Original Research Article

Field assessmentof insecticides as well as bio-pesticides to managethe tomato fruit borer*Helicoverpaarmigera* Hubner

ABSTRACT

A field experiment was conducted for the management of tomato fruit borerin thewinterperiodof 2021-22 at the Vegetable Research Station of C.S.A. University, Kanpur. The currentstudyassessed the effectiveness of some novelinsecticides as well asbio-pesticides on the Azad T-6 cultivar of tomato crop.Our teamused chemical insecticides such as Flubendiamide 39.35% S.C. (Suspension concentrate), Chlorantraniliprole 18.5% S.C. andFipronil 5% S.C. andbio-pesticides viz. Spinosad 45% S.C., *Helicoverpaarmigera*nuclear polyhedrosis virus (*Ha*NPV) 2% A.S. (Aqueous suspension), *Bacillusthuringiensis*subsp. *kurstaki* (Bt)5% W.P.(Wettable powder) and*Neemarin* 1500 ppm (parts per million) at their suggestedquantity. The observations on the number of larvae wererecorded from ten arbitrarilytagged plants in each plot treated with insecticides andbio-pesticides. It was recorded that Flubendiamide 39.35% S.C. @ 0.2 ml/lit was found to be the most efficient against the fruitborerlarvae trailed by Chlorantraniliprole 18.50 % S.C. @ 0.3 ml/litin decreasing the larval population anddisplayedmaximum percent decrease in fruit infestation over untreated control.Amongst the bio-pesticides,Spinosad 45% S.C. @ 0.2 ml/litwasfound to be the maximum effective over untreated control. All theusedinsecticides andbio-pesticides in the existing field experiment were found to be superior to thecontrol.

Keywords: *Bacillusthuringiensis*; Flubendiamide; larval population;Spinosad.

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.)is a memberof the family Solanaceae. It staysas one of the furthermostvital,remunerative vegetable crops with hugemarketable andnourishingworth. The tomato crop has a widevariety of climaticaladaptableness. It is cultivated in tropical andsubtropicalareasglobally for fresh fruits and processing uses. It is the world's greatestconsumed vegetable crop afterwardpotato and sweet potato. The tomato plantoriginated in Peruin South America[1]. It dispersed from America to other portions of the world during the 16th century period. Itwas introduced inIndia by Vasco-De-Gama, aninnate Portuguese. The important tomato-growing nationsof the world areChina, 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 afterChina. In India, tomato is grown in an 831-thousand-hectare land area with a yearlyyield of 20.30million tonnes. 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-hectarelandarea [3].But, in the background of the growing population, the everydayrequirement for tomatoes is mounting. So, additionalyield is desired from the existing per capita land area. Butagain, the land is a restrictive resource forfarming and there is no choicebut to produce additional food and other agrarian commodities from thecurrent amountof per capitaland area. So, the enhanced yield must comefrom the existingarea. Also, this must be accomplishedecologically, profitably andby a justifiablemethod. Tomato production in India is significantlylesser because of numerousreasons, of which the harmtriggered bypests is ofgreatsignificance [4].However, considerablefinancialloss is instigated by the tomato fruit borer. Crop losses due to this pest are projected at about 20 %to70% in India[5]. Tomato fruit borer, *Helicoverpaarmigera* (Hubner) (Lepidoptera: Noctuidae)is the greatestdamage-causing insect pest instigatinga typical41.45% injury to fruits, dipping the market worth,quality of the fruitandcausing a production loss of30% in overall and up to 35% in Uttar Pradesh [6]. The problem of *Helicoverpaarmigera* is enhanced due to its unambiguous attack on the fruits, voracious feeding behaviour, high movementand multivoltine overlapping generations. Losses of millions of rupeesonly due to this pesthave 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 controlthis damaging pest. As a consequence, it has triggeredunrest in the environment. It has directed to numerousharmful consequences like the build-up of insecticide resistance, pest resurgence,the killing of natural competitors of pests and insecticide residue depositin the tomato crop. In such circumstances,novel groups of insecticides and biological pesticidesoffer great possibility as they keep higher toxicity towards insects at lesserquantities and are not as persistent as the conventional group of chemicals[8]. Such insecticides are alsoharmless to natural competitors ofpests and the environment. To evade the adversative consequences of traditional insecticides on the non-target creatures, nature and health, it turns out to beessential to assess the novel insecticides which arealso effective at very low amounts.Henceforth keeping in sight,the benefits of usingnovelinsecticides andbio-pesticides against tomato fruit borer *Helicoverpaarmigera* (Hubner) on tomato(*Solanum lycopersicum* L.),their performance under field conditions wasassessed.

2. MATERIAL AND METHODS

The experiment was placed out in the randomized block design (RBD) with eight treatmentsand three replications in the field. The transplantation of plantlets was completed on 30th October 2021. The soilof the investigational field was sandy loam with normal fertility. Likewise, the field was well leveled having decentdrainagewithan irrigation facility. Saplings of tomato cultivar - Azad T-6 were transplanted in 3.0×2.7 m^2 plots inanarrangement of 60×45 cm along with suggestedtypical agronomical practices excludingcrop protection measures. The respective insecticides andbio-pesticides were sprayed on the tomato crop manually by usinga hand compression sprayer. Forcomparison of the performance, all the applied insecticides and bio-pesticides, as well as untreated control were maintained. The initial spray application was made at theappearance of the pest 60 days afterward transplanting,the second andthe third spray wereperformed15 and 30 days afterward the initial spray.

2.1 OBSERVATIONS

Observations were noted by counting the number of larvae per plant on ten arbitrarilytagged plants per plot on the 5^{th}, 10^{th} and 15^{th} day correspondingly, after each spray. The observations onthe 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 chemicalsbased ontheiractive ingredients, the desiredquantity of everyinsecticide andthe bio-pesticide was measured by using a micro-pipette and electronic balance and then finally mixed with the recommendedquantity of water. The preparation was diluted with water justbeforespraying with the assistance of an atomizer.

1.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 assessinginsecticides andbio-pesticideswas placed out in Randomized Block Design with three replications and eight treatments in the field for calculating the infestation percentage of *Helicoverpa armigera.* All thedatawasscrutinized statistically to compare the treatment consequence on the larval population of fruit borer. The larval population data was convertedbyusing 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 andwas calculated by using the followingequations.

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

SE(d)= Standard Error of Difference

EMS= error mean sum of square

r= Replication

2.CD= SE(d) × t (5%)

CD= Critical difference

t= Table value at 5% probability level

3. Percent reduction over control= $\frac{C-T}{C}$×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 andbio-pesticides.

3. RESULTS AND DISCUSSION

The outcomesrepresented that all the treatmentsefficientlyreduced 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.reportedthe minimum number of larvae trailed by Chlorantraniliprole 18.5% S.C. andFipronil 5% S.C. Flubendiamide 39.35% S.C., Chlorantraniliprole 18.5% S.C. andFipronil 5% S.C. were significantly superior over the rest of the treatments. Amongstbio-pesticides,Spinosad 45% S.C.offeredthe bestoutcomestrailed by *Ha*NPV 2% A.S. andBt 5% W.P.*Neemarin*1500 ppm was found minimum effective but betterperformed when compared to the untreated control.The observations were noted on the mean quantity of larvae of *H. armigera*afterwardthe 5^{th} 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., *Ha*NPV 2% A.S., Bt5% 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 10^{th} day of initial spray Flubendiamide 39.35% S.C., Chlorantraniliprole 18.5% S.C., Fipronil 5% S.C., Spinosad 45% S.C., *Ha*NPV 2% A.S.,Bt5% W.P. and*Neemarin* 1500 ppm efficientlyreduced the larval population up to 1.80, 1.90, 1.96, 2.70, 2.86, 3.10 and 3.20correspondingly. In instance of percent reduction of larval population over untreated controlexhibited i.e., 80.91%, 79.85%, 79.21%, 71.36%, 69.67%, 67.12% and 66.06% correspondingly. Observations were notedafterwardon the 15^{th} day of the initial spray which presenteda 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., *Ha*NPV 2% A.S.,Bt5% 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 afterwardthe second spray, the fruit borer larvae populationwas again documented lowerin plots treated with Flubendiamide 39.35% S.C., Chlorantraniliprole 18.5% S.C. andFipronil 5% S.C. In the event of bio-pesticides, Spinosad 45% S.C. was again detected best trailed by *Ha*NPV 2% A.S.,Bt5% W.P. and*Neemarin* 1500 ppm. Flubendiamide 39.35% S.C. andChlorantraniliprole 18.5% S.C. were significantly superior to the rest of the treatments. The mean larval population number was notedafterwardon the 5^{th}, 10^{th} and 15^{th} 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 5^{th} day, 1.76, 2.20, 2.86, 3.10, 3.46, 4.43 and 4.60 correspondinglyafterward the 10^{th} day and 1.26, 1.70, 2.10, 2.36, 2.96, 3.53 and 3.80 correspondinglyafterward the 15^{th} day. In event of percent reduction of fruit infestation over untreated control afterward the 5^{th}, $10^{th}$and 15^{th} day of second spray i.e., 83.27%, 77.42%, 74.91%, 72.74%, 69.64%, 66.88%and 64.88% correspondingly after the 5^{th} day, 87.02%, 83.77%, 78.90%, 77.13%, 74.48%, 67.33%and 66.07% correspondinglyafterward the 10^{th} day and 89.96%, 86.46%, 83.28%, 81.21%, 76.43%, 71.89%and 69.74% correspondinglyafterward the 15^{th} day of 2^{nd} spray on ten arbitrarilydesignated plants.

Finally, in the third spray, the outcomeexhibited that entirelyall the treatments once again efficientlydiminished the larval population of *H. armigera* when analysedagainstthe untreated control. Plots applied with Flubendiamide 39.35% S.C. was found maximumefficienttrailed by Chlorantraniliprole 18.5% S.C. andFipronil 5% S.C. In the situation of bio-pesticides, Spinosad 45% S.C. was detectedas leadingtrailed by *Ha*NPV 2% A.S,Bt5% W.P. and*Neemarin* 1500 ppm. Flubendiamide 39.35% S.C., Chlorantraniliprole 18.5% S.C. andFipronil 5% S.C. were found significantly superior over the remaining treatments. The mean larval population was notedafterward the 5th, 10thand 15th day afterward the final spray i.e., 1.90, 2.30, 2.66, 3.10, 3.30, 3.86 and3.95correspondinglyafterward the 5th day, 1.66, 1.90, 2.10, 2.40, 2.90, 3.60 and3.80correspondinglyafterward the 10th day and1.33, 1.76, 1.90, 2.10, 2.60, 3.23and 3.50correspondinglyafterward 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%and65.65% correspondinglyafterward the 5th day, 87.75%, 85.98%, 84.51%, 82.30%, 78.61%, 73.45% and71.97%correspondinglyafterward the 10th day and88.78%, 85.16%, 83.97%, 82.29%, 78.07%, 72.76%and70.48% correspondingly after the 15th day of third spray on ten arbitrarilytagged plants.

The outcomes of the currentstudy are in agreementwith the conclusions of[9]whodescribedthat 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 afterwardthe 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 andFlubendiamide for the control of *Helicoverpaarmigera* on tomato crop (Var. *Pathorkuchi*) in farmcircumstances. Pesticides applied thrice at 15 days afterwardfruit borer population build-up presented that Rynaxypyr 18.5% S.C. @ 40 g a.i./ha was superior over the rest ofthe 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 thehighest efficiency, which produced the maximum mean 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 ofthe 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*Ha*NPV @ 0.40 ml/L andBt@ 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 *Ha*NPVandBt withalternate spraying (11.78%, 9.64%) trailed by Bt(13.25%, 10.85%) and*Ha*NPV (17.67%, 13.11%)[13].The comparativeeffectiveness of nine diversepesticides against *Helicoverpaarmigera* (Hubner) in tomato cropin thewinterseason revealed that all nine pesticides were significantly superior tocontrol 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 ofthe 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 injurybecause 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 pesticideswere assessedagainst fruit borer larvae, *Helicoverpaarmigera* damaging tomato in thewintertime. Amongst nine pesticides such as Indoxacarb 14.5 S.C. (0.01%) was observedwiththe greatest efficiency against fruit borer larvaetrailed by Novaluron 10 % E.C. (0.01%) and Acephate 75 % S.P. (0.037%). *Bacillusthuringiensis*(0.012%) showedthe least effectivenesstrailed by *Ha*NPV (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 orderin terms of their effectiveness [16].

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

Treatments	Dose/ lit of water	Mean number of larvae of*H. armigera*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)
*Ha*NPV 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/ litof water**	**% Reduction of the larval population of *H. armigera* over control per ten plants**									
		After 1st spray			**After 2nd spray**			**After 3rd 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
*Ha*NPV 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

4. CONCLUSION

From the above discussion, it was found that spraying of insecticides andbio-pesticides significantly reduced the fruit borer larvae population in tomato crop. The present trialon theeffectiveness of insecticides alongwithbio-pesticidesshowed that Flubendiamide 39.35% S.C. wasmaximumefficient andexhibitedthe bestoverall percent forlarval reductioni.e., (85.04%) trailed by Chlorantraniliprole 18.5% S.C. (81.78%) andFipronil 5% S.C. (79.07%).On the other hand, among thebio-pesticides, Spinosad 45% S.C.providedthe outstandingoutcomes i.e., (75.61%), followed by *Ha*NPV 2% A.S. (72.50%), Bt5% W.P.(68.05%) and*Neemarin* 1500 ppm (66.42%) over the untreated control, respectively.Henceforth, it can beinterpreted that a novelgroup of insecticides alongwithbio-pesticidesshould be utilized in harmony with the present Integrated Pest Management practices to evade the complications associated with insecticidal resistance, pest resurgence, etc.

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