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Relative efficacy of bio-pesticides against fruit borer, *Helicoverpa armigera* (Hub.) on tomato

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ABSTRACT

The result showed that the three applications of spinosad 45 SC (200 ml/ha) were found most effective in reducing the population of tomato fruit borer larvae and fruit damage i.e. 76.96 and 5.45 per cent respectively followed by Ha-NPV at (250 LE/ha) and Bt (1.5 kg/ha) with 69.17 and 57.76 and 7.16 and 9.70 per cent in reduction larval population and fruit damage respectively. Neem oil (3%) was found least effective among all the treatments and caused lowest reduction in population of larvae (53.89 percent) and fruit damage (13.80 percent). The highest marketable yield of 108.55 kg/ plot was recorded in spinosad 45 SC (200 ml/ha) with highest C: B ratio of 1:2.056. It was followed by Ha-NPV (250 LE/ha) and Bt (1.5 kg/ha) treatment, which yielded 97.80 kg/plot and 94.06 kg/plot, respectively. Neem oil @ 3% yielded the lowest marketable yield (72.23 kg/plot).

Key words : Fruit borer, efficacy, spinosad, bio-pesticides, neem oil, marketable yield, tomato fruit damage.

INTRODUCTION

The tomato fruit borer, *Helicoverpa armigera* (Hub.) is a key pest as it infests fruits and makes them unfit for human consumption causing considerable (55%) crop loss (Selvanarayanan, 2000). It has been estimated that crops worth Rs. 1000 crore are lost annually by this pest (Jayraj *et al*., 1994). Over the years, the more common method for the control of this pest has been to have a film of a persistent effective insecticide over the foliage and fruiting bodies. However, the indiscriminate use of insecticides has eroded sustainability and resulted in buildup of pesticide residues, resistance to pesticides, resurgence and secondary outbreak of this pest (Fitt, 1989; Mehrotra, 1991); therefore, switching from the use of insecticides alone to more bio-intensive methods of pest management is desirable.

MATERIALS AND METHODS

The experiment on relative efficacy of bio-pesticides against fruit borer, *Helicoverpa armigera* (Hub.) on tomato was carried out at the Horticulture Farm of Rajasthan College of Agriculture, MPUAT, Udaipur during *Rabi* (October 2015 to April 2016). Geographically, Udaipur is located at 23.4°N longitude and 75°E latitude at an elevation of 579.5 MSL in the state of Rajasthan. The seeds of tomato variety 'Samradhi' were sown in well prepared nursery beds in third week of October, 2015 in the plots measuring 3.6 m x 3 m having row to row and plant to plant distance of 60 × 45 cm, respectively. The experiment was laid out in Randomized Block Design (RBD), each treatment was replicated four times the treatments use are shown in table 1. To estimate the population of *H. armigera larvae* "Direct visual counting method" was used. Five plants were selected randomly from each plots and tagged. The borer infested and healthy fruits of individual plots were sorted out after each harvest and the numbers of infested and marketable fruits were recorded. The fruit infestation and larval population were recorded 1 day before and 3, 5 and 7 days after spraying of each treatment.

The population data of *H. armigera* obtained was subjected for the conversion into per cent reduction using Henderson and Tilton (1952) formula as under:

$$\text{Per cent reduction in population} = 100 \left[1 - \frac{T_a \times C_b}{T_b \times C_a}\right]$$

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Where,
T_a = Number of insects after treatment
T_b = Number of insects before treatment
C_a = Number of insects in untreated check after treatment
C_b = Number of insects in untreated check before treatment.

The reduction percentage figures were transformed into arcsine values and subjected to analysis of variance. The data on percentage infestation of tomato fruits by borer was calculated at each picking by counting damage and healthy fruits in each spray application. The mean per cent fruit damage was calculated using formula:

$$\text{Mean fruit damage (\%)} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits}} = \times 100$$

Cost/Benefit ratio : The economics of different treatments was calculated by taking into consideration the cost of application of different treatments and prevailing market price of tomato. The total marketable fruit yields obtained from all plots were computed on hectare basis. The increase in fruit yield was calculated as yield in treated plots compared to untreated plots as follows:

$$\text{Per cent increased yield} = \frac{\text{Increase yield in treated plot}}{\text{Yield in untreated plot}} \times 100$$

Cost benefit ratio was calculated by deducting the cost of insecticidal treatments from price of increased yield over control by using following formula:

$$\text{B:C ration} = \frac{\text{Returns in treatment (Rs/ha)}}{\text{Returns in control (Rs/ha) – Cost of insecticides and labour (Rs/ha)}} \times 100$$

Marketable yield : The marketable yield of tomato after each picking was recorded separately for each treatment. The yield of all pickings was pooled together for each treatment separately and yield per hectare was computed.

RESULTS AND DISCUSSION

The efficacy of each treatment was studied in terms of mean reduction of larvae and fruit damage. Each treatment was applied three times at an interval of 15 days initiating first spray. The data recorded on mean reduction of larval population presented in table 1 and data on fruit damage have been presented in table 2. Study on marketable yield and economics of cost benefit ratio was conducted and obtained results has been presented in tables 3 and 4.

Table 1. Efficacy of bio-pesticides against *H. armigera* larvae infesting tomato crop during *rabi* 2015-16.

S. No.	Treatments	Dose / ha	Reduction in larval population days after spray (%)											
			1st Spray				2nd Spray				3rd Spray			
			PTP	3DAS	5 DAS	7 DAS	PTP	3 DAS	5 DAS	7 DAS	PTP	3 DAS	5 DAS	7 DAS
T_1	Neem oil 3000 ppm	3%	3.60	42.06 (44.91)	43.92 (48.12)	43.70 (47.74)	7.60	45.96 (51.6)	47.25 (53.89)	44.92 (49.86)	3.20	43.60 (47.57)	45.86 (51.49)	42.94 (46.43)
T_2	Ha-NPV (250LE)	250	2.80	45.17 (50.29)	50.63 (59.67)	47.58 (55.33)	5.20	47.36 (54.0)	48.06 (55.20)	46.88 (53.26)	2.60	50.73 (59.68)	56.61 (69.17)	54.76 (66.40)
T_3	Bt	1.5 kg	3.20	44.37 (48.91)	49.41 (57.61)	46.63 (54.12)	7.40	46.89 (53.2)	47.44 (54.21)	45.83 (51.45)	3.40	45.56 (50.98)	48.02 (55.20)	49.52 (57.76)
T_4	Spinosad 45 SC	200 ml	3.00	50.34 (59.18)	53.40 (64.29)	49.34 (57.48)	6.80	49.32 (57.3)	53.19 (63.81)	48.64 (56.25)	3.20	56.50 (69.21)	61.56 (76.96)	57.38 (70.51)
T_5	Control		3.40				7.20				2.80			
SEm ±				0.875	1.008	0.831		1.192	1.504	1.144		1.553	1.566	1.465
CD at 5%				2.695	3.106	2.560		3.674	4.633	3.525		4.784	4.825	4.515

Figure in parentheses are retransformed percentage values; DAS = Days after spray; PTP = Pre treatment population

Table 2. Efficacy of bio-pesticides against *H. armigera* larvae infesting tomato crop during *rabi* 2015-16.

S. No.	Treatments	Dose/ ha	Percentage fruit damage days after spray (%)								
			1st Spray			2nd Spray			3rd Spray		
			PTP	3 DAS	5 DAS	7 DAS	3 DAS	5 DAS	7 DAS	3 DAS	5 DAS	7 DAS
T1	Neem oil 3000 ppm	3%	22.96 (15.22)	23.84 (16.34)	21.81 (13.80)	27.33 (21.08)	28.79 (23.20)	26.40 (19.77)	30.30 (25.46)	27.48 (21.29)	25.93 (19.12)	28.78 (23.18)
T2	Ha-NPV (250LE)	250	21.93 (13.95)	20.56 (12.33)	18.24 (9.80)	20.66 (12.45)	19.19 (10.80)	18.09 (9.64)	21.79 (13.78)	19.67 (11.33)	15.52 (7.16)	18.29 (9.85)
T3	Bt	1.5 kg	22.68 (14.87	20.90 (12.73)	18.53 (10.10)	21.18 (13.05)	20.95 (12.78)	18.15 (9.70)	22.26 (14.35)	20.64 (12.43)	18.22 (9.78)	19.72 (11.39)
T4	Spinosad 45 SC	200 ml	22.71 (14.90)	18.43 (10.00)	15.23 (6.90)	19.28 (10.90)	16.08 (7.67)	13.68 (5.59)	18.06 (9.61)	15.52 (7.16)	13.50 (5.45)	16.15 (7.74)
T5	Control		22.61 (14.78)	25.25 (18.20)	29.69 (24.53)	33.18 (29.95)	34.20 (31.60)	34.94 (32.77)	36.59 (35.54)	37.58 (37.20)	38.25 (38.33)	39.61 (40.64)
SEm ±				0.673	0.947	1.154	1.268	1.372	1.351	1.480	1.649	1.671
CD at 5%				2.072	2.918	3.555	3.908	4.227	4.162	4.559	5.081	5.149

Figure in parentheses are retransformed percentage values; DAS = Days after spray; PTP = Pre treatment population

Table 3. Effects of different treatments on marketable yield of tomato during *rabi* 2015.

Treatments	Yield (kg/plot)	Yield (q/ha)
T_1: Neem oil @ 3000 ppm	72.23	167.20
T_2: Ha-NPV @ 250 LE	97.80	226.40
T_3: Bt @ 1.5 kg	94.06	217.74
T_4: Spinosad 45 SC @ 200 ml	108.55	251.29
T_5: control	52.06	120.51
SEm ±	0.980	
CD at 5%	3.01	

Mean larval reduction : The data recorded on mean reduction of fruit borer larvae after first spray reveal that all the treatments were significantly superior over control right from three days after spraying (Table 1). Application of Spinosad 45 SC (200 ml/ ha) was most effective with 59.18 per cent mean reduction in population of fruit borer larvae. It was followed by Ha-NPV (250 LE/ha) and Bt (1.5 kg/ha) which caused 50.29, 48.91 per cent mean reduction, respectively. While Neem oil (3%) was found least effective treatment which caused 44.91 per cent mean reduction. Fifth day after spraying Spinosad 45 SC (200 ml/ha) proved significantly superior with 64.29 per cent mean reduction of fruit borer larvae,

Table 4. Economics and cost benefit ratio of different treatments against *H. armigera* in tomato during *rabi* 2015.

Treatments	No. of sprays	Average yield (q/ha)	Gross return (Rs.)	Increased yield over control (q/ha)	Value of increased yield over control (Rs./ha)	Management Cost (labour + insecticide) (Rs./ha)	Net profit (Rs./ ha)	C:B ratio
T_1 Neem oil @ 3000 ppm	3	167.25	250875	46.74	70110	2820	67290	1:1.366
T_2 Ha NPV @ 250LE/ha	3	226.40	339600	105.89	158835	3420	155415	1:1.843
T_3 Bt @ 1.5 kg/ha	3	217.74	326610	97.23	145845	2595	143250	1:1.781
T_4 Spinosad 45 SC @ 200 ml/ha	3	251.29	376935	130.78	196170	2520	193650	1:2.056
T_5 Control	0	120.51	180765	-	-	-	-	-

(1) Present price of insecticides: Spinosad Rs. = 1200/70 ml; Bt Rs. = 500/kg; Neem oil Rs. = 200/lit; Ha-NPV Rs. = 750/250 LE
(2) Labour charge: 4 labour @ Rs. 250
(3) Sale price of tomato Rs. = 15/kg

similarly seventh day after spraying highest mean reduction (57.48%) was recorded in Spinosad 45 SC (200 ml/ha).

The data recorded on mean reduction of fruit borer larvae after second spray reveal that three days after the spray, Spinosad 45 SC (200 ml/ha) offered best control with 57.39 per cent mean reduction of fruit borer larvae and was significantly superior to all other treatments. It was followed by Ha-NPV (250 LE/ha) and Bt (1.5 kg/ha) with 54.09 and 53.27 per cent reduction, respectively, Neem oil (3%) was least effective among all the treatments and caused only 51.66 per cent reduction. Fifth day after the second spraying Spinosad 45 SC (200 ml/ha) proved significantly superior over all other treatments as it resulted in 63.81 per cent mean reduction in population of fruit borer larvae. Seven days after the second spraying Spinosad 45 SC (200 ml/ha) was found significantly superior over all other treatments as it caused 56.25 per cent mean reduction of *H. armigera* larvae.

The data recorded on mean reduction in pest population after the third spray revealed that at three days after third spray Spinosad 45 SC (200 ml/ha) caused maximum mean reduction of 69.21 per cent followed by Ha-NPV (250 LE/ha) and Bt (1.5 kg/ha) with 59.68 and 50.98 per cent reduction, respectively. Neem oil caused least reduction of 47.57 per cent reduction. It was observed fifth day after application, all the treatments followed the same trend of effectiveness. The highest mean reduction of 76.96 per cent of fruit borer larvae was recorded in Spinosad 45 SC (200 ml/ha) and was superior to all other treatments. The mean reduction in the fruit borer population at seven days after application of Spinosad 45 SC (200 ml/ha) was 70.51 per cent that was significantly higher as to all other treatments.

Mean fruit damage : The data recorded on mean fruit damage after the first spray reveal that all treatments were significantly superior over control in reducing fruit damage at three days after spray (Table 2). Spinosad 45 SC (200 ml/ha) exhibited minimum mean fruit damage of 10.00 per cent. It was followed by Ha-NPV (250 LE) and Bt (1.5 kg/ha) with 12.33 and 12.73 per cent mean fruit damage, respectively. Neem oil (3%) was least effective with mean fruit damage of 16.34 per cent, as against 18.20 per cent in untreated control. After five days of treatment application, the order of efficacy remained the same. Spinosad 45 SC (200 ml/ha) was most effective with minimum fruit damage of 6.90 per cent. The efficacy of these treatments followed the same trend after seven days of spray and spinosad 45 SC (200 ml/ha) exhibited minimum fruit damage of 10.90 per cent.

The data recorded on mean fruit damage after the second spray reveal that on the third day after second spray, spinosad 45 SC (200 ml/ha) was most effective as it exhibited only 7.67 per cent fruit damage. It was followed by Ha-NPV (250 LE) and Bt (1.5 kg/ha) with 10.80 and 12.78 percent fruit damage, respectively. Spray of Neem oil (3%) was least effective with 23.20 per cent fruit damage as against 31.60 per cent in untreated control. After five days of spraying, recorded data were almost similar to the result obtained at three day after spray. spinosad 45 SC (200 ml/ha) was most effective which recorded minimum fruit damage of 5.59 per cent. The efficacy of all treatments seven days after spray and spinosad 45 SC (200 ml/ha) was most effective with mean fruit damage 9.61 per cent.

The data recorded on mean fruit damage after the third spray reveal that at third day after third spray, spinosad 45 SC (200 ml/ha) was most effective as it exhibited only with a mean of 7.16 per cent fruit damage. It was followed by of Ha-NPV (250 LE) and Bt (1.5 kg/ha) with mean fruit damage of 11.33 and 12.43 per cent, respectively. Spray of Neem oil (3%) with 21.29 per cent and per cent fruit damage as against 37.20 per cent in untreated control. After five days of spraying spinosad 45 SC (200 ml/ha) was most effective with minimum mean fruit damage 5.45 per cent. Seven days after spraying again spinosad 45 SC (200 ml/ha) was most effective with mean fruit damage 7.74 per cent.

Marketable yield : The marketable yield of tomato among different treatment ranged from 52.06 to 108.55 kg/plot (Table 3). The highest marketable yield of 108.55 kg/plot was recorded in case of Spinosad 45 SC (200 ml/ha). It was significantly higher than all other treatments. It was followed by Ha-NPV (250 LE/ha) and Bt (1.5 kg/ha) which yielded 97.80 kg/plot and 94.06 kg/plot. Neem oil (3%) and which yielded 72.23 kg/plot against 52.06 kg/plot in control.

Economics and cost benefit ratio : The data presented in Table 4 revealed that all the treatments were found to be profitable over control. The maximum net profit of Rs. 193650 and the highest cost benefit ratio of 1:2.056, were recorded for spinosad 45 SC (200 ml/ha). It was followed by Ha-NPV (250 LE/ha) and Bt (1.5 kg/ha) with the net profit and C: B ratio of Rs. 155415, 143910 and 1:1.843, 1:1.781, respectively. The minimum net profit and cost benefit ratio of Rs. 67290 and 1:1.366 were recorded for Neem oil (3%).

These findings are in close conformity with the findings of Gosh *et al.* (2010) who reported that spinosad 45 SC @ 200 ml/ha was significantly superior in reducing *H. armigera* population and fruit damage in tomato. Similarly, the effectiveness of spinosad 45 SC (200 ml/ha) against *H. armigera* was also reported by Ghosal et al. (2012) in tomato. In the present investigation Spinosad 45SC also found effective. Boomathi *et al.* (2006) tested the toxicity of spinosad alone or in combination with the microbial insecticide (Ha-NPV) against second and third instar larvae of *H. armigera* in the laboratory. Spinosad alone (75 g a.i./ha) or in combination with Ha-NPV (1.5 x 10^{12} POBs/ml) recorded 100% mortality, 24 hours after treatment. Siddegowda *et al.* (2006) reported that Spinosad 45SC @ 22.5 g a.i./ha recorded significantly lower pod damage (6.68%) compared to other chemicals.

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