## ***Original Research Article***

**Evaluation of the efficacy of insecticides and biopesticides against *Helicoverpaarmigera* (Hubner) on tomato crop**


**ABSTRACT**

A field study was carried out for the control of Tomato fruit borer *Helicoverpaarmigera* during the *Rabi*(winter)season 2021-22 at Vegetable Research Station, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The present investigationevaluated the efficacy of insecticides and biopesticides on the Azad T-6 variety of tomato which was treated against Tomato fruit borer.We applied chemical insecticides viz. Flubendiamide 39.35% SC(Suspension concentrate), Chlorantraniliprole 18.5% SC and Fipronil 5% SC and biopesticides viz.Spinosad 45% SC, *Helicoverpaarmigera*nuclear polyhedrosis virus (*Ha*NPV) 2% AS(Aqueous suspension), *Bacillusthuringiensis*subsp. *kurstaki* (Bt)5% WP(Wettable powder) and Neemarin 1500 ppm at their recommended doses. The data on larval count was taken from ten randomly selected plants of each plot treated with insecticides and biopesticides separately. It was observed that Flubendiamide 39.35% SC @ 0.2 ml $lit^{-1}$ was found to be the most effective against the *Helicoverpaarmigera* followed by Chlorantraniliprole 18.5% SC @ 0.3 ml $lit^{-1}$ in reducing the larval population and showed highest percent reduction in fruit infestation over control. Among the biopesticides,Spinosad 45% SC @ 0.2 ml $lit^{-1}$ wasfound to be the most effective over untreated control. All the above treatments were found to be superior to untreated control.



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


## 1. INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) belongs to the family Solanaceae. It is one of the most essential and remunerative vegetable crops with immense commercial and nutritional value. Tomato has a wide range of climatic adaptability. It is grown in tropical and subtropical regions worldwide for fresh fruits and processing purposes. It is the world's most consumed vegetable crop after potato and sweet potato. The tomato originated from Peruin South America[1]. It spread from America to other parts of the world in the 16th century. Its transport was made in India by Vasco-De-Gama, a native of Portuguese. The leading tomato-growing countries in the world are China, India, Turkey, The United States of America, Egypt, Italy and Iran. The highest production of tomatoes in the world is from China (62.8 million tonnes) followed by India (20.3 million tonnes) (FAOSTAT 2021). India is the second largest producer of vegetables in the world next to China. In India, tomato is cultivated in an 831-thousand-hectare area with an annual production of 20300thousand tonnes. Andhra Pradesh, Madhya Pradesh, Karnataka, Gujrat and Odisha are the largest producer of tomatoes in India[2]. Whereas, in Uttar Pradesh, the annual production of tomatoes is 902 thousand tonnes from a 20.88-thousand-hectare area[3].However, in the background of the increasing population, the daily need for tomatoes is increasing. Therefore, more production is needed from per capita available land. But the land is a limiting resource of agriculture and there is no option except to produce more food and other agricultural commodities from less per capita available land. Therefore, increased production must come through increased yields from available land. Besides this should be achieved in an eco-friendly manner, cost-effective and sustainable manner. The tomato yield in India is considerably lower because of several factors, of which the damage caused by insect pests is the most important. It is devasted by various pests like fruit borer, whitefly, pinworms, serpentine leaf miner, aphids, spider mites and tobacco caterpillar [4].The prevalence of insect pests such as aphids, thrips, whitefly and leaf minerwere also found in significant numbers [5]. However, significant economic damage is caused by the fruit borer. Yield losses due to this pest are estimated at around 24 to 73% in India[6]. Tomato fruit borer, *Helicoverpaarmigera* (Hubner) (Lepidoptera: Noctuidae)is the most destructive insect pest causing average percent damage to fruits is 41.44%, reducing the market value and quality of the fruitandfound to cause a yield loss of up to 35% in general and up to 36% in Uttar Pradesh [7]. The problem of *Helicoverpaarmigera* is magnified due to its direct attack on fruiting structure, voracious feeding habits, high mobility, fecundity and multivoltine overlapping generations. Losses of millions of rupees solely due to this pesthave been reported in crops like chickpea, cotton, pigeon pea, groundnut,tomato and other crops of economic importance. Tomato being a commercial vegetable crop, farmers tend to overuse and even abuse insecticides in an ambitious approach to knock down this destructive pest. As a result, it has caused turbulence in the ecosystem. It has led to many problems like the build-up of insecticide resistance, pest resurgence, reduction or killing of natural enemies and insecticide residue in the tomato crop. In such a situation a newer group of insecticides and biological insecticides offer great scope as they maintain higher toxicity to insects at lower doses and are not persistent as the conventional group of insecticides[8]. Such insecticides are also reported safe to natural enemies and the environment. To avoid the adverse consequences of traditional insecticides on the non-target organism, environmental pollution, health hazard and the development of resistance, it becomes necessary to evaluate the new insecticides which are safe for natural enemies and the environment but also effective at very low doses.Hence keeping in view,the efficacy of new insecticides and biopesticides against tomato fruit borer, *Helicoverpaarmigera* (Hubner) on tomato, *Lycopersiconesculentum* (Mill.) under field conditions was evaluated.

## 2. MATERIALS AND METHODS

The field experiment was conducted during the *rabi*(winter)season of 2021-2022 at Vegetable Research Station, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The experiment was laid out in the randomized block design (RBD) with eight treatments (including untreated control) and three replications. The transplanting of seedlings was done on 30$^{th}$ October 2021. The soil type of the experimental field was sandy loam with average fertility. Also, the field was well leveled having good drainage and an adequate irrigation facility. Seedlings of Tomato variety Azad T-6 were transplanted in 3.0×2.7 m$^2$ plots with aspacing of 60×45 cm along with recommended standard agronomical practices except for crop protection measures. The respective insecticides and biopesticides were sprayed on the tomato crop manually by the hand compression sprayer. To compare the efficacy of treatments, both recommended insecticides, as well as untreated control was maintained. The first spray application was made at the initiation of pest at 60 days after transplanting, the second and third spraying was done at 15 and 30 days after the first spray.

## 2.1 OBSERVATIONS

Observations were recorded by counting the number of larvae per plant on ten randomly selected plants per plot on the $5^{th}$, $10^{th}$ and $15^{th}$ day respectively, after each spray. The data on the percentage infestation of tomato fruits by borer was calculated at each picking by counting the damaged and healthy fruits.

## 2.2 PREPARATION OF SPRAY SOLUTION

The concentration of insecticides based onthe active ingredient, the desired amount of each insecticide and the biopesticide was measured by micro-pipette and electronic balance and then mixed with the required amount of water. The formulation was diluted with water just at the time of spraying with the help 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 experiment for evaluating insecticides was laid out in Randomized Block Design with three replications and eight treatments for finding out the infestation percentage of *Helicoverpa armigera.* All the observations were analyzed statistically to compare the treatment effect on the larval population. The larval population data was transformed using square root transformation as$\sqrt{x + 0.5}$ values (where x=observed insect population per plot). The statistical analysis was made to determine the standard error and critical difference at a 5% significance level and calculated by the followingformula.

**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 and biopesticides.

## 3. RESULTS AND DISCUSSION

The results showed that all the insecticides and biopesticides effectively minimized the larval population of *H. armigera* when compared with the control (Table 1 and 2).

From the result of the first spray, Flubendiamide 39.35% SC recorded the least number of larvae followed by Chlorantraniliprole 18.5% SC and Fipronil 5% SC. Flubendiamide 39.35% SC, Chlorantraniliprole 18.5% SC and Fipronil 5% SC were significantly superior over the rest of the treatments. Among biopesticides,Spinosad 45% SC showed the best results followed by *Ha*NPV 2% AS and Bt 5% WP, whereas Neemarin 1500 ppm was found least effective but superior over the control.The observations were recorded on the mean number of larvae of *H. armigera* after the 5$^{th}$ day of the first spray i.e., 1.23, 1.40, 1.73, 2.06, 2.16, 2.56 and 2.60, respectively. In case of percent reduction of the larval population over control showed that Flubendiamide 39.35% SC was most effective having minimum fruit infestation with 78.90% reduction over control followed by Chlorantraniliprole 18.5% SC, Fipronil 5% SC, Spinosad 45% SC, *Ha*NPV 2% AS, Bt5% WP and Neemarin 1500 ppm i.e., 75.98%, 70.32%, 64.66%, 62.95%, 56.08% and 55.40%, respectively. After the 10$^{th}$ day of first spraying Flubendiamide 39.35% SC, Chlorantraniliprole 18.5% SC, Fipronil 5% SC, Spinosad 45% SC, *Ha*NPV 2% AS,Bt5% WPand Neemarin 1500 ppm effectively minimized the larval population up to 1.80, 1.90, 1.96, 2.70, 2.86, 3.10 and 3.20, respectively. In case of percent reduction of larval population over control showed i.e., 80.91%, 79.85%, 79.21%, 71.36%, 69.67%, 67.12% and 66.06%, respectively. Observations were recorded after the 15$^{th}$ day of the first spray which showed a maximum reduction of the larval population with the application of Flubendiamide 39.35% SC followed by Chlorantraniliprole 18.5% SC, Fipronil 5% SC, Spinosad 45% SC, *Ha*NPV 2% AS,Bt5% WPand Neemarin 1500 ppm i.e., 1.13, 1.43, 1.56, 1.86, 2.20, 2.27 and 2.50, respectively. Whereas in case of reduction in fruit infestation over control i.e., 85.32%, 81.42%, 79.74%, 75.84%, 71.42%, 70.51% and 67.53%, respectively.

After the second spray, the fruit borer population was once again recorded lower over control in plots treated with Flubendiamide 39.35% SC, Chlorantraniliprole 18.5% SC and Fipronil 5% SC. In the case of biopesticides, Spinosad 45% SC was observed best followed by *Ha*NPV 2% AS,Bt5% WPand Neemarin 1500 ppm. Flubendiamide 39.35% SC and Chlorantraniliprole 18.5% SC were significantly superior to the rest of the treatments. The mean larval population was recorded after the 5$^{th}$, 10$^{th}$ and 15$^{th}$ day after the second spraying i.e., 2.00, 2.70, 3.00, 3.26, 3.63, 3.96 and 4.20, respectively after the 5$^{th}$ day, 1.76, 2.20, 2.86, 3.10, 3.46, 4.43 and 4.60, respectively after the 10$^{th}$ day and 1.26, 1.70, 2.10, 2.36, 2.96, 3.53 and 3.80, respectively after the 15$^{th}$ day. In case of reduction in fruit infestation over control after the 5$^{th}$, 10$^{th}$ and 15$^{th}$ day of second spraying i.e., 83.27%, 77.42%, 74.91%, 72.74%, 69.64%, 66.88% and 64.88%, respectively after the 5$^{th}$ day, 87.02%, 83.77%, 78.90%, 77.13%, 74.48%, 67.33% and 66.07%, respectively after the 10$^{th}$ day and 89.96%, 86.46%, 83.28%, 81.21%, 76.43%, 71.89% and 69.74%, respectively after the 15$^{th}$ day on ten randomly selected plants per plot.

After the third spray, the result showed that all the treatments again effectively minimized the larval population of *H. armigera* when compared with the control. Plots treated with Flubendiamide 39.35% SC were found most effective followed by Chlorantraniliprole 18.5% SC and Fipronil 5% SC. In the case of biopesticides, Spinosad 45% SC was observed best followed by *Ha*NPV 2% AS,Bt5% WPand Neemarin 1500 ppm. Flubendiamide 39.35% SC, Chlorantraniliprole 18.5% SC and Fipronil 5% SC were found significantly superior to the rest of the treatments. The mean larval population was recorded after the 5$^{th}$, 10$^{th}$ and 15$^{th}$ day after the third spraying i.e., 1.90, 2.30, 2.66, 3.10, 3.30, 3.86 and 3.95, respectively after the 5$^{th}$ day, 1.66, 1.90, 2.10, 2.40, 2.90, 3.60 and 3.80, respectively after the 10$^{th}$ day and 1.33, 1.76, 1.90, 2.10, 2.60, 3.23 and 3.50, respectively after the 15$^{th}$ day. In case of reduction in fruit infestation over control after the 5$^{th}$, 10$^{th}$ and 15$^{th}$ day of second spraying i.e., 83.47%, 80.00, 76.86%, 73.04%, 71.30%, 66.43% and 65.65%, respectively after the 5$^{th}$ day, 87.75%, 85.98%, 84.51%, 82.30%, 78.61%, 73.45% and 71.97%, respectively after the 10$^{th}$ day and 88.78%, 85.16%, 83.97%, 82.29%, 78.07%, 72.76% and 70.48%, respectively after the 15$^{th}$ day on ten randomly selected plants per plot.

The results of the present investigation are in accordance with the results of[9]who reported that Flubendiamide @ 48 g a.i./ha caused a significant mean reduction of fruit borer larvae with 65.2, 77.5 and 84.6 percent at five days after the first, second and third spray during 2005-06, respectively and it was 70.0, 75.4 and 86.2 percent during 2006-07. The efficacy of some pesticides with a novel mode of action (Spinosad, Rynaxypyr, Indoxacarb, Flubendiamide) for the management of *Helicoverpaarmigera* on tomato (Var. Pathorkuchi) in field conditions. Insecticides applied thrice at 15 days after borer population build-up showed that Rynaxypyr 18.5% SC @ 40 g a.i./ha was superior over other treatments against *Helicoverpa*, with 98.04% reduction, closely followed by Spinosad 45% S.C. @ 60 g a.i./ha (88.03%) [10].Flubendiamide 480 SC at 200 ml/ha was found to be significantly the most effective, which caused the highest mean reduction of tomato fruit borer larvae by recording 89.94% [11]. Moreover,Rynaxypyr 18.5 SC @ 40 g a.i./ha was superior to other treatments against *Helicoverpa* with a 98.04 percent reduction in the fruit borer population [12].The efficacy of two microbial insecticides *Ha*NPV @ 0.4 ml/L and Bt@ 2 g/L along with their combination against *H. armigera*. The lowest fruit infestation (both in number and weight) was obtained from treatment *Ha*NPV and Btalternate spraying (11.78%, 9.64%) followed by Bt(13.25%, 10.85%) and *Ha*NPV (17.67%, 13.11%)[13].The relative efficacy of nine different insecticides against *Helicoverpaarmigera* (Hubner) in tomato during the *Rabi* (Winter) season revealed that all nine insecticides were significantly superior to untreated control in reducing *H. armigera* infestation. However, Flubendiamide recorded a minimum larval population (0.43 larva/plant) and 10.09 percent fruit damage on a weight basis to the remaining treatments which was identical to Chlorantraniliprole (0.58 larva/plant and 10.62% fruit damage) and Spinosad (0.68 larva/plant and 11.34% fruit damage) [14].The percent inflorescence damage due to pod borer was lowest in Chlorantraniliprole 18.5% SC (2.08%) and Flubendiamide 39.35% SC (3.64%) followed by Spinosad 45% SC (6.21%) as against control (31.18%) with 93.3, 88.3 and 80.1 percent reduction over control, respectively. Similarly, pod damage due to legume pod borer was lowest in Chlorantraniliprole (4.30%), Flubendiamide (6.03%) and Spinosad (8.80%) as against control (47.28%) with 90.9, 87.3 and 81.4 percent reduction over control, respectively [15].Nine newer and biorational insecticides were evaluated against fruit borer, *Helicoverpaarmigera* infesting tomato during the *rabi* (winter) season. Among nine insecticides, Indoxacarb 14.5 SC (0.01%) was found most effective against fruit borer followed by Novaluron 10 E.C. (0.01%) and Acephate 75 S.P. (0.037%). *Bacillusthuringiensis* 8 L (0.012%) proved least effective followed by *Ha*NPV (250 LE/ha) and Quinalphos 25 EC (0.02%). The treatments of Chlorantraniliprole 18.5% SC (0.02%), Abamectin 5 SG (0.01%) and Spinosad 2.5 SC (0.01%) ranked in middle order of their efficacy [16].

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

| Treatment | Dose lit⁻¹ of Water | Mean number of larval population (*H. armigera*)/ 10 plants | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | After 1st spray | | | After 2nd spray | | | After 3rd spray | | |
| | | 5 DAS | 10 DAS | 15 DAS | 5 DAS | 10 DAS | 15 DAS | 5 DAS | 10 DAS | 15 DAS |
| Flubendiamide 39.35% SC | 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% SC | 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% SC | 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% SC | 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% WP | 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 |
| CD 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. Efficacy of insecticides and biopesticides against the larval population of *Helicoverpa armigera* after the 5th, 10th and 15th day of first, second and third spray (DAS: Days after spray).**

| Treatment | Dose lit⁻¹ of Water | % Reduction of the larval population (*H. armigera*) over control/ 10 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% SC | 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% SC | 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% SC | 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% SC | 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% WP | 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 and biopesticides significantly reduced the fruit borer population in tomato crop. The present experiment on theefficacy of insecticides and biopesticides revealed that Flubendiamide 39.35% SC was found most effective and also showed the highest percent of fruit infestation reduction caused by *Helicoverpa armigera* i.e., (85.04%) followed by Chlorantraniliprole 18.5% SC (81.78%) and Fipronil 5% SC (79.07%). Among biopesticides, Spinosad 45% SC gave the best results i.e., (75.61%), followed by *Ha*NPV 2% A.S. (72.50%), Bt5% WP(68.05%) and Neemarin 1500 ppm (66.42%) over control, respectively.Hence, it is suggested that effective insecticides and biopesticides may be alternated in harmony with the existing Integrated Pest Management programs to avoid the problems associated with insecticidal resistance, pest resurgence, etc.



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