



Field Assessment of Insecticides as Well as Bio-Pesticides to Manage the Tomato Fruit Borer *Helicoverpa armigera* Hubner

Sneh Yadav ^{a*}, R. K. Pal ^a, Ajay Kumar Yadav ^b, Ankit Singh Yadav ^c and Gurwaan Singh ^d

^a Department of Entomology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur-208002, Uttar Pradesh, India.

^b Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur-208002, Uttar Pradesh, India.

^c Faculty of Agricultural Sciences, J.S. University, Shikohabad Distt., Firozabad-283135, Uttar Pradesh, India.

^d Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur-208002, Uttar Pradesh, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted for the management of tomato fruit borer in the winter period of 2021-22 at the Vegetable Research Station of C.S.A. University, Kanpur. The current study assessed the effectiveness of some novel insecticides as well as bio-pesticides on the Azad T-6 cultivar of tomato crop. Our team used chemical insecticides such as Flubendiamide 39.35% S.C. (Suspension concentrate), Chlorantraniliprole 18.5% S.C. and Fipronil 5% S.C. and bio-pesticides viz. Spinosad 45% S.C., *Helicoverpa armigera* nuclear polyhedrosis virus (*HaNPV*) 2% A.S. (Aqueous suspension), *Bacillus thuringiensis* subsp. *kurstaki* (Bt) 5% W.P. (Wettable powder) and *Neemarin* 1500 ppm (parts per million) at their suggested quantity. The observations on the number of larvae were recorded from ten arbitrarily tagged plants in each plot treated with insecticides and bio-pesticides. It was recorded that Flubendiamide 39.35% S.C. @ 0.2 ml/lit was

found to be the most efficient against the fruit borer larvae trailed by Chlorantraniliprole 18.50% S.C. @ 0.3 ml/lit in decreasing the larval population and displayed maximum percent decrease in fruit infestation over untreated control. Amongst the bio-pesticides, Spinosad 45% S.C. @ 0.2 ml/lit was found to be the maximum effective over untreated control. All the used insecticides and bio-pesticides in the existing field experiment were found to be superior to the control.

Keywords: *Bacillus thuringiensis*; Flubendiamide; larval population; Spinosad.

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is a member of the family Solanaceae. It stays as one of the furthermost vital, remunerative vegetable crops with huge marketable and nourishing worth. The tomato crop has a wide variety of climatical adaptableness. It is cultivated in tropical and subtropical areas globally for fresh fruits and processing uses. It is the world's greatest consumed vegetable crop afterward potato and sweet potato. The tomato plant originated in Peru in South America [1]. It dispersed from America to other portions of the world during the 16th century period. It was introduced in India by Vasco-De-Gama, an innate Portuguese. The important tomato-growing nations of the world are China, India, Turkey, The United States of America, Egypt, Italy and Iran. The maximum production of tomatoes in the world is from China (62.80 million tonnes) trailed by India (20.30 million tonnes) (FAOSTAT 2021). India is the 2nd largest producer of vegetables in the world after China. In India, tomato is grown in an 831-thousand-hectare land area. Andhra Pradesh, Madhya Pradesh, Karnataka, Gujrat and Odisha are the main producer states of tomatoes in India [2]. Whereas, in Uttar Pradesh, the yearly production of tomatoes is 902 thousand tonnes from a 20.88-thousand-hectare land area [3]. But, in the background of the growing population, the everyday requirement for tomatoes is mounting. So, additional yield is desired from the existing per capita land area. But again, the land is a restrictive resource for farming and there is no choice but to produce additional food and other agrarian commodities from the current amount of per capita land area. So, the enhanced yield must come from the existing area. Also, this must be accomplished ecologically, profitably and by a justifiable method. Tomato production in India is significantly lesser because of numerous reasons, of which the harm triggered by pests is of great significance [4]. However, considerable financial loss is instigated by the tomato fruit borer. Crop losses due to this pest are projected at about 20 % to 70 % in India [5]. Tomato

fruit borer, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is the greatest damage-causing insect pest instigating a typical 41.45 % injury to fruits, dipping the market worth, quality of the fruit and causing a production loss of 30 % in overall and up to 35 % in Uttar Pradesh [6]. The problem of *Helicoverpa armigera* is enhanced due to its unambiguous attack on the fruits, voracious feeding behaviour, high movement and multivoltine overlapping generations. Losses of millions of rupees only due to this pest have been described in many crops like chickpea, cotton, pigeon pea, groundnut, tomato and other crops of financial importance [7]. Tomato being a commercial vegetable crop, growers tend to misuse and even ruthlessly abuse insecticides to control this damaging pest. As a consequence, it has triggered unrest in the environment. It has directed to numerous harmful consequences like the build-up of insecticide resistance, pest resurgence, the killing of natural competitors of pests and insecticide residue deposit in the tomato crop. In such circumstances, novel groups of insecticides and biological pesticides offer great possibility as they keep higher toxicity towards insects at lesser quantities and are not as persistent as the conventional group of chemicals [8]. Such insecticides are also harmless to natural competitors of pests and the environment. To evade the adversative consequences of traditional insecticides on the non-target creatures, nature and health, it turns out to be essential to assess the novel insecticides which are also effective at very low amounts. Henceforth keeping in sight, the benefits of using novel insecticides and bio-pesticides against tomato fruit borer *Helicoverpa armigera* (Hubner) on tomato (*Solanum lycopersicum* L.), their performance under field conditions was assessed.

2. MATERIALS AND METHODS

The experiment was placed out in the randomized block design (RBD) with eight treatments and three replications in the field. The transplantation of plantlets was completed on

30th October 2021. The soil of the investigational field was sandy loam with normal fertility. Likewise, the field was well leveled having decent drainage with an irrigation facility. Saplings of tomato cultivar - Azad T-6 were transplanted in 3.0×2.7 m² plots in an arrangement of 60×45 cm along with suggested typical agronomical practices excluding crop protection measures. The respective insecticides and bio-pesticides were sprayed on the tomato crop manually by using a hand compression sprayer. For comparison of the performance, all the applied insecticides and bio-pesticides, as well as untreated control were maintained. The initial spray application was made at the appearance of the pest 60 days afterward transplanting, the second and the third spray were performed 15 and 30 days afterward the initial spray.

2.1 Observations

Observations were noted by counting the number of larvae per plant on ten arbitrarily tagged plants per plot on the 5th, 10th and 15th day correspondingly, after each spray. The observations on the percentage infestation of tomato fruits by fruit borer were calculated at all pickings by counting the injured and healthy fruits.

2.2 Preparation of Spray Solution

The concentration of chemicals based on their active ingredients, the desired quantity of every insecticide and the bio-pesticide was measured by using a micro-pipette and electronic balance and then finally mixed with the recommended quantity of water. The preparation was diluted with water just before spraying with the assistance of an atomizer.

$$\text{Amount of insecticide} = \frac{\text{Concentration requirement (\%)} \times \text{volume required (lit.)}}{\text{Concentration of toxicant in insecticide (\%)}}$$

2.3 Statistical Analysis

The trial for assessing insecticides and bio-pesticides was placed out in Randomized Block Design with three replications and eight treatments in the field for calculating the infestation percentage of *Helicoverpa armigera*. All the data was scrutinized statistically to compare the treatment consequence on the larval population of fruit borer. The larval population data was converted by using square root transformation as $\sqrt{x + 0.5}$ values (where

x=observed insect population per plot). The statistical study was made to determine the standard error and critical difference at a 5% significance level and was calculated by using the following equations.

$$SE(d) = \sqrt{\frac{2EMS}{r}}$$

SE(d)= Standard Error of Difference
EMS= error mean sum of square
r= Replication

$$CD = SE(d) \times t (5\%)$$

CD= Critical difference
t= Table value at 5% probability level

$$\text{Percent reduction over control} = \frac{C-T}{C} \times 100$$

Where,

C= Percent total number of larvae in untreated or control plot.

T= Percent total number of larvae in the treated plot by different insecticides and bio-pesticides.

3. RESULTS AND DISCUSSION

The outcomes represented that all the treatments efficiently reduced the larval population of tomato fruit borer when compared to the untreated control (Table 1 and 2).

From the outcome of the initial spray, Flubendiamide 39.35 % S.C. reported the minimum number of larvae trailed by Chlorantraniliprole 18.5 % S.C. and Fipronil 5 % S.C. Flubendiamide 39.35 % S.C., Chlorantraniliprole 18.5 % S.C. and Fipronil 5 % S.C. were significantly superior over the rest of the treatments. Amongst bio-pesticides, Spinosad 45 % S.C. offered the best outcomes trailed by *HaNPV* 2 % A.S. and *Bt* 5 % W.P. *Neemarin* 1500 ppm was found minimum effective but better performed when compared to the untreated control. The observations were noted on the mean quantity of larvae of *H. armigera* afterward the 5th day of the initial spray i.e., 1.23, 1.40, 1.73, 2.06, 2.16, 2.56 and 2.60 correspondingly. In the circumstance of percent reduction of the larval population over untreated control presented that Flubendiamide 39.35 % S.C. was maximum effective having least fruit infestation with 78.90 % reduction over untreated

control trailed by Chlorantraniliprole 18.5 % S.C., Fipronil 5 % S.C., Spinosad 45 % S.C., *HaNPV* 2 % A.S., Bt 5 % W.P. and *Neemarin* 1500 ppm i.e., 75.98 %, 70.32 %, 64.66 %, 62.95 %, 56.08 % and 55.40 % correspondingly. Afterward, on the 10th day of initial spray Flubendiamide 39.35 % S.C., Chlorantraniliprole 18.5 % S.C., Fipronil 5 % S.C., Spinosad 45 % S.C., *HaNPV* 2 % A.S., Bt 5 % W.P. and *Neemarin* 1500 ppm efficiently reduced the larval population up to 1.80, 1.90, 1.96, 2.70, 2.86, 3.10 and 3.20 correspondingly. In instance of percent reduction of larval population over untreated control exhibited i.e., 80.91 %, 79.85 %, 79.21 %, 71.36 %, 69.67 %, 67.12 % and 66.06 % correspondingly. Observations were noted afterward on the 15th day of the initial spray which presented a maximum decrease of the larval population with the application of Flubendiamide 39.35 % S.C. trailed by Chlorantraniliprole 18.5 % S.C., Fipronil 5 % S.C., Spinosad 45 % S.C., *HaNPV* 2 % A.S., Bt 5 % W.P. and *Neemarin* 1500 ppm i.e., 1.13, 1.43, 1.56, 1.86, 2.20, 2.27 and 2.50 correspondingly. While in instance of percent reduction in fruit infestation over untreated control i.e., 85.32 %, 81.42 %, 79.74 %, 75.84 %, 71.42 %, 70.51 % and 67.53 % correspondingly.

Subsequently afterward the second spray, the fruit borer larvae population was again documented lower in plots treated with Flubendiamide 39.35 % S.C., Chlorantraniliprole 18.5 % S.C. and Fipronil 5 % S.C. In the event of bio-pesticides, Spinosad 45 % S.C. was again detected best trailed by *HaNPV* 2 % A.S., Bt 5 % W.P. and *Neemarin* 1500 ppm. Flubendiamide 39.35 % S.C. and Chlorantraniliprole 18.5 % S.C. were significantly superior to the rest of the treatments. The mean larval population number was noted afterward on the 5th, 10th and 15th day of the second spray i.e., 2.00, 2.70, 3.00, 3.26, 3.63, 3.96 and 4.20 correspondingly after the 5th day, 1.76, 2.20, 2.86, 3.10, 3.46, 4.43 and 4.60 correspondingly afterward the 10th day and 1.26, 1.70, 2.10, 2.36, 2.96, 3.53 and 3.80 correspondingly afterward the 15th day. In event of percent reduction of fruit infestation over untreated control afterward the 5th, 10th and 15th day of second spray i.e., 83.27 %, 77.42 %, 74.91 %, 72.74 %, 69.64 %, 66.88 % and 64.88 % correspondingly after the 5th day, 87.02 %, 83.77 %, 78.90 %, 77.13 %, 74.48 %, 67.33 % and 66.07 % correspondingly afterward the 10th day and 89.96 %, 86.46 %, 83.28 %, 81.21 %, 76.43 %, 71.89 % and 69.74 % correspondingly afterward the 15th day of 2nd spray on ten arbitrarily designated plants.

Finally, in the third spray, the outcome exhibited that entirely all the treatments once again efficiently diminished the larval population of *H. armigera* when analysed against the untreated control. Plots applied with Flubendiamide 39.35 % S.C. was found maximum efficient trailed by Chlorantraniliprole 18.5 % S.C. and Fipronil 5 % S.C. In the situation of bio-pesticides, Spinosad 45 % S.C. was detected as leading trailed by *HaNPV* 2 % A.S., Bt 5 % W.P. and *Neemarin* 1500 ppm. Flubendiamide 39.35 % S.C., Chlorantraniliprole 18.5 % S.C. and Fipronil 5 % S.C. were found significantly superior over the remaining treatments. The mean larval population was noted afterward the 5th, 10th and 15th day afterward the final spray i.e., 1.90, 2.30, 2.66, 3.10, 3.30, 3.86 and 3.95 correspondingly afterward the 5th day, 1.66, 1.90, 2.10, 2.40, 2.90, 3.60 and 3.80 correspondingly afterward the 10th day and 1.33, 1.76, 1.90, 2.10, 2.60, 3.23 and 3.50 correspondingly afterward the 15th day. In circumstance of percent reduction in fruit infestation over the untreated control afterward the 5th, 10th and 15th day of final spray i.e., 83.47 %, 80.00 %, 76.86 %, 73.04 %, 71.30 %, 66.43 % and 65.65 % correspondingly afterward the 5th day, 87.75 %, 85.98 %, 84.51 %, 82.30 %, 78.61 %, 73.45 % and 71.97 % correspondingly afterward the 10th day and 88.78 %, 85.16 %, 83.97 %, 82.29 %, 78.07 %, 72.76 % and 70.48 % correspondingly after the 15th day of third spray on ten arbitrarily tagged plants.

The outcomes of the current study are in agreement with the conclusions of [9] who described that Flubendiamide @ 48 g a.i./ha produced a significant mean reduction of fruit borer larvae population with 65.20 %, 77.50 % and 84.60 % five days afterward the first, second and third spray during the year 2005-06, respectively and it was 70.00 %, 75.40 % and 86.20 % during the year 2006-07. The effectiveness of some pesticides with a new mode of action such as Spinosad, Rynaxypyr, Indoxacarb and Flubendiamide for the control of *Helicoverpa armigera* on tomato crop (Var. *Pathorkuchi*) in farm circumstances. Pesticides applied thrice at 15 days afterward fruit borer population build-up presented that Rynaxypyr 18.5 % S.C. @ 40 g a.i./ha was superior over the rest of the treatments against *Helicoverpa armigera*, with 98.04 % reduction trailed by Spinosad 45 % S.C. @ 60 g a.i./ha (88.03 %) [10]. Flubendiamide 480 S.C. at 200 ml/ha was found to be significantly better with the highest efficiency, which produced the maximum mean

Table 1. The larval population of *Helicoverpa armigera* (Hubner) after the 5th, 10th and 15th day of the first, second and third spray (DAS: Days after spray)

Treatments	Dose/ lit of water	Mean number of larvae of <i>H. armigera</i> per ten plants								
		After 1 st spray			After 2 nd spray			After 3 rd spray		
		5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS
Flubendiamide 39.35 % S.C.	0.2 ml	1.23 (1.31)	1.80 (1.51)	1.13 (1.27)	2.00 (1.58)	1.76 (1.50)	1.26 (1.32)	1.90 (1.54)	1.66 (1.46)	1.33 (1.35)
Chlorantraniliprole 18.5 % S.C.	0.3 ml	1.40 (1.37)	1.90 (1.54)	1.43 (1.38)	2.70 (1.78)	2.20 (1.64)	1.70 (1.48)	2.30 (1.67)	1.90 (1.54)	1.76 (1.50)
Fipronil 5 % S.C.	1.0 ml	1.73 (1.49)	1.96 (1.56)	1.56 (1.43)	3.00 (1.87)	2.86 (1.83)	2.10 (1.61)	2.66 (1.77)	2.10 (1.61)	1.90 (1.54)
Spinosad 45 % S.C.	0.2 ml	2.06 (1.60)	2.70 (1.78)	1.86 (1.53)	3.26 (1.93)	3.10 (1.89)	2.36 (1.69)	3.10 (1.89)	2.40 (1.70)	2.10 (1.61)
HaNPV 2 % A.S.	1.0 ml	2.16 (1.63)	2.86 (1.83)	2.20 (1.64)	3.63 (2.03)	3.46 (1.98)	2.96 (1.86)	3.30 (1.94)	2.90 (1.84)	2.60 (1.76)
Bt 5 % W.P.	1.5 gm	2.56 (1.74)	3.10 (1.89)	2.27 (1.66)	3.96 (2.11)	4.43 (2.22)	3.53 (2.00)	3.86 (2.08)	3.60 (2.02)	3.23 (1.93)
Neemarin 1500 ppm	3.0 ml	2.60 (1.76)	3.20 (1.92)	2.50 (1.73)	4.20 (2.16)	4.60 (2.25)	3.80 (2.07)	3.95 (2.10)	3.80 (2.07)	3.50 (2.00)
Control		5.83 (2.51)	9.43 (3.15)	7.70 (2.86)	11.96 (3.52)	13.56 (3.74)	12.56 (3.61)	11.50 (3.46)	13.56 (3.74)	11.86 (3.51)
S.E. (D)±		0.25	0.26	0.22	0.38	0.34	0.32	0.44	0.22	0.32
C.D. at 5 %		0.55	0.57	0.48	0.82	0.73	0.69	0.95	0.49	0.70

$\sqrt{x + 0.5}$ transformed values are given in parenthesis

Table 2. Effectiveness of treatments against the larval population of *Helicoverpa armigera* (Hubner) after the 5th, 10th and 15th day of first, second and third spray (DAS: Days after spray)

Treatments	Dose/ lit of water	% Reduction of the larval population of <i>H. armigera</i> over control per ten plants									
		After 1 st spray			After 2 nd spray			After 3 rd spray			Overall Mean (%)
		5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS	
Flubendiamide 39.35 % S.C.	0.2 ml	78.90	80.91	85.32	83.27	87.02	89.96	83.47	87.75	88.78	85.04
Chlorantraniliprole 18.5 % S.C.	0.3 ml	75.98	79.85	81.42	77.42	83.77	86.46	80.00	85.98	85.16	81.78
Fipronil 5 % S.C.	1.0 ml	70.32	79.21	79.74	74.91	78.90	83.28	76.86	84.51	83.97	79.07
Spinosad 45 % S.C.	0.2 ml	64.66	71.36	75.84	72.74	77.13	81.21	73.04	82.30	82.29	75.61
HaNPV 2 % A.S.	1.0 ml	62.95	69.67	71.42	69.64	74.48	76.43	71.30	78.61	78.07	72.50
Bt 5 % W.P.	1.5 gm	56.08	67.12	70.51	66.88	67.33	71.89	66.43	73.45	72.76	68.05
Neemarin 1500 ppm	3.0 ml	55.40	66.06	67.53	64.88	66.07	69.74	65.65	71.97	70.48	66.42
Control		0	0	0	0	0	0	0	0	0	0

reduction of fruit borer larvae by recording 89.94 % [11]. Furthermore, Rynaxypyr 18.5 S.C. @ 40 g a.i./ha was superior to the rest of the treatments against *Helicoverpa armigera* with a 98.04 % decrease in the fruit borer larvae population [12]. The effectiveness of two microbial bio-pesticides such as *HaNPV* @ 0.40 ml/L and *Bt* @ 2.0 g/L along with their combination against *H. armigera*. The least fruit infestation both in number and weight basis was found from treatment *HaNPV* and *Bt* with alternate spraying (11.78 %, 9.64 %) trailed by *Bt* (13.25 %, 10.85 %) and *HaNPV* (17.67 %, 13.11 %) [13]. The comparative effectiveness of nine diverse pesticides against *Helicoverpa armigera* (Hubner) in tomato crop in the winter season revealed that all nine pesticides were significantly superior to control in reducing *H. armigera* damage. But, Flubendiamide noted a least larval population (0.43 larva per plant) and 10.09 % fruit injury on a weight basis to the rest of the treatments which was similar to Chlorantraniliprole (0.58 larvae per plant and 10.62 % fruit injury) and Spinosad (0.68 larvae per plant and 11.34 % fruit injury) [14]. The % inflorescence injury because of pod borer was least in Chlorantraniliprole 18.5 % S.C. (2.08 %) and Flubendiamide 39.35 % S.C. (3.64 %) trailed by Spinosad 45 % S.C. (6.21 %) as against untreated control (31.18 %) with 93.30 %, 88.30 % and 80.10 % reduction over untreated control correspondingly. Likewise, pod injury due to legume pod borer was recorded least in Chlorantraniliprole (4.30 %), Flubendiamide (6.03 %) and Spinosad (8.80 %) as against untreated control (47.28 %) with 90.90 %, 87.30 % and 81.40 % reduction over untreated control correspondingly [15]. Nine novel and biorational pesticides were assessed against fruit borer larvae, *Helicoverpa armigera* damaging tomato in the wintertime. Amongst nine pesticides such as Indoxacarb 14.5 S.C. (0.01 %) was observed with the greatest efficiency against fruit borer larvae trailed by Novaluron 10 % E.C. (0.01 %) and Acephate 75 % S.P. (0.037 %). *Bacillus thuringiensis* (0.012 %) showed the least effectiveness trailed by *HaNPV* (250 L.E. per ha) and Quinalphos 25 % E.C. (0.02 %). The results of Chlorantraniliprole 18.5 % SC (0.02 %), Abamectin 5 % S.G. (0.01%) and Spinosad 2.5 % S.C. (0.01 %) were in mid order in terms of their effectiveness [16].

4. CONCLUSION

From the above discussion, it was found that spraying of insecticides and bio-pesticides

significantly reduced the fruit borer larvae population in tomato crop. The present trial on the effectiveness of insecticides along with bio-pesticides showed that Flubendiamide 39.35 % S.C. was maximum efficient and exhibited the best overall percent for larval reduction i.e., (85.04 %) trailed by Chlorantraniliprole 18.5 % S.C. (81.78 %) and Fipronil 5 % S.C. (79.07 %). On the other hand, among the bio-pesticides, Spinosad 45 % S.C. provided the outstanding outcomes i.e., (75.61 %), followed by *HaNPV* 2 % A.S. (72.50 %), *Bt* 5 % W.P. (68.05 %) and *Neemarin* 1500 ppm (66.42 %) over the untreated control, respectively. Henceforth, it can be interpreted that a novel group of insecticides along with bio-pesticides should be utilized in harmony with the present Integrated Pest Management practices to evade the complications associated with insecticidal resistance, pest resurgence, etc.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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