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Eco-friendly Management of Tomato Fruit Borer, *Helicoverpa armigera* (Hubner) Using Microbials and Botanicals in Manipur

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ABSTRACT

Field experiments were carried out at the Vegetable Research Farm, College of Agriculture, Central Agricultural University, Imphal, Manipur for two consecutive Rabi seasons, 2020-21 and 2021-22 to determine the efficacy of biorational insecticides and chlorantraniliprole against *Helicoperva armigera* on tomato under Manipur condition. Among the nine insecticides tested, chlorantraniliprole 18.5 SC @ 150 ml/ha was found most effective against *H. armigera* followed by green lipel (*Bacillus thuringiensis* var. *kurstaki*) @ 2500 ml/ha and green focus (botanical extract of *Derris indica*) @ 1000 ml/ha. Cow urine + *Artimisia nilagirica* proved to be the least effective followed by green pacer (*Metarrhizium anisopliae*). Among biorational insecticides tested, maximum fruit yield (19.12 t/ha) was harvested from the plots treated with green lipel which did not differ significantly from that of green focus (19.03 t/ha) treated plots.

Key words: Biorational insecticides, chlorantraniliprole, *Helicoverpa armigera*, rabi season, tomato, yield.

INTRODUCTION

Tomato (*Lycopersicon esculentum*) belongs to the family Solanaceae, and is one of the important vegetable crops of India because of its high nutritive value. Vitamin A present in tomato helps in preventing the development of night blindness and also helps to improve vision (Ganesan et al. 2012). During 2017-18, the highest production of tomato in India was Andhra Pradesh with a production of 2,744.32 thousand MT and its area was 61.67 thousand ha followed by Karnataka (2,081.59 thousand MT) but in Manipur, the total production of tomato was 33.72 thousand MT which occupies an area of 3.15 thousand ha (Anonymous 2018). Several factors affect the yield of tomato. Among several factors that cause low production of tomato, the damage caused by insect pests is one of the major constraints for low production of the yield of tomato. The crop is infested by several insect pests like leaf miner, lepidopterous fruit borers, tobacco caterpillar, white fly, aphid, hairy caterpillar etc. at different stages of the crop starting from seedling to harvesting stage. *Helicoverpa armigera* is one of the most destructive and polyphagous pests, attacking nearly 200 cultivated and wild host plants and is a key constraint in the production of several crops including tomato, chilli, cotton, maize, tobacco, okra, chickpea, sunflower (Dhillon et al. 2012, Ahmad et al. 2014).

H. armigera can effectively be controlled by chemical methods as it is easily available and it gives quick results. However, the indiscriminate use of synthetic chemical pesticides to control this pest resulted in the development of resistant strains among the target organisms, harmful pesticide residues in fruits, and are not economical in the long run (Naseby et al. 2000). These considerations gives rise to look for safer insecticides like biorational pest control that should protect the crop with minimum adverse impacts on the environment. The combination of a plant extract with insecticidal activity and an entomopathogen is a novel approach to fight against the resistance and resurgence issues made by insect pests (Srivastava et al. 2011). Limited attempts have been made on the management of *H. armigera* in tomato using biorational insecticides under the agro-climatic condition of Manipur. Keeping the above points in view, the present investigation was undertaken to study the bio-efficacy of insecticides on the incidence of tomato fruit borer in tomato genotype 'Manikhamnu' and to estimate the effect of test insecticides on the fruit yield of tomato crop.

MATERIAL AND METHODS

The field experiments were carried out to determine the efficacy of biorational insecticides against *H. armigera* on tomato. Tomato variety "Manikhamnu" was sown for two consecutive Rabi seasons, 2020-21 and 2021-22 at the Vegetable Research Farm, College of Agriculture, Central Agricultural University, Imphal, Manipur. The field experiments were laid out in randomised block design (RBD) with ten treatments including one insecticidal check and one untreated control each replicated three times. The experimental crop was grown row to row and plant to plant spacing of 60 x 45 cm with a plot size of 3 x 4 m by adopting the recommended agronomic practices.

The treatments were: T_1 = Green Racer (*Beauveria bassiana*) @ 2500 ml ha^{-1}; T_2 = Green Pacer (*Metarrhizium anisopliae*) @ 2500 ml ha^{-1}; T_3 = Green Lipel (*Bacillus thuringiensis var. kurstaki*) @ 2500 ml ha^{-1}; T_4 = Green Focus (botanical extract of *Derris indica*) @ 1000 ml ha^{-1}; T_5 = Purineem (a.i. natural alkaloids and triterpenes from neem) @ 1000 ml ha^{-1}; T_6 = Multineem (azadirachtin 300ppm) @ 1500 ml ha^{-1}; T_7 = Cow urine + *Artimisia nilagirica* @ 10000 ml ha^{-1}; T_8 = Chlorantraniliprole 18.5 SC @ 1500 ml ha^{-1}; T_9 = Baba (*Beauveria bassiana*) @ 500 ml ha^{-1}.

All the spray treatments were applied twice, one at the flowering stage and the other after 15 days of initial spray. All insecticides were applied in the evening hours. Care was taken at the time of spraying to avoid drifting the insecticidal spray solution from one plot to another and to give a thorough coverage to the plants. Plain water was sprayed on the plants of untreated control plots. Observation on larval population per plant was recorded one day before the treatment and 3^{rd}, 7^{th} and 14^{th} day after treatment on five randomly selected plants per plot. The per cent fruit infestation was computed based on of the cumulative data of all pickings. The damage of fruit borer was decided based on percentage of fruit infestation which was recorded on the number and weight basis using the following formulae

Fruit damage (%) (number basis) = (Number of infected fruits/Total number of harvested fruits)X100

Fruit damage (%) (weight basis) = (Weught of infected fruits/Total weight of harvested fruits)X100

Statistical analysis

The data obtained from the experiment were analyzed after suitable transformation for testing the treatment effects and their proper interpretation.

RESULTS AND DISCUSSION

Effect of biorational insecticides against larval population

The pooled mean data of two years revealed that chlorantraniliprole 18.5 SC @ 150ml/ha proved to be the most effective insecticide in the suppression of *Helicoverpa armigera* larva with a minimum mean larval population of 0.29 larvae/plant as against 1.57 in untreated control. The larval population of *H. armigera* was significantly lower in all the treated plots over control. Among the biorational insecticides, the maximum protection was given by the application of green lipel @ 2500 ml/ha with a minimum larval population of 0.42 larvae/plant followed by green focus @ 1000 ml/ha with a mean larval population of 0.46/plant which does not differ significantly from each other. The effectiveness of green lipel @ 2500 ml/ha (*Bacillus thuringiensis var. kurstaki*) might be due to their disruption on insect mid-gut membranes and the effect of the active toxin (Table 1).

The insecticide which was prepared from cow urine and *Artimisia nilagirica* @ 10,000 ml/ha was observed to be the least effective treatment with a population of 1.01 larvae/plant which was at par with the mean larval population of 0.89/plant recorded in the plots treated with green pacer @ 2500 ml/ha but significantly superior over untreated control. The results obtained here on the effectiveness of chlorantraniliprole 18.5 SC are in conformity with the findings of Patil et al. (2018) who reported that chlorantraniliprole 18.5 SC was found most effective against fruit borer. *Metarrhizium anisopliae* 1.15 WP (1 x 10^8 cfu/g) proved least effective followed by HaNPV (250 LE/ha) and *Beauveria bassiana* 1.15 WP (1 x 10^8 cfu/g). Knight and Flexner (2007) also reported the high effectiveness of chlorantraniliprole against Lepidopteran pests. Sathish et al. (2018) reported that among the biopesticides, spinosad 45 SC @ 0.20 ml/L and *B. thuringiensis* var. *kurstaki*

Table 1. Mean larval population of *Helicoverpa armigera* at 1st and 2nd spray during 2020-21, 2021-22 and pooled data

Treatment	Dose (ml/ha)	2020-21 1st spray	2020-21 2nd spray	2020-21 Pooled data	2021-22 1st spray	2021-22 2nd spray	2021-22 Pooled data	Overall pooled data
T_1= Green Racer (*Beauveria bassiana*)	2500	0.84 (1.16)	0.62 (1.06)	0.73 (1.11)	0.71 (1.10)	0.58 (1.04)	0.64 (1.07)	0.69 (1.09)
T_2= Green Pacer (*Metarrhizium anisopliae*)	2500	0.89 (1.18)	0.80 (1.14)	0.84 (1.16)	0.98 (1.22)	0.91 (1.19)	0.94 (1.20)	0.89 (1.18)
T_3= Green Lipel (*Bacillus thuringiensis var. kurstaki*)	2500	0.47 (0.98)	0.29 (0.89)	0.38 (0.94)	0.53 (1.02)	0.40 (0.95)	0.47 (0.98)	0.42 (0.96)
T_4= Green Focus (botanical extract of *Derris indica*)	1000	0.60 (1.05)	0.38 (0.94)	0.49 (0.99)	0.49 (0.99)	0.38 (0.94)	0.43 (0.97)	0.46 (0.98)
T_5= Purineem (a.i. natural alkaloids and triterpenes from neem)	1000	0.67 (1.08)	0.51 (1.01)	0.59 (1.04)	0.87 (1.17)	0.73 (1.11)	0.80 (1.14)	0.69 (1.09)
T_6= Multineem (azadirachtin 300ppm)	1500	0.69 (1.09)	0.62 (1.06)	0.66 (1.07)	0.80 (1.14)	0.62 (1.06)	0.71 (1.10)	0.68 (1.09)
T_7= Cow urine + *Artimisia nilagirica*	10,000	0.93 (1.20)	0.84 (1.16)	0.89 (1.18)	1.16 (1.29)	1.09 (1.26)	1.12 (1.27)	1.01 (1.23)
T_8= Chlorantraniliprole 18.5 SC	150	0.33 (0.91)	0.18 (0.82)	0.26 (0.87)	0.38 (0.94)	0.27 (0.88)	0.32 (0.91)	0.29 (0.89)
T_9= Baba (*Beauveria bassiana*)	500	0.56 (1.03)	0.49 (0.99)	0.52 (1.01)	0.91 (1.19)	0.69 (1.09)	0.80 (1.14)	0.66 (1.08)
T_0= Untreated control	-	1.40 (1.38)	1.33 (1.35)	1.37 (1.37)	1.71 (1.49)	1.82 (1.52)	1.77 (1.51)	1.57 (1.44)
SE(m)±		0.02	0.02	0.02	0.01	0.02	0.01	0.03
CD (P = 0.05)		0.05	0.05	0.05	0.04	0.05	0.04	0.10

Figures in parentheses are square root ($\sqrt{x+0.5}$) transformed values

@ 1.5 g/L were found to be effective. The present findings on the effectiveness of chlorantraniliprole against *H. armigera* are supported by Gadhiya et al. (2014) but are in partial agreement with that of Singh et al. (2017) who reported chlorantraniliprole as moderately effective insecticide. The order of efficacy of each of the treatments along with the test of significance is Chlorantraniliprole ˆ Green Lipel = Green Focus ˆ Baba = Multineem = Purineem = Green Racer ˆ Green pacer ˆ Cow urine + *Artimisia nilagirica* ˆ Untreated control.

Effect of biorational insecticides on the infestation of fruits by *H. armigera*

The mean fruit infestation due to tomato fruit borer on number and weight basis revealed that spraying of all the biorational insecticidal treatments resulted in a significant reduction of the borer (Table 2). The pooled data on fruit damage over two years revealed that chlorantraniliprole 18.5 SC @ 150 ml/ha provided maximum protection of tomato from the attack of *H. armigera* with a mean infestation of 2.81% (on a number basis) and 2.30% (on a weight basis) as against 20.53% (on number basis) and 20.44% (on weight basis) in untreated control. Among the different biorational insecticides, green lipel @ 2500 ml/ha with a record of 4.64% (on number basis) and 5.23% (on weight basis) and green focus @ 1000 ml/ha with a record of 4.93% (on number basis) and 5.50% (on weight basis) stood next to chlorantraniliprole, which are at par with each other. The results obtained here on the effectiveness of *B. thuringiensis* against *H. armigera* are in conformity with the findings of Ghimire et al. (2022) who found that spinosad gave the highest percentage reduction of pest over control followed by *B. thuringiensis*. Mahakalkar et al. (2009) revealed that the lowest fruit infestation was observed from the plots treated with HaNPV (11.78%) and *B. thuringiensis* (9.64%) in alternate spraying against *H. armigera*. Thakur et al. (1996) also reported that spraying the product of *Bacillus thuringiensis* var.

Table 2. Overall efficacy of insecticides in tomato var. Manikhamnu (pooled data of 2020-21 and 2021-22)

Treatment	Dose (ml/ha)	[1]Mean (%) fruit infestation		[2]Mean fruit yield (t/ha)
		Number basis	Weight basis	
T_1= Green Racer (*Beauveria bassiana*)	2500	8.13 (2.90)	10.23	17.53
T_2= Green Pacer (*Metarrhizium anisopliae*)	2500	14.78 (3.88)	13.52	16.82
T_3= Green Lipel (*Bacillus thuringiensis* var. kurstaki)	2500	4.64 (2.26)	5.23	19.12
T_4= Green Focus (botanical extract of *Derris indica*)	1000	4.93 (2.28)	5.50	19.03
T_5= Purineem (natural alkaloids and triterpenes from neem)	1000	7.89 (2.89)	6.82	17.47
T_6= Multineem (azadirachtin 300ppm)	1500	10.83 (3.36)	9.56	17.28
T_7= Cow urine + *Artimisia nilagirica*	10,000	16.51 (4.10)	16.60	16.50
T_8= Chlorantraniliprole 18.5 SC	150	2.81 (1.81)	2.30	20.30
T_9= Baba (*Beauveria bassiana*)	500	7.08 (2.73)	8.96	17.13
T_0= Untreated control	-	20.53 (4.56)	20.44	16.22
SE(m)±		0.10	0.82	0.56
CD (P = 0.05)		0.42	3.31	1.67

Figures in parentheses are square root ($\sqrt{x + 0.5}$) transformed valuesl [1]Average per cent fruit infestation of three replications based on total number/weight of six harvestings; [2]Mean of three replications

kurstaki at 3.5% gave significant reduction of larval population of *H. armigera* in tomato. Taking into consideration both the years, it was observed that Cow urine + *Artimisia nilagirica* @ 10000 ml/ha resulted in maximum fruit infestation of 16.51% (on a number basis) and 16.60% (on a weight basis). The present findings on the efficacy of cow urine + *Artimisia nilagirica* on *H. armigera* are supported by Ruparao (2020) who reported that mixing cow urine with extract of plant parts was found more effective in controlling crop pests than spraying cow urine alone but the mixture could not compete with synthetic pesticides for causing high pest mortality, reducing plant damage and increasing crop yield.

The relative efficacy of various treatments in managing *Helicoverpa armigera* over two years on infestation on number basis is - Chlorantraniliprole > green lipel > green focus > baba > purineem > green racer > multineem > green pacer > cow urine + *Artimisia nilagirica* > untreated control; and, Infestation on a weight basis is - Chlorantraniliprole > green lipel > green focus > purineem > baba >multineem > green racer > green pacer > cow urine + *Artimisia nilagirica* > untreated control.

Effect of biorational insecticides on fruit yield of tomato

The two-year mean fruit yield indicates that the minimum and maximum yield was recorded from cow urine + *A. nilagirica* @ 10,000 ml/ha and chlorantraniliprole 18.5 SC @ 150 ml/ha, respectively (Table 2). Application of green lipel @ 2500 ml/ha and green focus @ 1000 ml/ha proved equally efficacious and at par with chlorantraniliprole @ 150 ml/ha by recording productivity of 19.12 t/ha and 19.03 t/ha. In the untreated control plots lowest yield of 16.22 t/ha was harvested. The results obtained here on the higher fruit yield with the treatment *B. thuringiensis* are in agreement with the results noted by Rahman et al. (2014). Gopal and Senguttuvan (1997) and Sundarajan (2002) also reported the effectiveness of botanicals in controlling

Table 3. Avoidable fruit yield loss (%) of tomato var. Manikhamnu in different insecticidal treatments (Based on pooled fruit yield data of 2020-21 and 2021-22)

Treatment	Dose (ml/ha)	[1]Mean fruit yield (t/ha)	Increased fruit yield (t/ha)	Increased fruit yield (%)	Avoidable fruit yield loss (%)
T_1= Green Racer	2500	17.53	1.31	8.08	13.65
T_2= Green Pacer	2500	16.82	0.6	3.70	17.14
T_3= Green Lipel	2500	19.12	2.9	17.88	5.81
T_4= Green Focus	1000	19.03	2.81	17.32	6.26
T_5= Purineem	1000	17.47	1.25	7.71	13.94
T_6= Multineem	1500	17.28	1.06	6.54	14.88
T_7= Cow urine + *Artimisia nilagirica*	10000	16.50	0.28	1.72	18.72
T_8= Chlorantraniliprole 18.5 SC	150	20.30	4.08	25.15	00
T_9= Baba	500	17.13	0.91	5.61	15.62
T_0= Untreated control	-	16.22	0.00		20.10

[1]Mean of three replications

Helicoverpa armigera which increased the total yield of production in different crops.

Estimation of avoidable yield loss of test biorational insecticides

Considering the maximum realizable yield in chlorantraniliprole 18.5% SC treatment (20.30 t/ha) which also afforded maximum protection of the crop from *H. armigera* larval infestation, the avoidable yield loss was computed to be 20.10% in the untreated control plots (Table 3). Spraying of insecticides resulted in a reduction of the mean avoidable loss, which ranges from 5.81 to 18.72% in different insecticidal treatments, the lowest being in green lipel treatment (5.81%).

CONCLUSION

The experiment on the efficacy of biorational insecticides showed that chlorantraniliprole 18.5 SC @ 150 ml/ha was found most effective against *Helicoverpa armigera* followed by green lipel @ 2500 ml/ha and green focus @ 1000 ml/ha. The treatments baba, multineem, purineem, green racer and green pacer ranked in the middle order of their efficacy while the least effectiveness against *Helicoverpa armigera* was observed in cow urine + *Artimisia nilagirica* treatment. The present study concludes that biorational insecticides like green lipel @ 2500 ml/ha and green focus @ 1000 ml/ha might be incorporated in developing an IPM module for the management of *Helicoverpa armigera* in tomato in Manipur valley situations.

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