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Pankaj B Salunke

Ph.D. Student, Department of
Agricultural Entomology,
Maharashtra, India

SS Lande

Associate Professor, Department
of Entomology, COA, Amravati,
Maharashtra, India

Dr. GK Lande

Assistant Professor, Department
of Agricultural Entomology,
Maharashtra, India

AK Sadawarte

Associate Professor, Department
of Entomology, Dr. PDKV
Akola, Maharashtra, India

Evaluation of insecticide resistance to *Helicoverpa armigera* in pigeonpea growing area of Vidarbha

Pankaj B Salunke, SS Lande, Dr. GK Lande and AK Sadawarte

Abstract

Present investigation was carried out at Toxicology laboratory, Department of Entomology, Dr. PDKV, Akola with a view to evaluate level of insecticide resistance in pigeonpea pod borer, *Helicoverpa armigera* (Hubner) to commonly used insecticides collected from major pigeonpea growing districts of Vidarbha viz., Akola, Amaravati, Buldhana, Yavatmal and Washim. Log Dose Probit indicates LC₅₀ value of Cypermethrin in the range of 0.074 to 0.461 per cent with maximum in Yavatmal (0.461 per cent); LC₉₀ value within range of 0.190 to 1.840 per cent. LC₅₀ value of Quinalphos in the range of 0.018 to 0.071 per cent with maximum in Yavatmal (0.071 per cent); LC₉₀ value within range of 0.058 to 0.128 per cent. LC₅₀ value of Methomyl in the range of 0.026 to 0.083 per cent with maximum in Amaravati (0.083 per cent); LC₉₀ value within range of 0.071 to 0.130 per cent. LC₅₀ value of Indoxacarb in the range of 0.389 to 4.785 per cent with maximum in Yavatmal (4.785 per cent); LC₉₀ value within range of 6.631 to 51.548 per cent. LC₅₀ value of Spinosad in the range of 0.028 to 0.067 per cent with maximum in Amaravati (0.067 per cent); LC₉₀ value within range of 0.058 to 0.123 per cent. From present findings, it could be concluded that resistance level is visible with high in Indoxacarb, moderate to Cypermethrin, quinalphos, methomyl and low to spinosad; Yavatmal and Washim strain showed higher resistance level to cypermethrin, quinalphos and indoxacarb; Amaravati and Yavatmal strain showed higher resistance level to methomyl and spinosad.

Keywords: Cypermethrin, indoxacarb, methomyl, quinalphos, spinosad

1. Introduction

Helicoverpa armigera (Hubner) is the most dreaded species commonly known as cotton bollworm, pigeonpea pod borer, American bollworm. It is a polyphagous pest of worldwide occurrence inflicting annual crop damage worth US \$1 billion in India (Upendhar *et al.*, 2011)^[19]. In India this insect has been recorded on more than 200 hosts (Pawar, 1998)^[14].

About 250 species of insects belonging to 8 orders and 61 families have been found to attack on pigeonpea of this only few are economically important as pests. Among these gram pod borer, *Helicoverpa armigera* (Hubner), tur plume moth, *Exelastis atomosa* (Walsh) and tur pod fly, *Melanagromyza obtusa* (Mall) are important pod feeders of pigeonpea (Durairaj, 1999)^[6] causing considerable losses in grain yield ranging from 3-100 per cent. The losses due to *H. armigera* alone contribute upto 50 per cent (Thakre, 2001)^[18].

The management of *Helicoverpa* has become increasingly difficult due to indiscriminate and extensive use of chemical insecticides in past few decades which has led to development of resistance to insecticides (Armes *et al.*, 1996; Kranthi, 1997; Ramasubramaniam and Regupathy 2004)^[3, 9, 15]. Insecticide resistance in *H. armigera* in India was first recorded in 1987 when widespread field control failure were reported by farmers growing cotton and pulse crop in Andhra Pradesh (McCaffery *et al.*, 1989)^[12]. Resistance monitoring is an indispensable prerequisite in designing any IPM programme. Thus, an assessment of resistance profile and mechanism of resistance would be key for the management *H. armigera*. The present investigation was carried out to evaluate the level of resistance to commonly used insecticides in *H. armigera* collected from different locations of Vidarbha that will help to track the level of resistance to different groups of insecticides.

2. Materials and Methods

Test Insect: *H. armigera* Hub. (Lepidoptera: Noctuidae) larvae were collected from different fields of pigeonpea during 2013-14 from five major pigeonpea growing districts of Vidarbha. (Amravati, Yavatmal, Buldhana, Akola, Washim and Dr. PDKV).

Corresponding Author:

Pankaj B Salunke

Ph.D. Student, Department of
Agricultural Entomology,
Maharashtra, India

Field collected populations were reared on semi synthetic diet using standard rearing technique (Armes *et al.*, 1992) ^[2] in laboratory. Eggs collected from mating chamber were allowed to hatch and third instar larvae of F₁ generation of these field collected culture were used to evaluate the level of resistance of *H. armigera* to commonly used insecticides.

Insecticide

To evaluate level of insecticide resistance in pigeonpea pod borer, *Helicoverpa armigera* (Hubner) we are using five insecticides from different group. The insecticide used in present study were, Cypermethrin 10 EC (Cymbush), Quinalphos 25 EC (Eukalyx), Methomyl 40 SP (Lannate), Indoxacarb 15.8 EC (Avaunt) and Spinosad 45 SC (Spinctor).

Bioassay

The bioassays were conducted by surface coating method for formulated insecticides to evaluate the toxicity of test insecticides (Kranthi *et al.*, 2002) ^[10].

Analysis method

Probit analysis was conducted by using SPSS software available with Department of Entomology, Dr. PDKV, Akola.

3. Results and Discussion

Table 1: Toxicity and level of Cypermethrin resistance to *H. armigera* (Hubner)

Strain	LC ₅₀ (95% FL)	LC ₉₀ (95% FL)	Slope (±SE)	Chi square	RR over	
					FS	LS
Akola	0.297 (0.236 - 0.519)	0.853 (0.499 - 6.739)	2.796±0.82	1.063	1.36	4.01
Amaravati	0.319 (0.256 - 0.848)	0.700 (0.436 - 40.55)	3.758±1.53	1.007	1.46	4.31
Buldhana	0.246 (0.198 - 0.320)	0.567 (0.397 - 1.824)	3.536±1.01	1.279	1.12	3.32
Washim	0.439 (0.310 - 0.834)	1.840 (0.918 - 37.97)	2.059±0.67	2.255	2.01	5.93
Yavatmal	0.461 (0.350 - 0.835)	1.270 (0.751 - 26.97)	2.916±1.07	1.440	2.11	6.22
Dr. PDKV (Field)	0.218 (0.187 - 0.304)	0.543 (0.373 - 2.143)	3.624±1.09	1.294		
Lab Susceptible	0.074 (0.028 - 0.102)	0.190 (0.154 - 0.277)	3.131±0.87	0.714		

Yavatmal strain showed resistance ratio of 6.22 and 2.11 as compare to laboratory strain and Dr. PDKV strain, followed by Washim with 5.93 and 2.01, Amaravati with 4.31 and 1.46, Akola with 4.01 and 1.36, Buldhana with 3.32 and 1.12 respectively. The order of toxicity of Cypermethrin to *Helicoverpa armigera* (Hubner) collected from different locations of Vidarbha during 2012-13 was Yavatmal > Washim > Amravati > Akola > Buldhana > Dr. PDKV.

Toxicity and level of resistance of Quinalphos to *H. armigera* (Hubner)

The LDP assays of Quinalphos have indicated significant levels of resistance in the field collected populations especially from Yavatmal and Washim. The LC₅₀ values of

Log dose probit assays were carried to determine the median lethal concentration and level of resistance of different insecticides in *Helicoverpa armigera* (Hubner) strains collected from the different locations of Vidarbha, M.S., India.

Toxicity and level of resistance of Cypermethrin to *H. armigera* (Hubner)

The LDP assays of Cypermethrin have indicated significant levels of resistance in the field collected populations especially from Yavatmal and Washim. The LC₅₀ values of Cypermethrin ranged from 0.074 to 0.461 per cent (table 1). In Yavatmal population, level of resistance was high over all other strains observed. The LC₅₀ of Yavatmal strain was 0.461 per cent, while its LC₉₀ was 1.270 per cent. It was followed by Washim with LC₅₀ value 0.439, Amaravati with LC₅₀ value 0.319, Akola with LC₅₀ value 0.297 and Buldhana with 0.246 respectively. The laboratory strain was found most susceptible during 2012-13 amongst the strain tested. LC₅₀ for laboratory strain was 0.074 per cent where as LC₉₀ was 0.190 per cent. The fiducial limits at 95 percent of LC₅₀ were between 0.028 and 0.102 per cent. The Dr. PDKV strain was followed by laboratory strain having 0.218 per cent LC₅₀ value and LC₉₀ was 0.543 per cent.

Quinalphos ranged from 0.018 to 0.071 per cent (table 2). In Yavatmal population, level of resistance was high over all other strains observed. The LC₅₀ of Yavatmal strain was 0.071 per cent, while its LC₉₀ was 0.127 per cent. It was followed by Washim with LC₅₀ value 0.069, Amaravati with LC₅₀ value 0.065, Buldhana with LC₅₀ 0.063 and Akola with LC₅₀ 0.062, respectively. The laboratory strain was found most susceptible during 2012-13 amongst the strain tested. LC₅₀ for laboratory strain was 0.018 per cent whereas, LC₉₀ was 0.038 per cent. The fiducial limits at 95 percent of LC₅₀ were between 0.011 and 0.027 per cent. The Dr. PDKV strain was followed by laboratory strain having LC₅₀ value 0.058 per cent and LC₉₀ was 0.079 per cent.

Table 2: Toxicity and level of Quinalphos resistance to *H. armigera* (Hubner)

Strain	LC ₅₀ (95% FL)	LC ₉₀ (95% FL)	Slope (±SE)	Chi square	RR over	
					FS	LS
Akola	0.062 (0.059 - 0.067)	0.085 (0.077 - 0.108)	7.506±1.98	2.847	1.06	3.45
Amaravati	0.065 (0.061 - 0.071)	0.090 (0.079 - 0.122)	7.050±2.04	1.168	1.12	3.62
Buldhana	0.063 (0.058 - 0.068)	0.086 (0.077 - 0.114)	7.353±2.16	1.070	1.08	3.50
Washim	0.069 (0.059 - 0.080)	0.128 (0.102 - 0.229)	4.780±1.15	1.086	1.18	3.84
Yavatmal	0.071 (0.061 - 0.082)	0.127 (0.102 - 0.227)	5.066±1.25	0.638	1.22	3.95
DrPDKV (Field)	0.058 (0.053 - 0.064)	0.079 (0.071 - 0.107)	4.323±1.64	1.121		
Lab Susceptible	0.018 (0.011 - 0.027)	0.058 (0.054 - 0.067)	7.91±2.19	0.286		

Yavatmal strain showed resistance ratio of 3.95 and 1.22 as compare to laboratory and Dr. PDKV strain, followed by Washim with 3.84 and 1.18, Amaravati with 3.62 and 1.12, Buldhana with 3.50 and 1.08, Akola with 3.45 and 1.06, respectively. The order of toxicity of Cypermethrin to *Helicoverpa armigera* (Hubner) collected from different locations of Vidarbha during 2012-13 was Yavatmal > Washim > Amravati > Buldhana > Akola > Dr. PDKV.

Toxicity and level of resistance of Methomyl to *H. armigera* (Hubner)

The LDP assays of Methomyl have indicated significant level of resistance in the field collected population especially from

Amaravati. The LC₅₀ values of Methomyl ranged from 0.026 to 0.083 per cent (table 3). In Amaravati population, level of resistance was high over all other strains observed. The LC₅₀ of Amaravati strain was 0.083 per cent, while its LC₉₀ was 0.130 per cent. It was followed by Yavatmal with LC₅₀ value 0.080, Akola with LC₅₀ value 0.079, Buldhana and Washim with LC₅₀ value 0.078, respectively. The laboratory strain was found most susceptible during 2012-13 amongst the strain tested. LC₅₀ for laboratory strain was 0.026 per cent whereas, LC₉₀ was 0.071 per cent. The fiducial limits at 95 percent of LC₅₀ were between 0.018 and 0.037 per cent. The Dr. PDKV strain was followed by laboratory strain having LC₅₀ value 0.068 per cent and LC₉₀ was 0.107 per cent.

Table 3: Toxicity and level of Methomyl resistance to *H. armigera* (Hubner)

Strain	LC ₅₀ (95% FL)	LC ₉₀ (95% FL)	Slope (\pm SE)	Chi square	RR over	
					FS	LS
Akola	0.079 (0.070 - 0.086)	0.113 (0.100 - 0.150)	8.138 \pm 1.88	0.137	1.16	3.03
Amaravati	0.083 (0.074 - 0.093)	0.130 (0.109 - 0.213)	6.442 \pm 1.64	0.493	1.22	3.19
Buldhana	0.078 (0.071 - 0.084)	0.111 (0.099 - 0.140)	8.418 \pm 1.76	0.205	1.14	3.0
Washim	0.078 (0.070 - 0.086)	0.122 (0.105 - 0.180)	6.686 \pm 1.60	0.136	1.14	3.0
Yavatmal	0.080 (0.071 - 0.088)	0.122 (0.104 - 0.182)	7.011 \pm 1.77	0.158	1.17	3.07
DrPDKV (Field)	0.068 (0.059 - 0.077)	0.107 (0.097 - 0.140)	8.183 \pm 1.93	0.108		
Lab Susceptible	0.026 (0.018 - 0.037)	0.071 (0.065 - 0.081)	8.38 \pm 2.38	0.701		

Amaravati strain showed resistance ratio of 3.19 and 1.22 as compare to laboratory and DrPDKV strain followed by Yavatmal with 3.07 and 1.17, Akola with 3.03 and 1.16, Buldhana and washim was similar with 3.0 and 1.14, respectively. The order of toxicity of Methomyl to *Helicoverpa armigera* (Hubner) collected from different locations of Vidarbha during 2012-13 was Amravati > Yavatmal > Akola > Buldhana > Washim > Dr. PDKV.

Toxicity and level of resistance of Indoxacarb to *H. armigera* (Hubner)

The LDP assays of Indoxacarb have indicated significant levels of resistance in the field collected populations especially from Yavatmal and Washim. The LC₅₀ values of

Indoxacarb ranged from 0.389 to 4.785 per cent (table 4). In Yavatmal population, level of resistance was high over all other strains observed. The LC₅₀ of Yavatmal strain was 4.785 per cent, while its LC₉₀ was 14.995 per cent. It was followed by Washim with LC₅₀ value 4.592, Akola with LC₅₀ value 3.012, Amaravati with LC₅₀ value 2.399 and Buldhana with LC₅₀ value 1.743, respectively. The laboratory strain was found most susceptible during 2012-13 amongst the strain tested. LC₅₀ for laboratory strain was 0.389 per cent whereas, LC₉₀ was 6.631 per cent. The fiducial limits at 95 percent of LC₅₀ were between 0.151 and 0.663 per cent. The DrPDKV strain was followed by laboratory strain having LC₅₀ value 1.423 per cent and LC₉₀ was 18.32 per cent.

Table 4: Toxicity and level of Indoxacarb resistance to *H. armigera* (Hubner)

Strain	LC ₅₀ (95% FL)	LC ₉₀ (95% FL)	Slope (\pm SE)	Chi square	RR over	
					FS	LS
Akola	3.012 (1.973 - 19.40)	18.36 (6.316 - 17918)	1.632 \pm 0.61	3.583	2.11	7.74
Amaravati	2.399 (1.439 - 7.155)	32.461 (9.432 - 2691)	1.132 \pm 0.33	1.580	1.68	6.16
Buldhana	1.743 (0.877 - 5.023)	38.08 (9.494 - 9373.1)	0.956 \pm 0.30	3.265	1.22	4.48
Washim	4.592 (2.676 - 12.15)	51.548 (16.41 - 9289.9)	1.220 \pm 0.40	2.163	3.22	11.8
Yavatmal	4.785 (3.576 - 8.671)	14.995 (8.422 - 282.4)	2.583 \pm 0.90	1.850	3.36	12.3
DrPDKV (Field)	1.423 (0.537 - 4.527)	18.323 (6.44 - 2378.7)	1.353 \pm 0.45	1.102		
Lab Susceptible	0.389 (0.151 - 0.663)	6.631 (3.069 - 40.75)	1.04 \pm 0.24	3.028		

Yavatmal strain showed resistance ratio of 12.3 and 3.36 as compare to laboratory and DrPDKV strain, followed by Washim with 11.8 and 3.22, Akola with 7.74 and 2.11, Amaravati with 6.16 and 1.68, Buldhana with 4.48 and 1.22, respectively. The order of toxicity of Indoxacarb to *Helicoverpa armigera* (Hubner) collected from different locations of Vidarbha during 2012-13 was Yavatmal > Washim > Akola > Amravati > Buldhana > DrPDKV.

Toxicity and level of resistance of Spinosad to *H. armigera* (Hubner)

The LDP assays of Spinosad have indicated significant levels of resistance in the field collected populations especially from

Amaravati and Yavatmal. The LC₅₀ values of Spinosad ranged from 0.028 to 0.067 per cent (table 5). In Amaravati population, level of resistance was high over all other strains observed. The LC₅₀ of Amaravati strain was 0.067 per cent, while its LC₉₀ was 0.123 per cent. It was followed by Yavatmal with LC₅₀ value 0.062, Washim with LC₅₀ value 0.061, Buldhana with LC₅₀ value 0.060 and Akola with LC₅₀ value 0.058, respectively. The laboratory strain was found most susceptible during 2012-13 amongst the strain tested. LC₅₀ for laboratory strain was 0.028 per cent whereas, LC₉₀ was 0.058 per cent. The fiducial limits at 95 percent of LC₅₀ were between 0.014 and 0.038 per cent. The DrPDKV strain was followed by laboratory strain having LC₅₀ value 0.054

per cent and LC₉₀ was 0.079 per cent.

Amaravati strain showed resistance ratio of 2.39 and 1.24 as compare to laboratory and Dr. PDKV strain, followed by Yavatmal with 2.21 and 1.14, Washim with 2.18 and 1.12, Buldhana with 2.14 and 1.11, Akola with 2.07 and 1.07,

respectively. The order of toxicity of Spinosad to *Helicoverpa armigera* (Hubner) collected from different locations of Vidarbha during 2012-13 was Amravati > Yavatmal > Washim > Buldhana > Akola > Dr. PDKV.

Table 5: Toxicity and level of Spinosad resistance to *H. armigera* (Hubner)

Strain	LC ₅₀ (95% FL)	LC ₉₀ (95% FL)	Slope (±SE)	Chi square	RR over	
					FS	LS
Akola	0.058 (0.049 - 0.065)	0.096 (0.082 - 0.142)	5.784±1.34	0.173	1.07	2.07
Amaravati	0.067 (0.058 - 0.080)	0.123 (0.096 - 0.257)	4.870±1.30	0.091	1.24	2.39
Buldhana	0.060 (0.051 - 0.070)	0.109 (0.088 - 0.199)	4.993±1.30	0.199	1.11	2.14
Washim	0.061 (0.053 - 0.068)	0.100 (0.085 - 0.147)	5.930±1.33	0.409	1.12	2.18
Yavatmal	0.062 (0.055 - 0.069)	0.096 (0.083 - 0.132)	6.853±1.52	0.916	1.14	2.21
DrPDKV (Field)	0.054 (0.053 - 0.064)	0.079 (0.071 - 0.107)	4.323±1.64	1.121		
Lab Susceptible	0.028 (0.014 - 0.038)	0.058 (0.049 - 0.074)	4.452±1.27	0.866		

Log Dose Probit indicates LC₅₀ value of Cypermethrin in the range of 0.074 to 0.461 per cent with maximum in Yavatmal (0.461 per cent); LC₉₀ value within range of 0.190 to 1.840 per cent. LC₅₀ value of Quinalphos in the range of 0.018 to 0.071 per cent with maximum in Yavatmal (0.071 per cent); LC₉₀ value within range of 0.058 to 0.128 per cent. LC₅₀ value of Methomyl in the range of 0.026 to 0.083 per cent with maximum in Amaravati (0.083 per cent); LC₉₀ value within range of 0.071 to 0.130 per cent. LC₅₀ value of Indoxacarb in the range of 0.389 to 4.785 per cent with maximum in Yavatmal (4.785 per cent); LC₉₀ value within range of 6.631 to 51.548 per cent. LC₅₀ value of Spinosad in the range of 0.028 to 0.067 per cent with maximum in Amaravati (0.067 per cent); LC₉₀ value within range of 0.058 to 0.123 per cent.

The pesticides continue to play a pivotal role in pest control because of which the situation is accentuated by rapid rise in resistance toward insecticides. Several new insecticide molecules are being introduced in the market for controlling pests. In the present investigation efforts were made to monitor levels of insecticide resistance in *Helicoverpa armigera* (Hubner) collected from various locations of Vidarbha, M.S., India.

These findings are in same line with results reported by previous workers presented as follows, Arora and Yaqoob (2003) [4] conducted laboratory bioassay on *Helicoverpa armigera* field collected and susceptible strain and reported insecticides resistance factor of 2.88 was for carbaryl and 2.48 for cypermethrin. Kathuria *et al.*, (2004) [8] tested insecticides and their concentrations against *H. armigera* Sirsa population had developed 3.8, 2.5 fold resistance to cypermethrin and quinalphos respectively, when compared with Bhiwani population; and 1.4 and 2.3 fold resistance, respectively to the above insecticides in relation to Hisar population. Hisar population exhibited 2.8 and 1.6 fold resistance to cypermethrin and quinalphos, respectively as compared to Bhiwani population.

Ramasubramanian and Regupathy (2004) [15] monitored *Helicoverpa armigera* population and showed that the population developed very high level of resistance to synthetic pyrethroids i.e. fenvalerate, cypermethrin and deltamethrin, medium level of resistance to quinalphos, low level of resistance to methomyl and cent per cent susceptibility to the new chemistry spinosad. Shrivastava *et al.*, (2008) [17] studied the levels of resistance developed in a field strain of *H. armigera* (Hubner) and reported wide spread resistance from 100 per cent in cypermethrin and fenvalerate at the Khandwa location to above 50 per cent at the

Chhindwara location. High resistance of 46 per cent to quinalphos was found in the field strains of Khandwa as compared to the Chhindwara strains (12.51%).

Deshmukh *et al.*, (2010) [5] determined the efficacy of different insecticides against *Helicoverpa armigera* (Hubner), revealed that flubendiamide 0.007 per cent, indoxacarb 0.0075 per cent and spinosad 0.009 per cent were found the most effective. Alvi *et al.*, (2012) [1] assessed whether *H. armigera* had developed resistance, resistance ratios (RR) for cypermethrin, spinosad and indoxacarb were 1950, 200 and 380-fold, respectively, compared with the laboratory susceptible (Lab-PK) population. The selection also increased RR for cypermethrin, spinosad, indoxacarb to 9830, 370, 3090-fold.

Conclusion

The present investigation on the status of insecticide resistance in *H. armigera* to commonly used insecticides of different group viz., Synthetic pyrethroid, organophosphorous, carbamate, oxydiazine & macrocyclic lactones and with different mode of action in major pigeonpea growing districts of Vidarbha, Maharashtra, indicated that the resistance level is visible with high in Indoxacarb, moderate to Cypermethrin, quinalphos, methomyl and low to spinosad. In present investigation Yavatmal and Washim strain showed higher resistance level to cypermethrin, quinalphos and indoxacarb; Amaravati and Yavatmal strain showed higher resistance level to methomyl and spinosad. On the basis of present findings, it could be concluded that *H. armigera* population of Yavatmal was found most resistant whereas, Dr. PDKV population was found susceptible from all the populations. Evaluation of insecticide resistance in *H. armigera* revealed highest resistance to Indoxacarb followed by Cypermethrin, Quinalphos, Methomyl and lowest to Spinosad.

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