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Comparative efficacy and economics of selected insecticides against tomato fruit borer [*Helicoverpa armigera* (Hubner)

Mohammad Ruksana and Ashwani Kumar

Abstract
The current study was carried out at Central Research Farm, SHUATS, Naini, Prayagraj, U.P. during *rabi* season of 2021-22. Two applications of seven insecticides were used against *Helicoverpa armigera* and the result revealed that Spinosad 45% SC had lowest fruit infestation with 1.77 and 1.33 followed by Indoxacarb 14.5% SC (1.88 and 1.39), Emamectin benzoate 5% SG (1.97 and 1.48), Profenofos 50% EC (2.08 and 1.57), *Ha*NPV (2.17 and 1.70), Neem oil (2.24 and 1.79) and *Bacillus thuringiensis var. kurstaki* (2.28 and 1.18) respectively as compare to control (water spray) 3.71 and 6.10. Cost benefit ratio were found highest in Spinosad 45% SC 1:8.33, followed by Indoxacarb 14.5% SC (1:8.20), Emamectin benzoate 5%SG (1:8.16), T6 Profenofos 50%EC (1:7.07), *Ha*NPV (1:6.33), Neem oil (1:5.87), *Bacillus thuringiensis var. kurstaki* (1:5.60), and Control (1:5.43).

Keywords: Cost benefit ratio, efficacy, emamectin benzoate, *Helicoverpa armigera*, insecticides, spinosad, tomato

Introduction

Tomato, *Lycopersicon esculentum* (Miller), is an important vegetable crop grown around the world occupying the daily food regime of a majority of people (Hussain and Bilal, 2007) [5]. It is ranking second in importance next to potato (Babar *et al*., 2016) [2]. It is native of South America (Peru) from where it is supposed to have been spread all over the world. Tomato is important source of lycopene, which is powerful antioxidant that reduces risk of prostate cancer (Hussain and Bilal, 2007) [5]. The tomato is one of the most important "Protective food" because of its special nutritive value (Sathish *et al*., 2009) [13]. The highest tomato cultivating state is Madhya Pradesh with production about 2,970 tonnes followed by Andhra Pradesh with production about 2,217 tonnes.

A large number of insect pest attacks on tomato from nursery to harvesting of the crop. Tomato is more prone to insect pests attacked mainly by fruit borer, white fly, serpentine leaf miner, jassids, aphids, tobacco caterpillar, flea beetles and spider mites etc. In India, fruit borer (Lepidoptera: Noctuidae) one of the most important pests of tomato, limiting production and market value of produce young larvae feed exclusively on foliage, flower buds and flowers, while the later instars of these insects bore into fruit and render them unmarketable. (Meena and Raju 2014) [7]. The pest is active through the year at places having moderate climate but its activity is adversely affected by severe cold. *Helicoverpa armigera* is a serious pest in the flowering and fruiting stages causing severe damage upto 50% in tomato crop (Sathish *et al*., 2009) [13]. Considering the economic importance of pest, the study was conducted to test the comparative bioefficacy of insecticides with bio-pesticides against fruit borer.

Materials and Method

The present investigation was carried out during *rabi* season (October 2021 to March 2022) at Central Research Farm, SHUATS, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P. The tomato seeds of variety 'Pusa Ruby' were planted at 60 cm x 60 cm spacing.

The experiment was laid down in randomized block design (RBD) with eight treatments replicated thrice comprising of *Bacillus thuringiensis var kurstaki*, *Ha*NPV, Neem oil, Spinosad 45% SC, Indoxacarb 14.5% SC, Profenofos 50% EC, Emamectin Benzoate 5% SG and untreated control. All the treatments were applied two times using hand sprayer. The observations on pest incidence were recorded one day before spraying as pre- treatment count.

Post treatment count were taken at 3, 7 and 14 days after each spraying. For recording the larval population counts, five plants were selected randomly and tagged in each plot. The data on larval population was recorded and statistically analyzed with mean values obtained from the conversion of per cent fruit infestation (Gomez and Gomez, 1984) [4]. The cumulative per cent fruit damage was work out using the formula (Rahman *et al.*, 2014) [9].

$$\frac{\%\text{ Fruit infestation}}{\text{(Number basis)}} = \frac{\text{Number of infested fruits}}{\text{Total no. of fruits}} \times 100$$

In order to work out cost effective treatment modules against tomato fruit borer on tomato the "Incremental Cost Benefit Ratio" were worked out based on the total tomato fruit yield in terms of rupees per hectare, cost of inputs including treatment modules and labour charges, cost of application etc. and net monetary returns were calculated at the prevailing market rates during the period of experimentation. (Abbas *et al*., 2020) [1].

$$\text{BCR} = \frac{\text{Gross returns}}{\text{Total cost of cultivation}}$$

Where
BCR = Benefit Cost Ratio

Results and Discussion

The data on overall 1st spray larval population of tomato fruit borer on third, seven and fourteen days after 1st spraying revealed that Spinosad 45% SC (1.77) is significantly superior over all treatments, followed by T5 Indoxacarb 14.5% SC (1.88), T7 Emamectin Benzoate 5% SG (1.97), T6 Profenofos 50% EC (2.08), T2 *Ha*NPV (2.17), T3 Neem oil (2.24), T1 *Bacillus thuringiensis var kurstaki* (2.28), Control T0 (3.71). The treatments T3 Neem oil (2.24), T1 *Bacillus thuringiensis var kurstaki* (2.28) and Control (3.71).

Table 1: Comparative efficacy of selected insecticides on the larval population of tomato fruit borer (*Helicoverpa armigera*) on different days after 1st spray during *rabi* season 2021-2022

Treatments	Mean Larval Population of *Helicoverpa armigera* /5 plants				
	1DBS	3DAS	7DAS	14DAS	Mean
Control	2.83	3.00	3.73	4.40	3.71
Bacillus thuringiensis var. kurstaki	2.33	2.46	2.00	2.40	2.28
*Ha*NPV	2.53	2.33	1.93	2.26	2.17
Neem oil	2.40	2.40	2.00	2.33	2.24
Spinosad 45% SC	2.80	2.00	1.40	1.93	1.77
Indoxacarb 14.5% SC	2.66	2.06	1.60	2.00	1.88
Profenofos 50% EC	2.53	2.20	1.86	2.20	2.08
Emamectin Benzoate 5% SG	2.66	2.13	1.66	2.13	1.97
F-test	NS	S	S	S	S
CD (0.05)	-	0.28	0.39	0.27	0.48
CV	8.67	6.86	11.09	6.27	12.16

DAS: Days After Spray DBS: Days Before Spray

The data on overall 2nd spray larval population of tomato fruit borer on third, seventh and fourteen days after spraying revealed that Spinosad 45% SC (1.33) is significantly superior over all treatments, followed by T5 Indoxacarb 14.5% SC (1.39), T7 Emamectin Benzoate 5% SG (1.48), T6 Profenofos 50% EC (1.57), T2 *Ha*NPV (1.70), T3 Neem oil (1.79), T1 *Bacillus thuringiensis var kurstaki* (1.81), Control T**0** (6.10).

Table 2: Comparative efficacy of selected insecticides on the larval population of tomato fruit borer (*Helicoverpa armigera*) on different days after 2nd spray during *rabi* season 2021-2022

	Mean Larval Population of *Helicoverpa armigera* /5 plants				
Control	5.13	5.66	6.06	6.60	6.10
Bacillus thuringiensis var. kurstaki	2.40	2.06	1.46	1.93	1.79
*Ha*NPV	2.26	1.93	1.33	1.86	1.70
Neem oil	2.33	2.00	1.46	1.93	1.79
Spinosad 45% SC	1.93	1.40	1.06	1.53	1.33
Indoxacarb 14.5% SC	2.06	1.46	1.13	1.60	1.39
Profenofos 50% EC	2.20	1.66	1.26	1.80	1.57
Emamectin Benzoate 5% SG	2.13	1.53	1.20	1.73	1.48
F-test	NS	S	S	S	S
CD (0.05)	0.17	0.42	0.19	0.28	0.33
CV	-	11.02	5.09	6.78	8.89

Table 3: Comparative efficacy of selected insecticides on the larval population of tomato fruit borer (*Helicoverpa armigera*) on different days after overall 1st and 2nd spray during *rabi* season 2021-2022

Treatments	Overall mean of larval population of *Helicoverpa armigera*/ 5 plants		
	1st spray	2nd spray	1st and 2nd spray
Control	3.71	6.10	4.90
Bacillus thuringiensis var. kurstaki	2.28	1.81	2.04
*Ha*NPV	2.17	1.70	1.93
Neem oil	2.24	1.79	2.01

Spinosad 45% SC	1.77	1.33	1.55
Indoxacarb 14.5% SC	1.88	1.39	1.63
Profenofos 50% EC	2.08	1.57	1.82
Emamectin Benzoate 5% SG	1.97	1.48	1.72
CD (0.05)	0.48	0.33	1.69

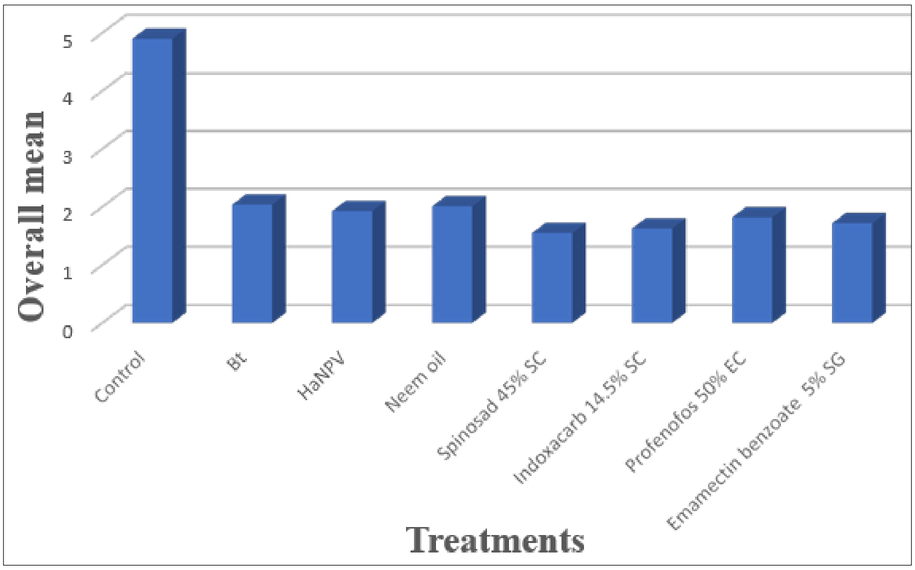

Fig 1: Graphical representation of comparative efficacy of selected insecticides on the larval population of tomato fruit borer (*Helicoverpa armigera*) on different days after overall 1st and 2nd spray

Treatments

The C:B ratio of various insecticide treatments were calculated which shows that maximum C:B ratio (1:8.33) was recorded in Spinosad 45% SC followed by T5 Indoxacarb 14.5% SC (1:8.20), T7 Emamectin benzoate 5%SG (1:8.16), T6 Profenofos 50%EC (1:7.07), T2 *Ha*NPV (1:6.33), T3 Neem oil (1:5.87), T1 *Bacillus thuringiensis var. kurstaki* (1:5.60), and T0 Control (1:5.43).

Table 4: Economics of different treatments

S. No.	Treatment	Yield (q/ha)	Total value of yield (₹)	Common cost (₹)	Treatment cost (₹)	Total cost (₹)	C:B ratio
1	Control	70	140000	25736	-	25736	1:5.43
2	*Bacillus thuringiensis var. kurstaki*	151	302000	25736	2400	28136	1:5.60
3	*Ha*NPV	172	344000	25736	2800	28536	1:6.33
4	Neem oil	160	320000	25736	3000	28736	1:5.87
5	Spinosad 45% SC	238	476000	25736	5618	31354	1:8.33
6	Indoxacarb 14.5% SC	228	456000	25736	4100	29836	1:8.20
7	Profenofos 50% EC	190	380000	25736	2220	27956	1:7.07
8	Emamectin Benzoate 5% SG	219	438000	25736	2160	27896	1:8.16

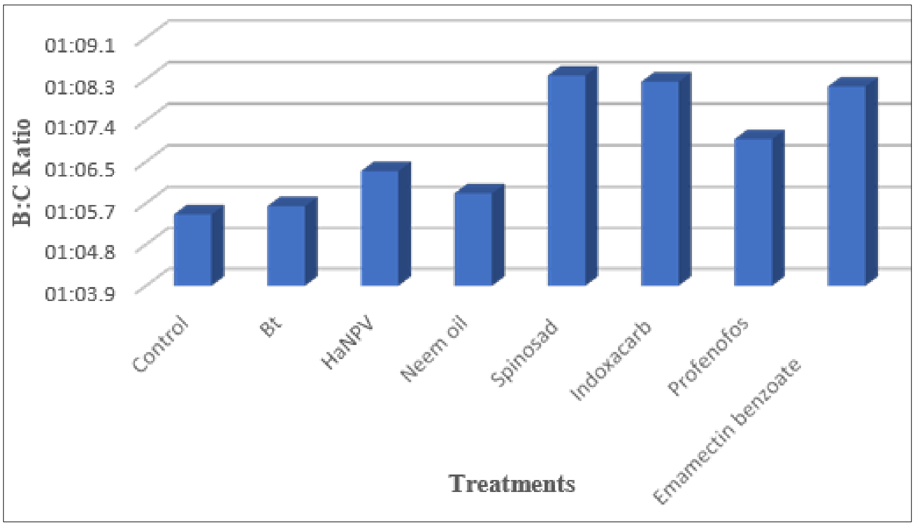

Fig 2: Graphical representation of economics of different treatments

Discussion

The finding of the present investigation revealed that lowest mean larval population of fruit borer of 1st and 2nd spray was recorded in T4 Spinosad 45% SC (1.77 and 1.33) followed by T5 Indoxacarb 14.5% SC (1.88 and 1.39), T7 Emamectin benzoate 5% SG (1.97 and 1.48), T6

Profenofos 50% EC (2.08 and 1.57), T2 *Ha*NPV (2.17 and 1.70), T3 Neem oil (2.24 and 1.79) and T1 *Bacillus thuringiensis var. kurstaki* (2.28 and 1.18) and T0 Control (3.71 and 6.10).

The overall mean larval population of tomato fruit borer was found superior in T4 Spinosad 45% SC (1.55), similar findings with Sapkal *et al.*, 2018 [11] resulting (1.04), followed by T5 Indoxacarb 14.5% SC (1.63) similar findings with Sathish *et al.*, 2018 [12] resulting (2.10), T7 Emamectin Benzoate 5% SG (1.72),T6 Profenofos 50% EC (1.82), similar findings with Patil *et al.*, 2018 [8] resulting (1.06),T2 *Ha*NPV (1.93), similar findings with Patil *et al.*, 2018 [8] resulting (1.25), T3 Neem oil (2.01), T1 *Bacillus thuringiensis var kurstaki* (2.04), Control T0 (4.90).

The yields of different treatments were found significant with each other. The highest fruit yield was registered in T4 Spinosad 45%SC (238 q/ha), similar with Singh *et al.*, 2017 [14] resulting (238.55q/ha), Tejeswari and Kumar, 2021 [15] resulting (230 q/ha) followed by T5 Indoxacarb 14.5% SC (228 q/ha), similar with Singh *et al.*, 2017 [14] resulting (265.20 q/ha), T7 Emamectin benzoate 5%SG (219 q/ha), T6 Profenofos 50%EC (190 q/ha), T2 *Ha*NPV (172 q/ha), similar with Choudhary *et al.*, 2017 [3] resulting (172 q/ha), T3 Neem oil (160 q/ha), similar with Kumar *et al.*, 2018 [6] resulting (167q/ha), T1 *Bacillus thuringiensis var. kurstaki* (151q/ha), similar with Sathish *et al.*, 2018 [12] resulting (148.25 q/ha), Tejeswari and Kumar, 2021 [15] resulting (151q/ha) and T0 Control (70q/ha).

The C:B ratio of various insecticide treatments were calculated and presented in which shows that maximum C:B ratio (1:8.33) was recorded in T4 Spinosad 45%SC similar with Tejeswari and Kumar, 2021[15] resulting (1:7.0) followed by T5 Indoxacarb 14.5% SC (1:8.20), similar with Reddy *et al.*, 2020 [10] resulting (1:10.8), T7 Emamectin benzoate 5%SG (1:8.16), Profenofos 50%EC (1:7.07), T2 *Ha*NPV (1:6.33), T3 Neem oil (1:5.87), similar with Tejeswari and Kumar, 2021 [15] resulting(1:5.6), T1 *Bacillus thuringiensis var. kurstaki* (1:5.60), similar with Tejeswari and Kumar, 2021 [15] resulting(1:5.2) and T0 Control (1:5.43).

Conclusion

The outcome of total experimentation efficacy of different insecticides against tomato fruit borer clearly suggested that T4 Spinosad 45% SC followed by, T5 Indoxacarb 14.5% SC, T7 Emamectin benzoate 5% SG proved to be effective in suppressing the fruit borer. While T6 Profenofos 50% EC, T2 *Ha*NPV ranked middle in order of their efficacy, then T3 Neem oil, T1 *Bacillus thuringiensis var kurstaki* found to be least effective in controlling *Helicoverpa armigera.* Among the treatments studied T4 Spinosad 45% SC gave the highest cost benefit ratio (1:8.33) and marketing yield (238 q/ha) under Prayagraj Agroclimatic conditions.

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