

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

ABSTRACT

A field study was carried out for the control of Tomato fruit borer *Helicoverpa armigera* during the *Rabi* season 2021-22 at Vegetable Research Station, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The present investigation evaluated 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, Chlorantraniliprole 18.5 SC and Fipronil 5 SC and biopesticides *viz.* Spinosad 45 SC, *Ha*NPV 2% AS, *Bt* 5 WP 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 *Helicoverpa armigera* 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 was found to be the most effective over untreated control. All the above treatments were found to be superior to untreated control.

Keywords: biopesticides; *Helicoverpa armigera*; larval population; tomato.

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 Peru in 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). 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 20300 thousand 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 devastated by various pests like tobacco caterpillar, whitefly, pinworms, serpentine leaf miner, aphids, spider mites and fruit borer. [4] reported that the fruit borer (*Helicoverpa armigera*) is among the major insect pests of the tomato crop. [5] reported the prevalence of insect pests such as aphid, thrips, whitefly, leaf miner, insects belonging to the Coccidae and Miridae families and cotton bollworm. However, the 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, *Helicoverpa armigera* (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 fruit [7] and found to cause a yield loss up to 35% in general and up to 36% in Uttar Pradesh. The problem of percent pest is magnified due to its direct attack on fruiting structure, voracious feeding habits, high mobility, fecundity and multivoltine overlapping generations. Losses solely due to this pest up to Rs. Ten thousand million have been reported in crops like chickpea, cotton, pigeon pea, groundnut, tomato, 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.

2. MATERIALS AND METHODS

The field experiment was conducted during the *rabi* 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 30th 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 m² plots with a spacing 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 were 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 5th, 10th and 15th 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 on the 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.

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

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 following the formula.

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

SE(d)= Standard Error of Difference

EMS= error mean sum of square

r= Replication

$$2. \text{CD} = \text{SE}(d) \times t(5\%)$$

CD= Critical difference

t= Table value at 5% probability level

$$3. \text{Percent reduction over control} = \frac{C-T}{C} \times 100$$

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 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 & 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 *HaNPV* 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 5th 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, *HaNPV* 2% AS, *Bt* 5 WP and Neemarin 1500 ppm i.e., 75.98%, 70.32%, 64.66%, 62.95%, 56.08% and 55.40%, respectively. After the 10th day of first spraying Flubendiamide 39.35 SC, Chlorantraniliprole 18.5 SC, Fipronil 5 SC, Spinosad 45 SC, *HaNPV* 2% AS, *Bt* 5 WP and 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 15th 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, *HaNPV* 2% AS, *Bt* 5 WP and 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 *HaNPV* 2% AS, *Bt* 5 WP and Neemarin 1500 ppm. Flubendiamide 39.35 SC and Chlorantraniliprole 18.5 SC were significantly superior over the rest of the treatments. The mean larval population was recorded after the 5th, 10th and 15th 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 5th day, 1.76, 2.20, 2.86, 3.10, 3.46, 4.43 and 4.60, respectively after the 10th day and 1.26, 1.70, 2.10, 2.36, 2.96, 3.53 and 3.80, respectively after the 15th day. In case of reduction in fruit infestation over control after the 5th, 10th and 15th day of second spraying i.e., 83.27%, 77.42%, 74.91%, 72.74%, 69.64%, 66.88% and 64.88%, respectively after the 5th day, 87.02%, 83.77%, 78.90%, 77.13%, 74.48%, 67.33% and 66.07%, respectively after the 10th day and 89.96%, 86.46%, 83.28%, 81.21%, 76.43%, 71.89% and 69.74%, respectively after the 15th 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 *HaNPV* 2% AS, *Bt* 5 WP and 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 5th, 10th and 15th 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 5th day, 1.66, 1.90, 2.10, 2.40, 2.90, 3.60 and 3.80, respectively after the 10th day and 1.33, 1.76, 1.90, 2.10, 2.60, 3.23 and 3.50, respectively after the 15th day. In case of reduction in fruit infestation over control after the 5th, 10th and 15th day of second spraying i.e., 83.47%, 80.00, 76.86%, 73.04%, 71.30%, 66.43% and 65.65%, respectively after the 5th day, 87.75%, 85.98%, 84.51%, 82.30%, 78.61%, 73.45% and 71.97%, respectively after the 10th day and 88.78%, 85.16%, 83.97%, 82.29%, 78.07%, 72.76% and 70.48%, respectively after the 15th day on ten randomly selected plants per plot.

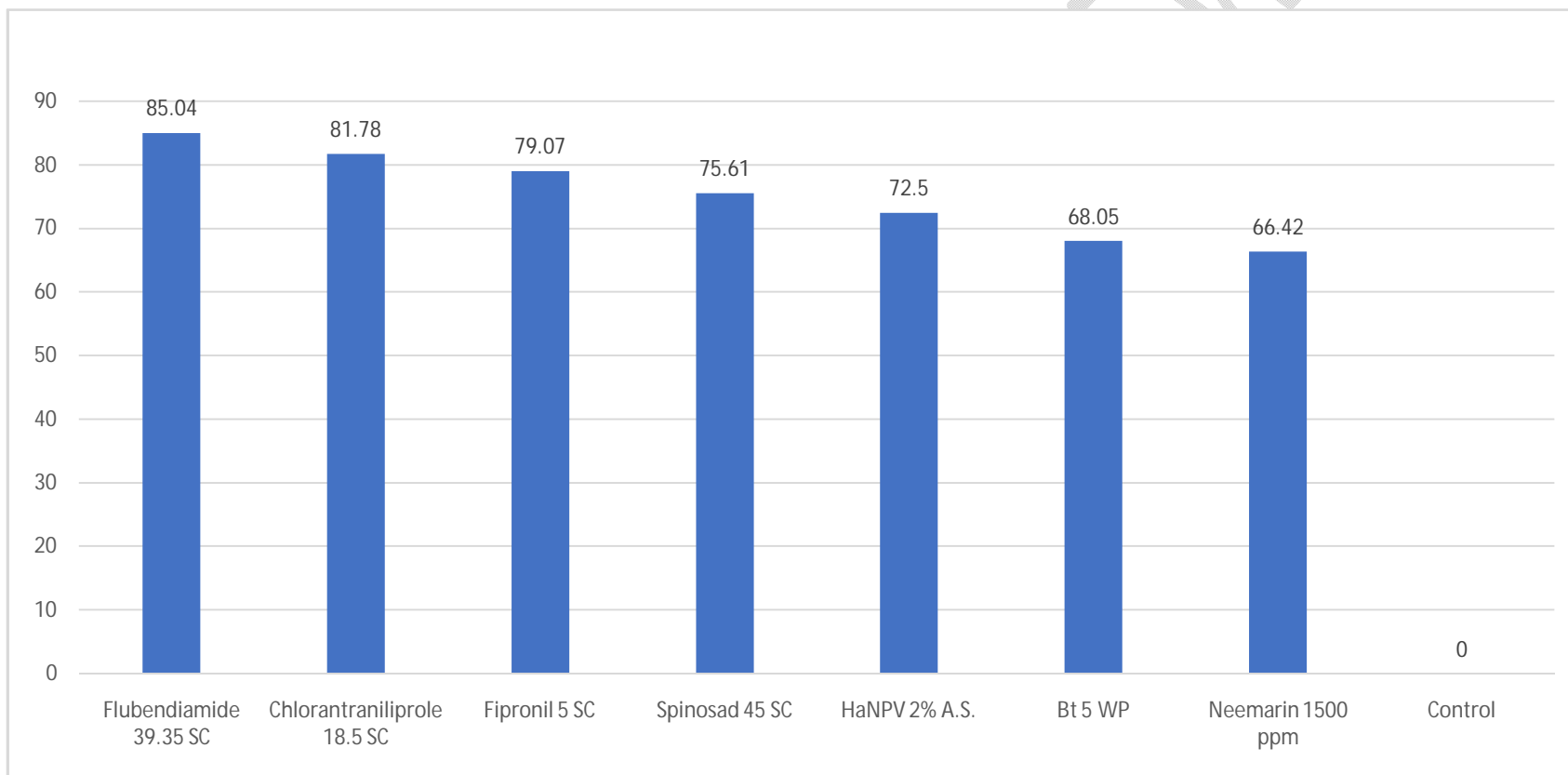
The results of the present investigation are in accordance with the results of [9] who reported that Flubendiamide @ 48 g a.i./ha caused a significant mean reduction of fruit borer larvae with 65.2, 77.5 and 84.6 percent at five days after the first, second and third spray during 2005-06, respectively and it was 70.0, 75.4 and 86.2 percent during 2006-07. [10] observed the efficacy of some pesticides with a novel mode of action (Spinosad, Rynaxypyr, Indoxacarb, Flubendiamide) for the management of *Helicoverpa armigera* 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%). [11] also recorded that 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%. Moreover, [12] observed that 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. [13] tested the efficacy of two microbial insecticides *HaNPV* @ 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 *HaNPV* and *Bt* alternate spraying (11.78%, 9.64%) followed by *Bt* (13.25%, 10.85%) and *HaNPV* (17.67%, 13.11%). [14] conducted an experiment on the relative efficacy of nine different insecticides against *Helicoverpa armigera* (Hubner) in tomato during the Rabi season revealing that all the 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).

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 (<i>H. armigera</i>)/ 10 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 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)
<i>Ha</i> 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)
<i>Bt</i> 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

Fig. 1. Overall mean efficacy (%) of different insecticides and biopesticides over control.



4. CONCLUSION

The experiment on the efficacy 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 best results i.e., (75.61%), followed by *Ha*NPV 2% A.S. (72.50%), *Bt* 5 WP (68.05%) and Neemarin 1500 ppm (66.42%) over control, respectively (Fig. 1).

REFERENCES

1. Thompson HC and Kelly WC. Vegetable crops. *McGraw Hill Book Company, New York*. 1957; P. 476.
2. The Department of Agriculture and Farmers Welfare. (First Advance Estimates) of Area and Production of Horticultural crops Category-wise: All India, 2021-2022.
3. National Horticulture Board (NHB). Indian Production of Tomato (HSCODE-1088); 2021-2022.
4. Mandal SK. Bio efficacy of cyazypyr 10% O.D., a new anthranilic diamide insecticide against the insect pests of tomato, its impact on natural enemies and crop health. *Acta Phytopathologica et Entomologica Hungarica*. 2012; 47(2):233-249.
5. Oda M, Hanboonsong Y, Jamjanya T, Srichompoo K and Kotaki T. Occurrence of insect pests in a tomato field under a pesticide-free dry season water-saving cultivation in northeast Thailand. *J.A.R.Q., Japan Agricultural Research Quarterly*. 2012; 46(1):59-64.
6. Ahmad R and Rai AB. 25 Years of research on *Helicoverpa armigera* at I.I.P.R. (Indian Institute of Pulses Research Center, Kanpur). Edited by Diwakar Upadhaya. 2009; pp. 53.
7. Sapkal SD, Sonkamble MM and Gaikwad BB. Seasonal incidence of tomato fruit borer, *Helicoverpa armigera* (Hubner) on tomato, *Lycopersicon esculentum* (Mill.) under protected cultivation. *Journal of Entomology and Zoology Studies*. 2021; 6(4):1911-1914.
8. Gavkare O, Patil MU, Kulkarni AV and Gupta S. The new group of insecticides. *Popular Kheti.*, 2013; Volume-1, Issue-3.
9. Ameta OP and Bunkar GK. Efficacy of flubendiamide against fruit borer, *Helicoverpa armigera* (Hub.) in tomato with safety to natural enemies. *Indian Journal of Plant Protection*, 2007; 35 (2):235-237.
10. Abhijit KP, Krishnaiah KR and Sudhakar K. Studies on some insecticides with a novel mode of action for the management of tomato fruit borer (*Helicoverpa armigera*). *Journal of Crop and Weed*, 2012; 8(2):126-129.

11. Jat SK and Ameta OP. Relative efficacy of bio-pesticides and newer insecticides against *Helicoverpa armigera* (Hubner) in tomato. *The Bioscan, An International Journal of Life Science*, 2013; 8(2):579-582.
12. Ghosal A, Chatterjee ML and Manna D. Studies on some insecticides with novel modes of action for the management of tomato fruit borer (*Helicoverpa armigera* Hub.). *Journal of Crop and Weed*. 2012; 8(2):126-129.
13. Rahman A, Haque MA, Alam SN, Mahmudunnabi M and Dutta NK. Efficacy of Microbials as Insecticides for the management of Tomato (*Lycopersicon esculentum*) fruit borer, *Helicoverpa armigera* (Hubner). *The Agriculturists*, 2014; 12(1):68-74.
14. Archana TA, Radadia GG, Shinde CU and Patil D. Relative efficacy of newer insecticides against *Helicoverpa armigera* (Hubner) in tomato under South Gujrat condition. *International Journal of Plant Protection*. 2015; 8(2):250-255.

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