Biorational Management of Major Insect-Pests with Special Reference to Tomato Fruit Borer, (*Helicoverpa armigera* Hubner)

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ABSTRACT: The present work entitled "Biorational management of major insect-pests with special reference to tomato fruit borer, (*Helicoverpa armigera* Hubner)" was carried out at Hi-tech farm, in RMD College of Agriculture & Research Station, Ambikapur, Chhattisgarh during the Rabi season of 2024-25. In this study, several biorational treatments were compared. Chlorantraniliprole had the lowest rate of tomato fruit borer infestation (4.07%) followed by *Bacillus thuringiensis* (5.36%), *Nuclear Polyhedrosis Virus* (6.58%), and *Metarhizium anisopliae* (7.20%), *Beauveria bassiana* (7.71%), *Verticillium lecanii* (7.95%). Chlorantraniliprole > *Bacillus thuringiensis* > *Nuclear Polyhedrosis Virus* > *Metarhizium anisopliae* > *Beauveria bassiana* > *Verticillium lecanii* > Control plot was the order of the effective treatment. Among the evaluated treatments, Chlorantraniliprole, Bacillus thuringiensis, and Nuclear Polyhedrosis Virus were the most effective.

Keywords: Biorational treatments, insecticides, *Chlorantraniliprole, Bacillus thuringiensis.*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.), belonging to the family Solanaceae is the most important vegetable commonly cultivated both for fresh market and processing. It originated in tropical America. It is a significant crop cultivated in tropical and subtropical climate. Tomato fruit comprise water (93.1%), fat (0.3g), calorie (23), vitamin 'A' (320 I.U), vitamin 'B1' (0.07 mg), vitamin 'B2'(0.01mg), carbohydrates (3.6%), nicotinic acid (0.4 mg), vitamin 'C'(31mg), fibre (0.7%), calcium (20 mg), phosphorus (36 mg), protein (1.9%), and iron (0.8 mg). Tomato also tops the vegetable in canned products. It is also used in salad, ketchup, puree, sauces, and other processed foods (Singh *et al*. 2023). The production and quality of tomato fruits are significantly impacted by a range of insect pests that infest the crop at various growth stages. Although there are several pests affecting tomatoes, some cause significant economic damage. Major insect pests include the fruit borer, *Helicoverpa armigera*, and various sucking pests such as whitefly (*Bemisia tabaci* Gennadius), aphid (*Aphis gossypii* Glover), and thrips (*Frankliniella schultzei* Trybom). The, fruit borer *Helicoverpa armigera (Hubner)* (Lepidoptera: Noctuidae) is a highly destructive pest causing significant yield losses in tomato (Muthukumaran and Selvanarayanan 2013; Habib *et al.,* 2022). Additional pests include *Ferrisia virgata* (Cockerell), serpentine

leaf miner (*Liriomyza trifolii* Burgess), and tomato leaf miner (*Tuta absoluta* Meyrick) (Kachave *et al.,* 2020).

The main mechanisms of action of *Bacillus* spp. Involve the production and release of antibiotics, toxins, siderophores, and lytic enzymes, as well as the induction of systemic resistance. Currently, various commercial formulations utilize the strains of the genus *Bacillus* as an active ingredient due to their colonization capacity, ease of reproduction, and high persistence associated with the formation of endospores. Endospore formation is of particular importance, as it enables these bacteria to survive under adverse climatic conditions. However, the efficacy and performance of these products in commercial tomato production remain unknown. The population dynamics of different insect pests and their natural enemies were observed significantly influenced by weather parameters and the damage caused by these insect pests are affected by fluctuation in abiotic factors (Singh *et al*., 2023). The aim of this study is to evaluate the efficacy of biorational products in controlling diseases in greenhouse tomato production. The ultimate goal was to incorporate these tactics into an integrated disease management system for commercial tomato production (Esquivel-Cervantes *et al.* 2022).

Excessive reliance on synthetic insecticides for its management has resulted in cross-resistance and multiple resistance development in *H. armigera.*

Among the alternative management options, organic manures, botanical pesticides, and biopesticides are considered effective and eco-friendly alternatives to manage pest populations below the economic threshold level (ETL) while reducing pesticides residues in food. However, the efficacy is often limited due to rapid photodegradation of their active compounds under field conditions. Therefore, studies were undertaken to stabilize neem-based compounds with other botanicals namely pungam and sweet-flag biopesticides namely *HaNPV*, *Bacillus thuringiensis* (Bt), *spinosad* and Pseudomonas *florescens* application in pot culture experiments to ascertain their use in eco-friendly pest management and their safety to egg parasitoid, *Trichogram ma chilonis* Ishii (Sathish *et al.,* 2009).

MATERIALS AND METHOD

The experiment was conducted at Raj Mohini Devi College of Agriculture and Research Station, Ajirma, Ambikapur, District Surguja (C.G.) during the September month of 2023-2024 year. The pre-treatment observations were recorded from randomly selected five plants at each treatment and the total number of fruit borer infected plants were counted by visual observation after application of the treatment. To determine fruit borer infestation the count was taken one day before the first spray and 3, 5 and 7 days after each spray, second application was applied at 15 days interval of first spray. The treatments were sprayed two times in the same manner as mentioned earlier and data was be interpreted through Randomized block design.

Experimental details:

Crop:	Tomato
Variety:	Saaho
Season:	Rabi
Spacing:	50×60cm.
Plot size:	2.7×4.5m^2
Date of Sowing:	13/10/2024
Date of transplanting:	16/11/2024
Treatment:	7
Replication:	3
Design:	Randomized Block Design (RBD)

Table 1: Treatment details.

Sr. No.	Treatments	Formulation %	Dosage (ml. or g. per liter of water)
T1	*Beauveria bassiana*	10^9 CFU/ml.	10ml.
T2	*Metarhizium anisoplia*	10^7 CFU/ml.	10ml.
T3	*Bacillus thuringiensis (Bt.)*	10^{10} CFU/ml.	10ml.
T4	*Nuclear Polyhedrosis Virus (NPV)*	1×10^9PIBs/ml.	2.5ml.
T5	*Chlorantraniliprole*	18.5%SC	0.4ml.
T6	*Verticillium lecanii*	1×10^8CFUs/ml.	10ml.
T7	Control (Untreated)	-	-

Fruit damage percentage caused by fruit borer will be recorded on the basis of damage fruit and healthy fruit during each harvesting of the fruits. The percentage of fruit and leaves infestations will be calculated on the following way.

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

RESULTS AND DISCUSSION

A. First spray against tomato fruit borer (Helicoverpa armigera)

All the biopesticides were found significantly superior over untreated control in minimizing the incidence of tomato fruit borer at all the days of observations after the first application of biopesticides.

Day before first spray. The data present in (Table 2) revealed that pre-treatment population *Helicoverpa armigera* was found uniform in experimental area with 10.21% to 12.88% infestation as the data are statistically non-significant.

Three days after first spraying. Third day after the first spray, T5 (chlorantraniliprole 18.5% SC @ 0.4 ml/L) recorded the minimum infestation at 3.11% fruit infestation, statistically similar to, T3 (*Bacillus thuringiensis* 10^{10} CFU/ml @10ml /L) with a infestation of 4.07 % fruit infestation, T4 (Nuclear Polyhedrosis Viruse 1×10^9 PIBs/ml @ 2.5 ml/L) showed a infestation of 5.96%, T2 (*Metarhizium anisopliae* 10^7CFU/ml @ 10ml/L) recorded 6.42%, T1 (*Beauveria bassiana* 10^9CFU /ml @ 10ml/L) demonstrated 6.66% and T6 (*Verticillium lecanii* 1×10^8CFUs/ml @10ml/L) had 6.81%. In contrast, T7 the untreated control plot recorded a higher fruit infestation at 12.54%.

Seven days after first spraying. Seven days after post first biopesticide spray T5 (chlorantraniliprole 18.5% SC @ 0.4 ml/L) displayed the lowest infestation at 5.17%/5 plants, statistically comparable to T3 (*Bacillus thuringiensis* 10^{10} CFU/ml @10ml /L) at 7.13%/5 plants. The remaining treatments followed a sequential pattern with statistically comparable results. Specifically, T4 Nuclear Polyhedrosis Viruse 1×10^9 PIBs/ml @ 2.5 ml/L showed 8.01%/5 plants fruit infestation, T2 (*Metarhizium anisopliae* 10^7CFU/ml @ 10ml/L) recorded 8.66%/5 plants, T1 (*Beauveria bassiana* 10^9CFU /ml @ 10ml/L) demonstrated 9.26% and T6 (*Verticillium lecanii* 1×10^8CFUs/ml @10ml/L) recorded 9.43%. These treatments were statistically comparable. The control group T7 recorded the highest fruit infestation at 13.27%, significantly inferior to all tested biopesticide treatments.

Ten days after first spraying. Ten days after post first spray, T5 (chlorantraniliprole 18.5% SC @ 0.4 ml/L) recorded the minimum fruit infestation at 4.11%/5 plants, statistically similar to T3 (*Bacillus thuringiensis* 10^{10} CFU/ml @10ml /L with a fruit infestation of 5.12% /5 plants. T4 (Nuclear Polyhedrosis Viruse 1×10^9 PIBs/ml @ 2.5 ml/L) showed a fruit infestation of 6.10%/5 plants, T2 (*Metarhizium anisopliae* 10^7CFU/ml @ 10ml/L) recorded 6.54%/5 plants, T1 (*Beauveria bassiana* 10^9CFU /ml @ 10ml/L) demonstrated 7.31%/5 plants and T6 (*Verticillium lecanii* 1×10^8CFUs/ml @10ml/L) had 7.66%/5 plants. In contrast, T7 the untreated control plot recorded a higher fruit infestation at 13.38%/5 plants.

Twelve days after first spraying. Twelve days after post first biopesticide spray T5 (chlorantraniliprole 18.5% SC @ 0.4 ml/L) displayed the lowest fruit infestation at 5.09%/5 plants, statistically comparable to T3 (*Bacillus thuringiensis* 10^{10} CFU/ml @10ml /L) at 6.14%/5 plants. The remaining treatments followed a sequential pattern with statistically comparable results. Specifically, T4 Nuclear Polyhedrosis Viruse 1×10^9 PIBs/ml @ 2.5 ml/L showed 7.23%/5 plants fruit infestation, T2 (*Metarhizium anisopliae* 10^7CFU/ml @ 10ml/L) recorded 8.18%/5 plants, T1 (*Beauveria bassiana* 10^9CFU /ml @ 10ml/L) demonstrated 8.39% and T6 (*Verticillium lecanii* 1×10^8CFUs/ml @10ml/L) recorded 8.86%. These treatments were statistically comparable. The control group T7 recorded the highest fruit infestation at 13.95%, significantly inferior to all tested biopesticide treatments.

B. Second spray against tomato fruit borer (Helicoverpa armigera)
The information regarding the fruit infestation of *Helicoverpa armigera* following the second spray was illustrated in (Table 1). All the biorational treatments exhibited significant superiority over the untreated control in reducing the fruit infestation of tomato fruit borer. The caused by *Helicoverpa armigera* decreased on the 3rd, 7th, 10th and 12th days after spraying.

Day before Second spray. The data present in (Table 2) revealed that pre-treatment fruit infestation of a *Helicoverpa armigera* was found uniform in experimental area with 11.87% to 14.16% fruit infestation as the data are statistically non-significant.

Third days after second spraying. Third day after the second spray, T5 (chlorantraniliprole 18.5% SC @ 0.4 ml/L) recorded the minimum fruit infestation at 4.97%/5 plants, statistically similar to T3 (*Bacillus thuringiensis* 10^{10} CFU/ml @10ml /L) with a fruit infestation of 6.87%/5 plants. T4 (Nuclear Polyhedrosis Viruse 1×10^9 PIBs/ml @ 2.5 ml/L) showed a fruit infestation of 7.74%/5 plants, T2 (*Metarhizium anisopliae* 10^7CFU/ml @ 10ml/L) recorded 8.59%/5 plants, T1 (*Beauveria bassiana* 10^9CFU /ml @ 10ml/L) demonstrated 9.40% and T6 (*Verticillium lecanii* 1×10^8CFUs/ml @10ml/L) had 9.69%/5 plants. In contrast, T7 the untreated control plot recorded a higher fruit infestation at 14.27%/5 plants.

Seventh days after second spraying. Seven days after post second biopesticide spray T5 (chlorantraniliprole

18.5% SC @ 0.4 ml/L) recorded the minimum fruit infestation at 3.03%/5 plants, demonstrating superiority and statistical parity with T3 (*Bacillus thuringiensis* 10^{10} CFU/ml @10ml /L) at 4.28%/5 plants, and T4 (Nuclear Polyhedrosis Viruse 1×10^9 PIBs/ml @ 2.5 ml/L) with a fruit infestation of 5.61%/5 plants. T2 (*Metarhizium anisopliae* 10^7CFU/ml @ 10ml/L) recorded 6.01%, T1 (*Beauveria bassiana* 10^9CFU /ml @ 10ml/L) demonstrated 6.62%, and T6 (*Verticillium lecanii* 1×10^8 CFUs/ml @10ml/L) had 6.83%/5 plants. These treatments effectively reduced fruit infestation compared to T7 the untreated control plot which recorded 14.40% fruit infestation.

Ten days after second spraying. Ten days after post second spray, T5 (chlorantraniliprole 18.5% SC @ 0.4 ml/L) recorded the minimum fruit infestation at 3.15%/5 plants, statistically similar to T3 (*Bacillus thuringiensis* 10^{10} CFU/ml @10ml /L) with a fruit infestation of 4.23%/5 plants. T4 (Nuclear Polyhedrosis Viruse 1×10^9 PIBs/ml @ 2.5 ml/L) showed a fruit infestation of 5.41%/5 plants, T2 (*Metarhizium anisopliae* 10^7CFU/ml @ 10ml/L) recorded 6.06%/5 plants, T1 (*Beauveria bassiana* 10^9CFU /ml @ 10ml/L) demonstrated 6.56%/5 plants and T6 (*Verticillium lecanii* 1×10^8CFUs/ml @10ml/L) had 6.68%/5 plants. In contrast, T7 the untreated control plot recorded a higher fruit infestation at 14.63%/5 plants.

Twelve days after second spraying. Twelve days after post second biopesticide spray T5 (chlorantraniliprole 18.5% SC @ 0.4 ml/L) displayed the lowest fruit infestation at 4.12%/5 plants, statistically comparable to T3 (*Bacillus thuringiensis* 10^{10} CFU/ml @10ml /L) at 5.01%/5 plants. The remaining treatments followed a sequential pattern with statistically comparable results. Specifically, T4 (Nuclear Polyhedrosis Viruse 1×10^9 PIBs/ml @ 2.5 ml/L) showed 6.57%/5 plants fruit infestation, T2 (*Metarhizium anisopliae* 10^7CFU/ml @ 10ml/L) recorded 7.11%/5 plants, T1 (*Beauveria bassiana* 10^9CFU /ml @ 10ml/L) demonstrated 7.42% and T6 (*Verticillium lecanii* 1×10^8CFUs/ml @10ml/L) recorded 7.64%/5 plants. These treatments were statistically comparable. The control group T7 recorded the highest fruit infestation at 14.85%, significantly inferior to all tested biopesticide treatments.

Over all mean. Over all mean statistical analysis of all first and second spray observations (3, 7, 10 and 12 DAS) showed that all insecticidal treatment was found to be significantly effective compared to control (13.92 % fruit infestation/5 plant) in reducing the fruit infestation.
chlorantraniliprole 18.5% SC @ 0.4 ml/L most effective against fruit borer as it recorded the lowest fruit infestation of 4.07% fruit infestation/5 plant followed by, *Bacillus thuringiensis* 10^{10} CFU/ml @10ml /L (5.36% fruit infestation/5 plant). However, Nuclear Polyhedrosis Viruse 1×10^9 PIBs/ml @ 2.5 ml/L (6.58% fruit infestation/5 plants), *Metarhizium anisopliae* 10^7CFU/ml @ 10ml/L, *Beauveria bassiana* 10^9CFU /ml @ 10ml/L, *Verticillium lecanii* 1×10^8CFUs/ml @10ml/L was also found effective, as recorded fruit infestation ranged from 7.20% to 7.95% fruit infestation/5 plant and superior over untreated.

Biswas *et al*. 2020; Halder *et al.* 2022; Buragohain *et al.,* 2021 reported that Tracer 45SC-treated plots recorded the lowest fruit borer infestation throughout the entire fruiting period, with infection levels of 11.05%, 10.88%, and 11.28% during the early, mid, and late fruiting stages, respectively.

Kumar *et al*. (2023) concluded that among different treatments, effective treatments were emamectin benzoate 5 SG @ 12g a.i./ha and indoxacarb 14.5 SC a.i./ha. The indoxacarb 14.5 SC a.i./ha caused significant maximum reduction in the population of pod borer.

Dedeepya *et al.* (2023; Gupta *et al.* (2018) reported that the Neem Seed Kernel Extract proved to be the most effective, followed by Nimbicide, Neem Leaf Extract, HaNPV, Neem Oil, and *Bacillus thuringiensis*. Among the treatments, Neem Seed Kernel Extract showed the highest cost benefit ratio (C: B) of 1:18.51

Table 2: Efficacy of some biorational insecticides against Fruit borer (*Helicoverpa armigera*) on tomato.

Treatments	% Fruit damage of tomato fruit borer (*Helicoverpa armigera*) recorded /5 plants											Overall Mean
		First spray					Second spray					
	Dose (ml/L)	1DBS	3 DAS	7DAS	10DAS	12DAS	1DBS	3DAS	7DAS	10DAS	12DAS	
Beauveria bassiana 10^9CFU	10ml.	10.34 (18.76)	6.66 (14.96)	9.26 (17.17)	7.31 (15.69)	8.39 (16.84)	13.60 (21.64)	9.40 (17.86)	6.62 (14.91)	6.56 (14.84)	7.42 (15.81)	7.71 (16.12)
Metarhizium anisoplia 10^7CFU/ml.	10ml.	10.75 (19.14)	6.42 (14.68)	8.66 (17.11)	6.54 (14.82)	8.18 (16.62)	14.16 (22.11)	8.59 (17.04)	6.01 (14.19)	6.06 (14.25)	7.11 (15.47)	7.20 (15.56)
Bacillus thuringiensis 10^{10}CFU/ml.	10ml.	12.69 (20.87)	4.07 (11.63)	7.13 (15.49)	5.12 (13.07)	6.14 (14.35)	11.87 (20.15)	6.87 (15.19)	4.28 (11.94)	4.23 (11.87)	5.01 (12.94)	5.36 (13.39)
Nuclear Polyhedrosis Viruse (NPV) 1×10^9PIBs/ml.	2.5ml.	12.88 (21.03)	5.96 (14.13)	8.01 (16.44)	6.10 (14.30)	7.23 (15.60)	13.86 (21.86)	7.74 (16.16)	5.61 (13.70)	5.41 (13.45)	6.57 (14.85)	6.58 (14.86)
Chlorantraniliprol 18.5%SC	0.4ml.	10.21 (18.64)	3.11 (10.16)	5.17 (13.15)	4.11 (11.70)	5.09 (13.04)	12.73 (20.90)	4.79 (12.65)	3.03 (10.02)	3.15 (10.23)	4.12 (11.71)	4.07 (11.64)
Verticillium lecanii 1×10^8CFUs/ml.	10ml.	12.67 (20.85)	6.81 (15.12)	9.43 (17.88)	7.66 (16.07)	8.86 (17.32)	13.31 (21.39)	9.69 (18.14)	6.83 (15.15)	6.68 (14.98)	7.64 (16.05)	7.95 (16.38)
Control		11.47 (19.80)	12.54 (20.74)	13.27 (21.36)	13.38 (21.46)	13.95 (21.93)	14.14 (22.09)	14.27 (22.19)	14.40 (22.30)	14.63 (22.49)	14.85 (22.66)	13.92 (21.90)
SEm ±		2.433	0.617	0.451	0.618	0.618	0.723	0.483	0.457	0.678	0.508	-
CD at 5%		NS	1.900	1.388	1.903	1.903	NS	1.488	1.407	2.090	1.564	-
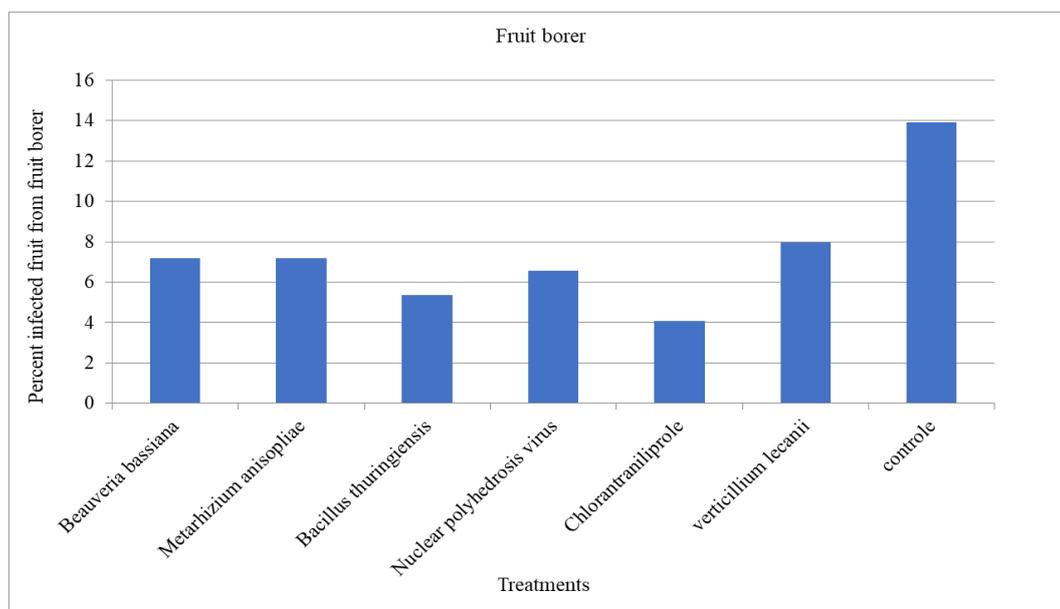
Figures in parenthesis are ($\sqrt{}$X+0.5) transformed values, Figures in parenthesis are arcsine transformed DBS=Day before spray

Fig. 1. Efficacy of insecticides against fruit borer infestation (%) on tomato crop.

CONCLUSION

From a pest management perspective, the biorational approach to controlling the tomato fruit borer (*Helicoverpa armigera*) showed promising outcomes. Among the evaluated treatments, Chlorantraniliprole, *Bacillus thuringiensis*, and Nuclear Polyhedrosis Virus were the most effective. These treatments significantly reduced the overall percentage of fruit infestation. In addition, they support beneficial soil microbial activity, which is vital for sustainable agriculture and long-term soil health.

Conflict of Interest. The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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