North India, but moderate in Central and South India. Resistance to endosulfan was low to moderate in *H. armigera*, but resistance to endosulfan was high *i.e.*, 36 to 91- folds in Meingeli strain, collected from Chattisgarh, India. Regupathy and Ayyasamy (2003) reported that the endosulfan resistance frequency ranged between 30.7 and 57.3 per cent. Sekhar *et al.* (1996) reported resistance to endosulfan as 46 per cent during 1994-95. Ahmad *et al.* (1995) observed moderate level of resistance to endosulfan. Ahmad *et al.* (1988) reported that the Thailand strain showed two fold resistance to endosulfan. Mc Caffery *et al.* (1989) observed that *H. armigera* collected in October 1987 from Coastal cotton growing districts in Andhra Pradesh were moderately resistant to endosulfan. According to Armes *et al.* (1992) very low level of resistance *i.e.*, 7-folds was reported from India. Kranthi *et al.* (2001) showed resistance to endosulfan generally low across India by using discriminating dosages. Armes *et al.* (1996) reported two fold of resistance during 1991-95. In the present study, low level of resistance to endosulfan was observed due to

Table. Source and purity of different insecticides

S. No.	Common Name	Trade Name	Formulation	Per cent purity	Manufacturer agencies
1.	Endosulfan	Endocel	35 EC	98.75	Excel Crop Care Ltd. (Mumbai)
2.	Cypermethrin	Cyperguard	25 EC	94.00	Gharda Chemicals Ltd. (Mumbai)
3.	Quinalphos	Ekalux	25 EC	71.50	Gharda Chemicals Ltd. (Mumbai)
4.	Methomyl	Dunnate	40 SP	82.00	Dhanuka Pesticides Ltd. (New Delhi)
5.	Spinosad	Tracer	78.2 SL	98.00	De-Nocil Ltd. (Mumbai)

Table 1. Toxicity of different insecticides to field population of *H. armigera* (Fatehabad) during 2005-06 and 2006-07 (pooled mean)

S. No.	Insecticides	LD_{50}* (LD_{50})	Fiducial Limit (95%)	Resistance Index	χ^2 (Chisquare)
1.	Endosulphan	0.160 (0.031)	0.098-0.226	5.175	4.067
2.	Cypermethrin	0.916 (0.007)	0.396-1.963	130.978	4.145
3.	Quinalphos	0.081 (0.010)	0.092-0.164	5.600	5.764
4.	Methomyl	1.845 (0.010)	1.200-3.64	14.192	1.075
5.	Spinosad	0.069 (0.062)	0.016-0.177	1.112	11.717

*Susceptible strains figure in parenthesis.

Table 2. Toxicity of different insecticides to field population of *H. armigera* (Sirsa) during 2005-06 and 2006-07 (pooled mean)

S. No.	Insecticides	LD_{50}* (LD_{50})	Fiducial Limit (95%)	Resistance Index	χ^2 (Chisquare)
1.	Endosulphan	0.226 (0.031)	0.147-0.310	7.285	9.843
2.	Cypermethrin	0.542 (0.007)	0.183-1.325	77.796	6.562
3.	Quinalphos	0.049 (0.010)	0.020-0.115	4.950	4.403
4.	Methomyl	0.530 (0.130)	0.290-1.025	4.075	6.412
5.	Spinosad	0.085 (0.062)	0.011-0.203	1.370	9.913

*Susceptible strains figure in parenthesis.

Table 3. Toxicity of different insecticides to field population of *H. armigera* (Hisar) during 2005-06 and 2006-07 (pooled mean)

S. No.	Insecticides	LD_{50}* (LD_{50})	Fiducial Limit (95%)	Resistance Index	χ^2 (Chisquare)
1.	Endosulphan	0.232 (0.031)	0.201-0.310	7.47	5.409
2.	Cypermethrin	0.885 (0.007)	0.472-1.673	126.495	13.902
3.	Quinalphos	0.059 (0.010)	0.022-0.146	5.900	4.507
4.	Methomyl	2.38 (0.130)	0.940-4.840	18.345	1.735
5.	Spinosad	0.08 (0.062)	0.030-0.153	1.290	21.303

*Susceptible strains figure in parenthesis.

Table 4. Toxicity of different insecticides to field population of *H. armigera* (Bhiwani) during 2005-06 and 2006-07 (pooled mean)

S. No.	Insecticides	LD_{50}* (LD_{50})	Fiducial Limit (95%)	Resistance Index	χ^2 (Chisquare)
1.	Endosulphan	0.160 (0.031)	0.098-0.226	5.175	4.067
2.	Cypermethrin	0.916 (0.007)	0.396-1.963	130.978	4.145
3.	Quinalphos	0.081 (0.010)	0.092-0.164	5.600	5.764
4.	Methomyl	1.845 (0.010)	1.200-3.64	14.192	1.075
5.	Spinosad	0.069 (0.062)	0.016-0.177	1.112	11.717

*Susceptible strains figure in parenthesis.

Table 5. Toxicity of different insecticides to field population of *H. armigera* (Jind) during 2005-06 and 2006-07 (pooled mean)

S. No.	Insecticides	LD_{50}* (LD_{50})	Fiducial Limit (95%)	Resistance Index	χ^2 (Chisquare)
1.	Endosulphan	0.071 (0.031)	0.0190-0.134	2.290	9.727
2.	Cypermethrin	0.205 (0.007)	0.086-0.402	32.33	3.222
3.	Quinalphos	0.034 (0.010)	0.005-0.113	3.400	7.965
4.	Methomyl	0.225 (0.130)	0.145-0.340	1.730	7.100
5.	Spinosad	0.071 (0.062)	0.009-0.164	1.153	9.651

*Susceptible strains figure in parenthesis.

Table 6. Comparative resistance of *H. armegera* of different districts to insecticides during 2005-06 and 2006-07 (Pooled mean)

Insecticides	Resistance index				
	Fatehabad	Sirsa	Hisar	Jind	Bhiwani
Endosulplan	5.175	7.285	7.47	2.290	3.838
Cypermethrin	130.978	77.496	126.495	32.330	26.916
Quinalphos	5.600	4.950	5.900	3.400	2.400
Methomyl	14.192	4.075	18.345	1.730	1.276
Spinosad	1.112	1.370	1.290	1.153	1.080

selection pressure of this insecticide being low (Dhawan, 2005).

Similarly, low level 2.40- to 5.90-fold of resistance was observed to quinalphos. Kranthi (2005) also observed low level of resistance in North and Central India, but moderate level in South India. Regupathy and Ayyasamy (2003) reported that quinalphos resistance frequency ranged between 27.8 and 45.4 per cent. In present studies, resistance to quinalphos was low as the insecticide was used mostly in early season.

The studies carried out presently showed high level of resistance to cypermethrin. Mc Caffery *et al.* (1991) reported that *H. armigera* collected from cotton growing areas of South Sulawesi, Indonesia in 1987 and 1988 were resistant to cypermethrin. Mc Caffery *et al.* (1989) observed that *H. armigera* collected in October 1987 from coastal cotton growing districts in Andhra Pradesh was highly resistant to cypermethrin. Ahmad *et al.* (1997) reported higher level of resistance against cypermethrin and cyfluthrin. According to Kranthi *et al.* (2001), higher level of resistance was observed against synthetic pyrethroids in those regions where pyrethroid use was most frequent *i.e.*, 4-8 applications per season. According to Ahmad *et al.* (1997), high level of resistance to cypermethrin and fenvalerate was observed that led to the development of insecticide resistance by creating the selection pressure for resistant genotype.

According to Armes *et al.* (1992) high level of resistance to cypermethrin was recorded in strains collected from cotton growing areas of Guntur and Coimbatore, during 1989. Kranthi *et al.* (1997) observed high resistance frequencies to cypermethrin and fenvalerate in population collected from Central India during 1993-94, 1994-95 and 1995-96 cropping seasons. According to Kranthi *et al.* (2001), pyrethroid resistance was 54-folds in *H. armigera* during 1995 and 1999. Kapoor *et al.* (2000) reported that the resistance to cypermethrin ranged from 3 to 5-folds as compared to susceptible strain. In Coimbatore, resistance to cypermethrin was found to be 25 to 140-folds during 1992-93 (Armes *et al.*, 1996). Seasonal increase in LD_{50} of cypermethrin during 1991-94 was noticed by Armes *et al.* (1996) in the population collected from different regions of Indian subcontinents. Regupathy and Ayyasamy (2003) reported that the level of resistance increased from 76.5 to 84.2 per cent to cypermethrin (0.1ug) during 1995-2002. Sekhar *et al.* (1996) reported increased resistance to cypermethrin from 46.8 to 95.7 per cent during 1992-95. Martin *et al.* (2003) observed 14-folds resistance in West Africa during 2003. Kranthi (2005) reported high level of resistance to cypermethrin throughout India. In Haryana, one of the reason for high resistance was indiscriminate use of synthetic pyrethroids particularly, cypermethrin for the management of cotton bollworms. In most of the sprays, farmers used synthetic pyrethroids alone or in combinations. In present studies, low level of resistance was observed to spinosad that ranged from 1.08- to 1.37-folds. Kranthi (2005) reported very low level of resistance to spinosad and methomyl throughout India. One of the reasons for its limited use is the high cost of insecticides and farmers use these molecules only when required. In present studies, resistance to methomyl ranged from 1.27- to 18.34- folds. Similar reports were made by Choudhary *et al.* (2004) and Armes *et al.* (1996) who reported resistance levels of 2- to 38- folds to methomyl in different parts of India with highest at 162-folds in Guntur (Andhra Pradesh).

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