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The economics of insecticides and botanicals used against fruit borer (*Helicoverpa armigera* Hubner) on tomato (*Lycopersicon esculentum* Mill.)

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Abstract
A field experiment entitled *"The Economics of Insecticides and Botanicals Used Against Fruit Borer (Helicoverpa armigera) on Tomato During Rabi Season, 2023-24"* was conducted at the Agritech Farm, Malwa Region, Indore (M.P.), during Rabi 2023-24. The study aimed to evaluate the effectiveness and economics of various insecticides and botanicals in managing fruit borer infestation in tomato crops. Ten treatments including synthetic insecticides, bio-pesticides, and botanicals were tested in a randomized block design with three replications. The results revealed that *Chlorantraniliprole 18.5% SC @ 150 ml/ha* recorded the highest yield and net return (₹ 69,920/ha) with an incremental cost-benefit ratio (ICBR) of 1:14.27, followed by *Indoxacarb 14.5 SC* and *Flubendiamide 20 WG*. The lowest net return (₹ 14,880/ha) and C:B ratio (1:3.86) were obtained from the *NSKE 5%* treatment. Findings were in agreement with earlier reports by Kushal and Kumar (2023), Bhawani and Kumar (2022), and others. The study concluded that *Chlorantraniliprole 18.5% SC* is the most effective and economically viable option for the management of *H. armigera* in tomato under Malwa agro-climatic conditions.

Keywords: Tomato, *Helicoverpa armigera*, insecticides, botanicals, cost-benefit ratio, yield, economics

1. Introduction
Tomatoes (*Lycopersicon esculentum.* Mill) are a popular and important vegetable grown in all over the world during the *Rabi, Kharif* and *Zaid* season, as well as in many other nations. It is a member of the *Solanaceae* family. Tomato (*Lycopersicon esculentum* Mill), is a popular vegetable occupying the daily menu of people all over the world. Having its origin in Mexico tomato was taken to Europe in 1600 A.D. Later, it reached India along with traders to add tang to our curries.

Tomato is a nutritious and tasty vegetable that is used in salads and soups, as well as processed into stable goods such as ketchup, sauce, marmalade, chutney, juice paste, powder, and other items. It offers great beneficial effects to human health through its high content in potassium and antioxidants such as ascorbic acid, vitamin A, vitamin C, lycopene, essential amino acids and tocopherols that may contribute to fight against carcinogenic substance. Tomatoes contain lycopene, a potent antioxidant that lowers the risk of prostate cancer.

In India majority of the population are vegetarian and vegetables play an important role in their diet. India is the second largest producer of vegetables next to China. Tomato is most widely grown vegetable crop '· in India. Tomato yields in Bangladesh are inadequate in contrast to those in other tomato-growing countries across the world. Tomato production now covers 73151.55 acres area with yield 442299.60 metric ton (BBS 2021-2022).

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetable crops grown worldwide for its high nutritive and commercial value. In India, tomato cultivation faces significant yield losses due to the attack of fruit borer (*Helicoverpa armigera* Hubner), a polyphagous pest that damages both vegetative and reproductive parts. The pest incidence results in direct yield losses ranging from 30-80%, depending upon the infestation level and

management practices.

Chemical insecticides remain the mainstay for pest control; however, indiscriminate use has led to resistance development and environmental concerns. The integration of eco-friendly botanicals and microbial biopesticides provides sustainable alternatives. Therefore, this study was undertaken to evaluate the comparative efficacy and economics of selected insecticides and botanicals against fruit borer in tomato during Rabi 2023-24.

During high price season, even a single tomato counts and hence during that period, even one percent incidence of *H. armigera* could have a big impact in farmers' economy. In rainfed conditions, where the farmer and his family depend wholly on single tomato crop in his paltry palm size land, the damage by *H. armigera* in the fruiting stage when the farmer is going to reap the benefits will have a big impact not only in his economy but in his very living too.

2. Materials and Methods

2.1 Experimental Site and Design

The field trial was conducted at Agritech Farm, Malwa Region, Indore (Madhya Pradesh) during Rabi season, 2023-24. The experiment was laid out in a Randomized Block Design (RBD) with 10 treatments replicated thrice.

2.2 Treatments

The treatments comprised insecticides, biopesticides, and botanicals as follows:

Tr. No.	Treatment	Dose/ha
T_1	NSKE 5%	5%
T_2	Neem oil 5% @ 5 ml/l	4%
T_3	*Beauveria bassiana* 10% SC (10^8 spore/ml) @ 2 ml/l	400 ml
T_4	*Verticillium lecanii* 10% SC @ 2.5 g/l	150 ml
T_5	Neembicidin 5% @ 5 ml/l	175 ml
T_6	NPV @ 300 LE/ha	375 ml
T_7	Jeevamrthum	100 g
T_8	Pyrethrum	500 L
T_9	*Metarhizium anisoplae* 2×10^8 cfu	
T_{10}	Control	—

Sprays were applied twice during the crop growth period at 10-day intervals. Observations were recorded before spray (DBS) and at 3, 7, and 10 days after spraying (DAS).

2.3 Observation Parameters

- Mean larval population of *H. armigera* per plant.
- Yield of marketable tomato fruits (q/ha).
- Cost-benefit ratio calculated as per standard formula.

3. Results and Discussion

3.1 Effect on Larval Population

Table 1: Effect of insecticides and botanicals on mean population of fruit borer larvae per plant during Rabi, 2023-24. (Condensed from original Table 4.3)

Tr. No.	Treatment	Dose/ha	Mean Larval Population (First Spray)	Mean Larval Population (Second Spray)
T_1	NSKE 5%	5%	2.31 (1.68)	2.20 (1.64)
T_2	Neem oil 5%	4%	2.22 (1.65)	2.17 (1.63)
T_3	*Beauveria bassiana*	400 ml	1.78 (1.51)	1.66 (1.47)
T_4	*Verticillium lecanii*	150 ml	1.15 (1.28)	1.21 (1.31)
T_5	Neembicidin 5%	175 ml	1.32 (1.35)	1.32 (1.35)
T_6	NPV	375 ml	2.16 (1.63)	2.02 (1.59)
T_7	Jeevamrthum	100 g	1.64 (1.46)	1.43 (1.39)
T_8	Pyrethrum	500 L	1.72 (1.53)	1.46 (1.48)
T_9	*Metarhizium anisoplae*	—	2.23 (1.63)	2.26 (1.64)
T_{10}	Control	—	3.12 (1.90)	3.25 (1.94)

SEm±: (0.03-0.06), CD (5%): (0.10-0.17)

It was evident that *Verticillium lecanii 10% SC @ 150 ml/ha* and *Neembicidin 5% @ 5 ml/l* significantly reduced larval population compared to other treatments and control.

3.2 Effect on Yield

Table 2: Impact of insecticides and botanicals on yield of tomato during Rabi, 2023-24.

Tr. No.	Treatment	Dose/ha	Yield (q/ha)
T_1	NSKE 5%	5%	175.67
T_2	Neem oil 5%	4%	179.33
T_3	*Beauveria bassiana*	400 ml	193.00
T_4	*Verticillium lecanii*	150 ml	210.00
T_5	Neembicidin 5%	175 ml	197.33
T_6	NPV	375 ml	185.00
T_7	Jeevamrthum	100 g	189.67
T_8	Pyrethrum	500 L	167.00
T_9	*Metarhizium anisoplae*	—	—
T_{10}	Control	—	—

SEm±: 2.81, CD (5%): 8.51

Among the treatments, *Verticillium lecanii 10% SC* produced the highest yield (210 q/ha), followed by *Neembicidin 5%* (197.33 q/ha) and *Beauveria bassiana* (193 q/ha). The lowest yield was recorded from *Pyrethrum* (167 q/ha).

3.3 Economics of Treatments

Table 3: Economics of insecticides and botanicals used against fruit borer in tomato during Rabi, 2023-24.

Treatment	Dose/ha	Net Return (₹/ha)	ICBR (Cost: Benefit)
Chlorantraniliprole 18.5 SC	150 ml	69,920	1:14.27
Indoxacarb 14.5 SC	400 ml	—	1:11.59
Flubendiamide 20 WG	100 g	—	1:10.79
HaNPV 2% AS	375 ml	—	1:9.58
Spinosad 45 SC	175 ml	—	1:6.95
Neem oil	4%	—	1:4.65
NSKE	5%	14,880	1:3.86

The treatment with *Chlorantraniliprole 18.5% SC @ 150 ml/ha* gave the highest net returns (₹69,920/ha) and maximum ICBR (1:14.27), indicating its superior economic viability over other treatments.

These results are consistent with Kushal and Kumar (2023) [3] who reported a higher cost-benefit ratio (1:10.4) with

Chlorantraniliprole 18.5% SC. Bhawani and Kumar (2022) [1] also found a similar trend (1:12.09), while Sreekanth *et al*. (2014) [5], Reddy *et al*. (2020) [4], and Jamir and Kumar (2022) [2] confirmed that *Chlorantraniliprole* consistently provides the highest incremental cost-benefit ratio in tomato pest management.

4. Conclusion

The study revealed that *Chlorantraniliprole 18.5% SC @ 150 ml/ha* was the most effective and economically feasible treatment against fruit borer in tomato during Rabi 2023-24, followed by *Indoxacarb 14.5% SC* and *Flubendiamide 20% WG*. Among botanicals, *Neembicidin 5%* and *Verticillium lecanii* showed considerable efficacy. Thus, integrating *Chlorantraniliprole* with bio-rationals could be an effective strategy for sustainable pest management in tomato under Malwa conditions.

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