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INSECTICIDAL RESISTANCE IN *HELICOVERPA ARMIGERA* (HUBNER) INFESTING CHICKPEA

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ABSTRACT

A laboratory experiment was conducted at Post Graduate Laboratory, Department of Agricultural Entomology, College of Agriculture, Latur, Maharashtra, India during 2017-18. Resistance to five test insecticides viz., chlorantraniliprole, cyantraniliprole, emamectin benzoate, indoxacarb and spinosad was investigated against *H. armigera* infesting chickpea from different locations of Western Maharashtra (Ahmednagar, Kolhapur, Nashik, Pune, Sangali, Satara and Solapur). Results revealed that, *H. armigera* infesting chickpea of Solapur recorded 7.00-fold resistance to indoxacarb 15.8% EC which was higher than other field populations *H. armigera*. The resistance ratios varied greatly among the populations and high resistance factor of indoxacarb 15.8% EC against all field populations of *H. armigera* infesting chickpea from all 7 locations revealed that development of decreased susceptibility to low level resistance against this insecticide whereas chlorantraniliprole 18.5% SC, cyantraniliprole 10.26% OD, emamectin benzoate 5% SG and spinosad 45% SC found to be toxic.

Key words: *Helicoverpa armigera*, resistance, chickpea, indoxycarb, chlorantraniliprole, cyantraniliprole, emamectin benzoate, spinosad, Ahmednagar, Kolhapur, Nashik, Pune, Sangali, Satara, Solapur

Helicoverpa armigera (Hubner) is a prominent polyphagous pest damaging chickpea in many global agricultural systems. Almost 30% of all pesticides used worldwide are directed against *H. armigera* (Ahmad, 2007). The unrestrained usage of a limited group of insecticides against successive pest generations of *H. armigera* imposed severe selection pressure ensuing in resistance and leading to field control failures. *H. armigera* is the noctuid species reported enormous cases of insecticide resistance worldwide with evolved resistance against organochlorines, organophosphates, carbamates, pyrethroids (Kranthi et al., 2002 and www.pesticideresistance.org), spinosad (Aheer et al., 2009), emamectin benzoate, indoxacarb (Qayyum et al., 2015) and *Bacillus thuringiensis*-derived toxins (Zhang et al., 2011). The field populations of *H. armigera* also indicated development of resistance to multiple insecticides (Faheem et al., 2013). Insecticide resistance in *H. armigera* is reported due to the combined effects of insensitivity of acetylcholine esterase to insecticides, expression of higher levels of esterases, phosphatases and a specific protein called p-glycoprotein ATPase (Srinivas et al., 2004). Hence the change in susceptibility in insect-pests to different insecticides is need to be detected from time to time which alert growers about changes in resistant populations, development of novel resistance and helping them in taking correct pest control decisions and improve the sustainable use of insecticides. Hence keeping this in view, the present investigation was planned to detect the levels of insecticidal resistance in the field populations of *H. armigera* infesting chickpea grown in different districts of Western Maharashtra region of Maharashtra during 2017-18.

MATERIALS AND METHODS

Large sized larvae of *H. armigera* were collected from chickpea fields grown in different districts of Western Maharashtra region of Maharashtra separately in clean plastic vials along with sufficient green pods to avoid starvation. Immediately these larvae were carried to the Post Graduate Laboratory, Dept. of Agril. Entomology, College of Agriculture, Latur for further culturing. The collected L1 larvae were individually reared on natural diet (green pods) till pupation in round plastic vials (measuring 4 cm dia and 5 cm height). The pupae were transferred to round clean plastic containers (measuring 16 cm diameter and 16 cm height) covering top with muslin cloth secured firmly with rubber band. The sexes were determined in pupal stages on the basis of distance between genital and anal apertures. It is less in the case of male and more in the case of female (Srivastava and Pande, 1966; Dani et al., 1980). The freshly emerged adults were released into standard oviposition cage (measuring 50 cm x 30 cm) covered

with black muslin cloth. The oviposition cage was placed over the water trough in order to create humidity. The proportion of female and male in the cage was 1:1 in order to get fertilized eggs. Cotton swab dipped into 10 per cent honey solution was provided to serve as food for the adults. A strip of cotton cloth toweling (6 x 17 cm) and/or chickpea pods were hung vertically inside each oviposition cage as oviposition substrate. The eggs laid on the toweling and/ or chickpea pods were kept in a transparent plastic box (26 cm x 17 cm x 6 cm). The eggs from each pair were kept separately. After hatching, neonate larvae were transferred separately into plastic vials to avoid cannibalism. Daily the larvae were fed on natural diet. The 2nd instar larvae of 'F1' generation were used for conducting the bioassay studies. The rearing of *H. armigera* population collected from different districts of Western Maharashtra region was carried out separately at ambient room temperature of 28 ± 3^0 C. The susceptible population of *H. armigera* was developed by rearing five generations of *H. armigera* without selection pressure of any insecticide under laboratory conditions (Tripathy and Singh, 2000).

The insecticides which are commonly used by farmers (viz., chlorantraniliprole, cyantraniliprole, emamectin benzoate, indoxacarb and spinosad) were selected for studying the levels of insecticide resistance in *H. armigera* infesting chickpea. All the insecticides were procured from market and dilutions required were prepared from the formulated product only with distilled water. In *H. armigera* bioassay, each insecticide was used in five concentrations (two lower than recommended, one recommended and two higher than recommended) rendering 20 to 80 per cent mortality in pilot tests. However, care was taken to retain the recommended dosage of each insecticide as one of the concentrations. Newly moulted 2nd instar larvae of *H. armigera* from F_1 laboratory culture were exposed to different insecticides using pod dip method (IRAC Method No. 7) recommended by Insecticide Resistance Action Committee with slight modification. Formulated insecticides were diluted using distilled water as a solvent. Sufficient number of non-infested, untreated and fresh pods was collected from unsprayed chickpea plots. Then these pods were dipped into the test solution for 60 seconds, dried on paper towel and transferred to lebelled clean plastic rearing vials. Two treated pods per treatment were maintained in each vial to avoid starvation stress during the test. One newly moulted 2nd instar F1 larva was placed on these dried pods and then the vial was covered with a plastic lid. Ten larvae per treatment per replication were exposed to treated pods. Three replicates each of five concentrations and one control (distilled water) were used for each test insecticide at ambient room temperature. Observation on larval mortality was recorded at 48 hrs after exposure period. Larvae regarded as dead when they were not able to move on probing with a blunt probe or brush. The setup of bioassays was maintained separately for every location. The mortality data of each treatment was corrected with respect to control mortality as per Abbott (1925) for *H. armigera* bioassays. The resistance factor (RF) was calculated with formula given by Pate and Bhamare (2016). The resistance ratio values were used to indicate resistance levels or categories as given by Reddy and Bhamare (2016).

RESULTS AND DISCUSSION

The resistance ratios of test insecticides for all 7 locations of Western Maharashtra was found to be in the range of 2.18 to 2.58 fold for chlorantraniliprole 18.5%SC, 2.31 to 2.93 fold for cyantraniliprole 10.26%OD, 1.60 to 1.94 fold for emamectin benzoate 5%SG, 5.23 to 7.00 fold for indoxacarb 15.8%EC and 1.52 to 1.98 fold for spinosad 45%SC. The toxicity of test insecticides was noticed in the order of spinosad 45%SC > emamectin benzoate 5%SG > chlorantraniliprole 18.5%SC > cyantraniliprole 10.26%OD > indoxacarb 15.8%EC.

Spinosad 45%SC, emamectin benzoate 5%SG, chlorantraniliprole 18.5%SC and cyantraniliprole 10.26%OD were more toxic and *H. armigera* populations were found to be susceptible to these insecticides whereas decreased susceptibility to low level of resistance developed for indoxacarb 15.8%EC against *H. armigera*. These results are in conformity with the findings of Karjule et al. (2017) who monitored development of insecticide resistance in *H. armigera* infesting pigeonpea from Marathwada region and exhibited that all the populations indicated susceptibility to chlorantraniliprole 18.5%SC (1.13 to 1.96 fold), cyantraniliprole 10.26% OD (1.74 to 2.10 fold) and emamectin benzoate 5%SG (2.09 to 2.54 fold). From Telangana, Deepa (2015) indicated that *H. armigera* larvae collected from Mahaboobnagar population recorded the resistance factor of 1.3, 2.0 and 2.6 fold to chlorantraniliprole at 24, 48 and 72 hours, respectively and 1.1, 1.7 and 2.5 fold resistance ratio to emamectin benzoate at 24, 48 and 72 hours, respectively. Similarly, Bird (2015) revealed that the resistance ratio for chlorantraniliprole was 2.9 fold. Bird et al. (2017) could not detected resistance in *H. armigera* populations to

Table 1. Insecticidal resistance in field population of *H. armigera* infesting chickpea

Sr. No.	Strain	Chlorantraniliprole 18.5% SC		Cyantraniliprole 10.26% OD		Emamectin benzoate 5% SG		Indoxacarb 15.8% EC		Spinosad 45% SC	
		LC_{50} ml/ g/ l	RR	LC_{50} ml/ g/ l	RR	LC_{50} ml/ g/ l	RR	LC_{50} ml/ g/ l	RR	LC_{50} ml/ g/ l	RR
1	Ahmednagar	0.0343	2.28	0.0509	2.57	0.0202	1.60	0.1035	6.72	0.0124	1.82
2	Kolhapur	0.0388	2.58	0.0517	2.61	0.0224	1.77	0.0806	5.23	0.0104	1.52
3	Nashik	0.0354	2.36	0.0582	2.93	0.0217	1.72	0.0959	6.22	0.0119	1.75
4	Pune	0.0375	2.50	0.0570	2.87	0.0245	1.94	0.1078	7.00	0.0122	1.79
5	Sangali	0.0328	2.18	0.0521	2.63	0.0196	1.55	0.0815	5.29	0.0135	1.98
6	Satara	0.0363	2.42	0.0528	2.66	0.0209	1.65	0.0961	6.24	0.0125	1.83
7	Solapur	0.0372	2.48	0.0459	2.31	0.0232	1.84	0.1037	6.73	0.0120	1.76
8	Susceptible	0.0150	-	0.0198	-	0.0126	-	0.0154	-	0.0068	-

emamectin benzoate and also reported low but detectable levels of survival of *H. armigera* at discriminating concentrations of indoxacarb. Gill and Dhawan (2006), Stanley et al. (2009), Khan et al. (2010) and Pan et al. (2017) revealed that *H. armigera* was highly susceptible to spinosad. Wang et al. (2017) showed that the indoxacarb-selected population, Yishui population, Shandong and Handan populations exhibited decreased sensitivity, low-level resistance and moderate-level resistance to indoxacarb 15.8%EC, with the resistance ratios of 4.36, 8.06 and 15.34 fold, respectively. More or less similar trend of results were obtained by Agboyi et al. (2016) revealed that spinosad was more toxic to *P. xylostella* populations than the other insecticides with LC_{50} and LC_{90} values less than 1 and 15 µg per ml, respectively. Reddy and Bhamare (2016) exhibited that *Earias vittella* population from different locations of Marathwada region registered variations in susceptibility to chlorantraniliprole 18.5%SC, cyantraniliprole 10.26%OD and emamectin benzoate 5%SG.

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AUTHOR CONTRIBUTION STATEMENT

A S Bade and V K Bhamare conceived and designed research, A S Bade conducted research, analyzed the dada and wrote the manuscript which was guided by V K Bhamare.

CONFLICT OF INTEREST

No conflict of interest.

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