Journal of Entomology, 1 (1): 21-23, 2004
ISSN 1812-5670

Evaluation of Indoxacarb Against Pyrethroid Resistant Population of *Helicoverpa armigera* Hub.

T. Ramasubramanian and A. Regupathy
Department of Entomology, Tamil Nadu Agricultural University, Coimbatore- 641 003, Tamil Nadu, India

Abstract: The bouquet bioassay experiments under laboratory condition revealed that the percentage mortality of *Helicoverpa armigera* was more than 70% even at the lowest rate of 10 g a.i ha^{-1} (1/10th recommended dose) and the percentage survival was in the range of just 7.5-20.0% at the recommended dose of indoxacarb. Good biological efficacy of this new molecule was also reflected in the suppression of larval population and reduction of damage to bolls, squares, locules and kapas in the field. The increased susceptibility of pyrethroid resistant populations of *H. armigera* to indoxacarb in Tamil Nadu could be due to the activation by carboxyl esterases in to its more toxic metabolite.

Key words: *Helicoverpa armigera*, indoxacarb, pyrethroid resistance

INTRODUCTION

The Cotton bollworm, *Helicoverpa armigera* Hubner (Noctuidae: Lepidoptera) is considered as one of the major threats to present day intensive agriculture in India, where it has developed resistance to all the major conventional groups (synthetic pyrethroids, organophosphates, organochlorines and carbamates) of insecticides used against it[1]. Over dependence of a particular group of chemistry is one of the important reasons for rapid development of resistance. This was evidenced by very high level of resistance to synthetic pyrethroids[1], which occupied 50-70% of the insecticides sprayed over the cotton crop in India[2]. Hence newer molecules with novel mode of action are currently essential for the management of pyrethroid resistant *H.armigera*. Indoxacarb, the first commercialized pyrazoline type sodium channel blocker[3] belonging to the new class oxadiazines that was discovered and developed by E. I. DuPont and Co.[4] had entered in to Indian market recently to manage the cotton bollworms. The level of resistance in *H.armigera* to this new insecticide and its field efficacy against pyrethroid resistant population of Tamil Nadu, India are discussed in this study.

MATERIALS AND METHODS

Laboratory measurement of resistance by bouquet bioassay / foliar residue bioassay / terminal bud bioassay: Cotton leaves, squares and bolls were surface sterilized with 0.5% sodium hypochlorite, rinsed in sterile water and shade dried. Then they were dipped in respective concentration of the insecticide for 30 sec. They were drained and dried at room temperature. The turgidity was maintained by surrounding the petiole with a cotton wool saturated with water. The petioles of the leaves/squares/bolls with cotton swab were kept immersed in water in a vial. The entire setup was kept enclosed in mylar film cage and third instar larvae (30-40 mg weight) were allowed to feed. Mortality was recorded at 24 h intervals up to 6 days then percentage resistance was computed.

Field evaluation: Indoxacarb was evaluated at Agricultural Research Station, Bhavanisagar, Tamil Nadu (Latitude-11°29' N; Longitude-77°8'E; Altitude-256 mMSL) during winter, 2002. Six treatments (recommended dose-100 g.a.i.ha^{-1}, 1/10th RD, 1/3rd RD, 3RD, 10RD and untreated check) were imposed in a Randomized Block Design with four replications. The ruling variety MCU-5 was planted with a spacing of 75x30 cm, so that an area of 8x8 m could accommodate 284 plants for each replication.

Eggs of *H. armigera* were collected from heavily infested farmer's fields in local area of the experimental site. The population of that particular local area was maintained in the laboratory and assessed for the level of resistance to fenvalerate (representative of synthetic pyrethroids) through discriminating dose (0.2 μg) bioassay before spraying.

Two hundred eggs were placed in each replication at the rate of two eggs plant^{-1} on fresh leaves near young bolls on top one-third portion of the plant and the site of placing egg was tagged. These 100 plants were examined after a week to know per cent emergence and settling. The egg placement was repeated in case of poor emergence. Spraying was taken with different doses of the insecticide

Corresponding Author: T. Ramasubramanian, Department of Entomology, Tamil Nadu Agricultural University, Coimbatore- 641 003, Tamil Nadu, India Email: tramasubbu@rediffmail.com

in respective plots with hand operated knap-sack sprayer fitted with triple action nozzle delivering 450-600 ml of spray fluids minute^{-1}. Enough care was taken to avoid drift to adjacent plots.

Pre and post treatment observations

***H. armigera* larval population:** Early third instar *H. armigera* larvae were counted on 100 selected plants prior to the application of insecticide as well as second and seventh day after imposing the treatments.

Bollworm damage: The extent of damage caused by bollworm was assessed before and 2, 7, 14 and 21 days after treatment. The bollworm incidence was assessed on the basis of shed squares, bolls, locules and bad kapas.

The total number of squares and those damaged by bollworms was counted at ten randomly selected plants per replication. The total number of bolls collected from ten randomly selected plants per plot at each picking was assessed for number of damaged bolls; number of damaged locules and the percentage was worked out. Total kapas collected from ten plants was weighed. Bad and good kapas were separated. Bad kapas by good kapas was expressed in terms of percentage (w/w basis).

RESULTS AND DISCUSSION

Indoxacarb at recommended dose (RD= 100 g a.i ha^{-1}) exerted 73.25-76.65% reduction in larval population under field condition after first and second spray respectively (Table 2). Under laboratory condition the percentage mortality was more than 70% even at the lowest rate of 10 g a.i ha^{-1} (1/10th RD) and the percentage survival or resistance was in the range of just 7.5-20.0% at recommended dose of indoxacarb (Table 1). Good biological efficacy of this new molecule was also reflected in the reduction of damage to bolls, squares, locules and kapas (Table 3). The mean percent reduction over control on bollworm incidence at recommended dose of indoxacarb was 52.0 - 54.83, 57.44, 56.88 and 63.46 on square, boll, locule and bad kapas basis, respectively While that at 10th RD, was 70.45-72.73, 78.57, 88.52 and 89.10, and at the lowest dose (1/10th RD) percent reduction over control was 33.48 - 39.3, 27.69, 20.34 and 29.29 on square, boll, locule and bad kapas basis, respectively. Application of indoxacarb at recommended dose resulted in 15.50 quintals of kapas ha^{-1}. The highest yield of 18.80 quintals ha^{-1} was obtained at 10 RD. The yield obtained in all the treatments was superior over untreated check.

The *H. armigera* population from the experimental site showed 98.5% resistance to fenvalerate (representative of synthetic pyrethroids) on the basis of discriminating dose diagnosis. Synergistic suppression studies with piperonylbutoxide (Mixed function oxidase inhibitor) and profenofos (Carboxyl esterase inhibitor) revealed that this peak level of resistance was attributed to enhanced activity of mixed function oxidases and carboxyl esterases[5]. Of the several mechanisms, the detoxification through mixed function oxidases and to a certain extent carboxyl esterases was reported to play a dominant role in the development of resistance in *H. armigera* populations of Tamil Nadu[6,7]. The over dependence of synthetic pyrethroids which constituted 50-70% of the insecticides used in cotton eco system[2] for the past one decade enhanced the activity of detoxification enzymes. Activation of the parent oxadiazines to the S-enantiomers of the N-decarbomethoxyllated metabolites, which are powerful sodium channel blockers, is the toxic mechanism of action

Table 1: Effect of different doses of indoxacarb on *H. armigera* - bouquet bioassay

		Cotton leaves			Cotton squares			Cotton bolls		
Treatments	Dose (g a.i.ha^{-1})	Corrected % mortality	% Survival	SE	Corrected % mortality	% Survival	SE	Corrected % mortality	% Survival	SE
T_1 1/10th RD	10	77.5	22.5	6.6	75.0	25.0	6.9	70.0	30.0	7.3
T_2 1/3rd RD	33.3	92.5	7.5	4.2	80.0	20.0	6.4	75.0	25.0	6.9
T_3 RD	100	92.5	7.5	4.2	85.0	15.0	5.7	80.0	20.0	6.4
T_4 3 x RD	300	95.0	5.0	3.5	85.0	15.0	5.7	82.5	17.5	6.1
T_5 10 x RD	1000	100	0	0	100	0	0	92.5	7.5	4.2
T_6 Control	-	0	100	0	-	100	0	0	100	0

RD: Recommended Dose; SE: Standard Error

Table 2: Effect of different doses of indoxacarb on larval population of *H. armigera*

		Corrected % reduction over untreated check 2 DAT		Corrected % reduction over untreated check 7 DAT	
Treatments	Dose (g.a.i. ha^{-1})	First application	Second application	First application	Second application
T_1 1/10th RD	10	50.45 (45.26) ^{e}	49.10 (44.48) ^{e}	54.72 (47.71) ^{e}	50.18 (45.10) ^{e}
T_2 1/3rd RD	33.3	55.13 (47.94) ^{d}	57.53 (49.33) ^{d}	62.73 (52.40) ^{d}	61.30 (51.57) ^{d}
T_3 RD	100	66.93 (54.90) ^{c}	70.02 (56.82) ^{c}	73.25 (58.86) ^{c}	76.65 (61.11) ^{c}
T_4 3xRD	300	74.90 (59.93) ^{b}	76.80 (61.21) ^{b}	78.97 (62.72) ^{b}	81.47 (64.52) ^{b}
T_5 10xRD	1000	80.18 (63.58) ^{a}	87.70 (69.49) ^{a}	83.85 (66.30) ^{a}	89.80 (71.38) ^{a}

Figures in parentheses are Arcsine (Sqr (x/100) transformed values; where, x is corrected percent reduction, Means followed by a common letter(s) are not significantly different

Table 3: Effect of different doses of indoxacarb on bollworm incidence

	Square basis										
	First application		Second application		Boll basis		Locule basis		Bad kapas basis		Kapas Yield
Treatment	% damage*	% reduction	% damage*	% reduction	% damage*	% reduction	% damage**	% reduction	% damage**	% reduction	quintals ha^{-1}
T_1 1/10th RD	26.95 (31.25)^{d}	33.48 (35.32)^{e}	22.25 (28.12)^{c}	39.30 (38.81)^{e}	26.25 (30.81)^{e}	27.69	17.55 (4.25)^{e}	20.34	11.03 (3.40)^{e}	29.29	11.80^{c}
T_2 1/3rd RD	21.70 (27.73)^{c}	45.10 (42.18)^{d}	18.83 (25.69)^{c}	45.43 (42.37)^{d}	20.80 (27.10)^{d}	42.70	13.65 (3.76)^{d}	38.04	8.45 (2.10)^{d}	45.83	12.50^{c}
T_3 RD	18.15 (25.17)^{bc}	52.00 (46.14)^{c}	15.10 (22.83)^{b}	54.83 (47.77)^{c}	15.45 (23.10)^{c}	57.44	9.50 (3.16)^{c}	56.88	5.70 (2.49)^{c}	63.46	15.50^{b}
T_4 3 x RD	15.05 (22.81)^{ab}	61.53 (51.67)^{b}	12.95 (21.18)^{b}	63.55 (52.87)^{b}	11.25 (19.58)^{b}	69.01	5.95 (2.54)^{b}	72.99	3.50 (1.10)^{b}	77.56	16.00^{b}
T_5 10 x RD	12.05 (20.28)^{a}	70.45 (57.08)^{a}	9.45 (17.88)^{a}	72.73 (58.53)^{a}	7.78 (16.18)^{a}	78.57	2.53 (1.74)^{a}	88.52	1.70 (1.48)^{a}	89.10	18.80^{a}
T_6 Control	42.80 (40.84)^{e}	-	39.73 (39.16)^{d}	-	26.30 (37.03)^{f}	-	22.03 (4.74)^{f}	-	15.60 (4.00)^{f}	-	9.00^{d}

*: Figures in parentheses are Arcsine (Sqr (x/100) transformed values; where, x is per cent damage, **: Figures in parentheses are Sqr (x+0.5) transformed values; where, x is percent damage, Means followed by a common letter(s) are not significantly different

in Lepidoptera[4]. The increased activity of carboxyl esterases in *H. armigera* was reported to enhance the toxicity of indoxacarb by converting it to a more toxic metabolite DCJW (N-decarbomethoxyllated JW 062)[8]. This could be the reason for increased susceptibility of pyrethroid resistant populations of *H.armigera* to indoxacarb in Tamil Nadu. Negative cross resistance (0.42 - 0.63 fold) to indoxacarb observed in the pyrethroids selected populations of *H. armigera* in the laboratory[5] also seems to support the results obtained in the present investigation. This insecticide was considered as the best option to manage the Australian *H. armigera* showing high level of carboxyl esterase activity[9]. Hence, indoxacarb may be included as one of the components in insecticide rotation strategy to manage the pyrethroid resistant *H.armigera* populations in Tamil Nadu.

ACKNOWLEDGMENTS

The financial support from the Common Fund for Commodities (CFC) Europe, International Cotton Advisory Committee (ICAC), USA and Natural Resources Institute (NRI), UK is acknowledged.

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