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Laboratory Measured Resistance and Field Control of *Helicoverpa armigera*Hub. by thiodicarb

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Abstract: Resistance to thiodicarb was diagnosed in the field population of *Helicoverpa armigera* from Tamil Nadu, India. Bouquet bioassay results in the laboratory indicated the level of resistance was 30.0 - 45.0% at recommended dose (1000g.a.i ha^{-1}) of thiodicarb. The suppression of larval population and reduction of damage to bolls, squares, locules and kapas in the field also in agreement with the laboratory results.

Key words: *Helicoverpa armigera*, thiodicarb, insecticide resistance

INTRODUCTION

The cotton bollworm, *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae) is a serious pest on cotton, bhendi, tomato, pigeon pea, chick pea and sunflower in India. This pest alone responsible for 15 per cent decline in cotton crop yield, the monitory value of which is 2000 crores ($450m) (Regupathy *et al.,* 1999). Chemical insecticides are currently essential for the control of *H.armigera* and are likely to remain an important component of IPM. However, insecticide resistance is a major threat to the economic production of cotton in India. This pest has developed resistance to all the synthetic pyrethroids throughout the Indian sub continent (Armes *et al.,* 1996) due to their indiscriminate usage (Banerjee *et al.,*2000). But carbamates were rarely used on cotton and their incorporation in the IRM strategy may delay the development of resistance. The carbamate, thiodicarb has both larvicidal and ovicidal activities, which are very valuable in the management of resistant *H.armigera.* Hence, a research was carried out to detect the level of resistance to thiodicarb and its field efficacy against pyrethroid resistant *H.armigera* populations of Tamil Nadu and the results are discussed in this paper.

MATERIALS AND METHODS

Laboratory measurement of thiodicarb 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 chemical for about 30 seconds. 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: Thiodicarb was evaluated at Cotton Research Station, Srivilliputtur, Tamil Nadu (Latitude - 9°5'N; Longitude-77°6'E; Altitude –137.9mMSL) during summer, 2002. Six treatments (recommended dose–1000g.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 recently released ruling variety from the station SVPR-3 was planted with a spacing of 75x30 cm, so that an area of 8x 8m could accommodate 284 plants for each replication.

Eggs 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 and thiodicarb through discriminating dose (0.2µg for fenvalerate and 1.5% w/v for thiodicarb) 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 chemistry 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. Standard agronomic practices were followed for crop growth.

Pre and post treatment observations

***H.armigera*:** 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. The live larvae were collected 7 days after treatment reared through F_1 generation and assessed for resistance by applying discriminating doses in laboratory.

Boll worm 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 by shed squares, bolls, locules and bad kapas basis.

The total number of squares and those damaged by boll worms were 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

Laboratory measured thiodicarb resistance: At recommended dose (RD–1000g.a.i. ha^{-1}) the level of resistance was 30.0-45.0%. The resistance frequency decreased to 10.0-27.5% when the dose was increased to ten fold. Similarly the resistance level increased to 45.0-65.0% as the dose was reduced by ten fold. At 3RD,the survival was 15.0-37.5% and at 1/3rd RD it was 35.0-55.0% (Table 1).

Impact on larval population: The larval population was in the range of 75.5-92.53 per 100 plants prior to the application of insecticide. The recommended dose (RD) of thiodicarb reduced 53.3% of the larval population, which was on par with 3RD (Table 2). The reduction in population was 69.13% when the dose was increased to ten times. At lower doses the reduction was 39.65% (1/3rd RD) and 35.15% (1/10th RD). However, these two treatments were not significantly different with each other. The population showed 33.3% resistance in the lab before it was subjected to selection pressure in the field. However, the level of resistance increased marginally (33.9 - 40.8%) with increase in dose.

Impact on bollworm incidence: The bollworm incidence was assessed on the basis of square damage, boll damage, locule damage, and bad kapas weight.

Square basis: The efficacy of thiodicarb in reducing square damage decreased from 63.45% at 10 RD to 21.68% at 1/10th RD over control. The reduction over control was 47.28% at RD. One third and three times of RD effected 34.85 and 56.87% reduction over control. The treatments were significantly different with each other in reducing the square damage (Table 3).

Boll basis: The plot, which received the recommended dose of thiodicarb, recorded 41.86% reduction in boll damage over the control plot. This was on par with 1/3rd and 3 RD. The per cent reduction in boll damage over untreated check was 21.17 and 57.52% respectively in the plots sprayed with the lowest (1/10th) and the highest (10 RD) dose of insecticide.

Locule basis: The level of incidence at RD (9.65%) was comparable with 3 RD (9.15%) The corresponding per cent reduction over untreated check was 41.34 and 44.38% respectively. The mean percent reduction over untreated check was 21.28 and 69.91% respectively at the lowest (1/10th RD) and the highest doses (10 RD) respectively.

Bad kapas basis: The per cent reduction in bad kapas proportion over untreated check increased with increase in dose; the reduction being 17.60 and 61.82% at 1/10th and 10 RD respectively. At RD the reduction in bad kapas proportion was 38.55% more than that of untreated check. This was comparable with 1/3rd RD and 3 RD.

Impact on kapas yield: The kapas yield in untreated check was 7.30 quintals ha^{-1}. Application of thiodicarb at RD resulted in 13.03 quintals ha^{-1}. Increasing the dose by three times did not increase the yield significantly and was on par with recommended dose, but ten times increase over RD significantly increased the yield to 16.0 quintals ha^{-1}.

At lower doses, the yield was 10.0 (1/3rd RD) and 9.53 (1/10th RD) quintals ha^{-1}, which were on par with each other. However, all the treatments were significantly superior over untreated check.

Earlier studies reported that thiodicarb was the most effective chemical against both eggs and first instar larvae of *H.armigera* (Kuwazawa, 1999). But, the present investigation on the efficacy against third instar larvae of *H.armigera* was found to be at moderate level only. This was also reflected in the bollworm damage in terms of square, boll, locule, and bad kapas basis. The moderate level of efficacy of thiodicarb was traced to the development of resistance in the field population of *H.*armigera from Tamil Nadu. The monitoring studies conducted at 7-14 days interval revealed a considerable

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

		Cotton leaves					Cotton Squares					Cotton bolls				
Treatment	Dose (g a.i./ha)	No. Dosed	No. Dead	% Mortality	% Resistance	SE	No. Dosed	No. Dead	% Mortality	% Resistance	SE	No. Dosed	No. Dead	% Mortality	% Resistance	SE
T1 1/10th RD	100	40	14	35.0	65.0	7.6	40	22	52.6	45.0	7.9	40	20	50.0	50.0	8.0
T2 1/3rd RD	333.3	40	18	45.0	55.0	7.9	40	26	63.2	35.0	7.6	40	21	52.5	47.5	7.9
T3 RD	1000	40	22	55.0	45.0	7.9	40	28	68.4	30.0	7.3	40	24	60.0	40.0	7.8
T4 3 x RD	3000	40	25	62.5	37.5	7.7	40	34	84.2	15.0	5.7	40	27	67.5	32.5	7.5
T5 10 x RD	10000	40	29	72.5	27.5	7.1	40	36	89.5	10.0	4.8	40	30	75.0	25.0	6.9
T6 Control	-	40	-	0	100	0	40	2	-	95.0	3.4	40	-	-	100	0

RD: Recommended dose; SE : Standard Error

Table 2: Effect of different doses of thiodicarb on larval population of *H.armigera* in the field

			2 DAT		4DAT		%resistance of F_1 field survived population
Treatment	Dose (g a.i./ha)	Precount*	Post count*	Corrected % reduction**	Post count*	Corrected % reduction**	
T1 1/10th RD	100	82.00 (1.92) ^{a}	53.00 (1.73) ^{c}	31.43 (34.00)^{d}	47.80 (1.68)^{d}	35.15 (36.36)^{c}	33.9±6.4
T2 1/3rd RD	333.3	75.50 (1.88) ^{a}	45.30 (1.66) ^{bc}	36.80 (37.33) ^{d}	40.50 (1.61) ^{cd}	39.65 (38.94) ^{c}	34.5±6.3
T3 RD	1000	78.80 (1.89)^{a}	39.30 (1.60)^{b}	47.40 (43.50)^{c}	33.03 (1.52)^{b}	53.30 (46.90)^{b}	37.5±7.1
T4 3 x RD	3000	92.53 (1.97)^{a}	39.03 (1.60) ^{b}	55.45 (48.13)^{b}	34.03 (1.53)^{bc}	58.72 (50.03)^{b}	38.9±5.8
T5 10 x RD	10000	90.00 (1.96)^{a}	29.50 (1.48)^{a}	65.53 (54.07)^{a}	25.03 (1.40)^{a}	69.13 (50.24)^{a}	40.8±4.5
T6 Control	-	88.00 (1.94)^{a}	83.50 (1.92)^{d}	-	79.00 (1.90) ^{e}	-	33.3±6.1

The laboratory resistance through discriminating dose bioassay (1.5%w/v) before application of treatment was 33.3± 6.1.

DAT: Days after treatment

*: Figures in parentheses are Log (x) transformed values; where, x is no. of larvae 100 plants^{-1}

**: Figures in parentheses are Arcsine (Sqr (x/100) transformed values; where, x is corrected percent reduction

Means followed by a common letter are not significantly different by DMRT (P= 0.05)

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

		Square basis		Boll basis		Locule basis		Bad kapas basis		
Treatment	Dose g.a.i.ha^{-1}	% Damage*	% Reduction	% Damage*	% Reduction	% Damage**	% Reduction	% Damage**	% Reduction	Kapas yield Quintals ha^{-1}
T1 1/10th RD	100	28.80 (32.43)^{d}	21.68	21.90 (27.89)^{d}	21.17	12.95 (3.67)^{c}	21.28	11.33 (3.44)^{d}	17.60	9.53^{c}
T2 1/3rd RD	333.3	20.40 (26.83)^{c}	34.85	18.15 (25.19)^{c}	34.67	12.30 (3.57)^{c}	25.23	9.70 (3.19)^{cd}	29.45	10.00^{c}
T3 RD	1000	17.65 (24.80)^{bc}	47.28	16.15 (23.65)^{bc}	41.86	9.65 (3.17)^{b}	41.34	8.45 (2.10)^{bc}	38.55	13.03^{b}
T4 3 x RD	3000	15.60 (23.24)^{b}	56.87	14.23 (22.14)^{ab}	48.78	9.15 (3.10)^{b}	44.38	7.10 (2.75)^{b}	48.36	13.53^{b}
T5 10 x RD	10000	12.05 (20.29)^{a}	63.45	11.80 (20.08)^{a}	57.52	4.95 (2.33)^{a}	69.91	5.25 (2.40)^{a}	61.82	16.00^{a}
T6 Control	-	37.40 (37.68)^{e}	-	27.78 (31.78)^{e}	-	16.45 (4.11)^{d}	-	13.75 (3.77)^{e}	-	7.30^{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 per cent damage

Means followed by a common letter are not significantly different by DMRT (P= 0.05)

level resistance (33.3%) to thiodicarb in different populations including one from the experimental location i.e. CRS, Srivilliputtur (Ramasubramanian, 2003). This is the reason for moderate level of efficacy observed with thiodicarb even though it was familiar with farmers very recently. Such significant level of resistance due to insensitive acetylcholine esterase in field population of *H.armigera* had been reported earlier in Australia (Gunning *et al.*, 1996). Based on the results obtained in the present investigation, it may be advisable to use the thiodicarb in rotation with other insecticides, which may delay the development of resistance to this new chemistry.

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