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Assessment of Insecticides Performance for Managing Tomato Fruit Borer (*H. armigera* L.) Under Field Conditions

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Abstract

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops in India, but its productivity is severely constrained by the fruit borer, *Helicoverpa armigera* (Lepidoptera: Noctuidae). The pest causes extensive damage by boring into fruits, resulting in yield losses of up to 50% and poor marketability. The present study was conducted during 2022-23 and 2023-24 on the "Assessment of Insecticides Performance for Managing Tomato Fruit Borer (*H. armigera* L.) Under Field Conditions". The experiment was laid out in a Randomized Block Design with eleven treatments and three replications. Tested formulations included Cyantraniliprole, Flubendiamide, Novaluron, Quinalphos, Fluxametamide, Indoxacarb, Phosalone, Chlorantraniliprole, Lambda-cyhalothrin, Azadirachtin, and an untreated control. Pre- and post-treatment observations were recorded on larval populations and fruit damage. Results across both years revealed that Chlorantraniliprole (18.5 SC at 150 ml/ha) consistently achieved the greatest reduction in larval populations and fruit damage, with mean infestation levels of only 6-8%. Indoxacarb (14.5 SC at 500 ml/ha) and Flubendiamide (20 WG at 100 ml/ha) also performed effectively, recording fruit damage between 10-18%. Fluxametamide provided moderate control, while conventional insecticides such as Quinalphos, Phosalone, and Lambda-cyhalothrin showed only partial suppression. Azadirachtin was least effective, with damage levels close to untreated control plots. Overall, the findings confirm that newer chemistries, particularly Chlorantraniliprole, offer superior protection against H. armigera and should be integrated into sustainable pest management programs for tomato cultivation.

Keywords: Tomato, fruit borer, fruit infestation & percentage fruit damage

Introduction

Tomato (*Solanum lycopersicum* L.), belonging to the Solanaceae family, is one of the world's most important vegetable crops, valued both for direct consumption and processing into products such as sauces, juices, and powders. Originating in South America and domesticated in Mexico, tomatoes have gained global significance due to their adaptability, nutritional richness, and economic contribution. In India, tomatoes hold a crucial position in horticulture. As of 2023, they were cultivated on 812.92 thousand hectares, producing 20,448.41 thousand metric tonnes with an average productivity of 25.16 t/ha. Madhya Pradesh stands as one of the leading producers, with productivity surpassing the national average. However, pest infestations remain a persistent challenge, threatening yield and quality.

Botanically, tomatoes are short-lived perennials in native conditions but cultivated as annuals. They are categorized into determinate (bushy, synchronous fruiting) and indeterminate (vine-like, extended harvest) varieties. Cultivation requires warm climates (21-27 °C), fertile well-drained soils, and adequate sunlight. Nursery raising, transplanting, staking, and caging are standard practices that improve establishment, reduce disease, and enhance fruit quality. Improved hybrids like 'Pusa Ruby' have further strengthened productivity through higher yield potential and stress tolerance.

Nutritionally, tomatoes are recognized as functional foods. They contain 93% water, are low in calories, and are rich in dietary fiber, vitamins (A, C, B-complex, folic acid), and minerals (iron, magnesium, phosphorus, copper). Despite their value, tomato cultivation in India faces constraints. Post-harvest losses due to poor storage and transport, fluctuating market prices, and resource degradation are critical issues. More significantly, insect pests cause heavy crop losses. Major pests include the tomato leaf miner (*Tuta absoluta*), whitefly (*Bemisia tabaci*), fruit borer (*Helicoverpa armigera*), aphids (Aphis gossypii), jassids (*Amrasca biguttula biguttula*), leaf miners (*Liriomyza trifolii*), and cutworms (*Agrotis spp*.). These pests not only damage plants directly but also act as vectors for viral diseases like Tomato Leaf Curl Virus (ToLCV). Overreliance on chemical pesticides has led to resistance, secondary pest resurgence, and environmental concerns. The tomato fruit borer (*Helicoverpa armigera* L.) is a highly destructive pest causing severe yield and quality losses in tomato production. Its larval feeding on ripening fruits renders them unmarketable, often resulting in yield reductions of 30-50%. Due to its polyphagous nature, high reproductive capacity, and resistance to conventional insecticides, effective management remains challenging. Field evaluation of newer insecticides is essential to identify efficient, eco-friendly options. Assessing their performance under field conditions helps determine their efficacy in reducing fruit damage, ensuring higher yields, and minimizing pesticide resistance, thereby supporting sustainable tomato cultivation and improved farmer profitability.

Material and Methods

The field experiment was laid out in a Randomized Block Design (RBD) with three replications and eleven treatments. Each treatment was randomized independently within replications to minimize bias. Every plot consisted of five rows with eight plants per row, totaling 40 plants per plot. To avoid cross-contamination, a spacing of 0.5 m between plots and 1 m between replications was maintained. From each plot, five plants were randomly tagged for detailed observations.

The insecticidal treatments included a wide range of novel and conventional formulations: Cyantraniliprole (10.26 OD, 900 ml/ha), Flubendiamide (20 WG, 100 ml/ha), Novaluron (10 EC, 750 ml/ha), Quinalphos (25 EC, 1000 ml/ha), Fluxametamide (10 EC, 400 ml/ha), Indoxacarb (14.5 SC, 500 ml/ha), Phosalone (35 EC, 1285 ml/ha), Chlorantraniliprole (18.5 SC, 150 ml/ha), Lambda-cyhalothrin (5 EC, 300 ml/ha), and Azadirachtin (1.00% EC, 10,000 ppm, 1000 ml/ha). An untreated control was maintained for comparative assessment.

Prior to treatment application, pre-treatment observations were recorded 24 hours in advance to establish baseline pest populations and crop health. Post-treatment observations were conducted on the 1st, 3rd, and 7th days after spraying. For larval population assessment, five randomly selected plants from each plot were carefully examined, and the number of *H. armigera* larvae was recorded.

To assess fruit damage, harvested fruits were categorized into healthy and infested groups. The percentage of fruit damage was calculated by dividing the number of damaged fruits by the total harvested fruits. This provided an accurate estimation of yield loss attributable to fruit borer infestation.

The experiment's design allowed for reliable evaluation of treatment performance by minimizing environmental variability and ensuring statistical validity. Randomization and replication enhanced the precision of data, while the inclusion of both chemical and botanical insecticides allowed for a comparative assessment of different management strategies.

Overall, this methodological framework enabled a comprehensive evaluation of insecticidal efficacy under field conditions, thereby generating results relevant to integrated pest management (IPM) programs for sustainable tomato cultivation.

Table 1: Details of treatments used in the study

Treatment	Treatment Name	Formulation	Dose (g or ml/ha)
T_1	Cyantraniliprole	10.26 OD	900 ml/ha.
T_2	Flubendiamide	20 WG	100 ml/ha.
T_3	Novaluron	10 EC	750 ml/ha.
T_4	Quinalphos	25 EC	1000 ml/ha.
T_5	Fluxametamide	10EC	400 ml/ha.
T_6	Azadirachtin	01.00% EC (10000 PPM)	1000 ml/ha.
T_7	Indoxacarb	14.5SC	500 ml/ha.
T_8	Phosalone	35EC	1285 ml/ha.
T_9	Chlorantraniliprole	18.5 SC	150 ml/ha.
T_{10}	Lambda-cyhalothrin	5EC	300 ml/ha.
T_{11}	Control		

Table 2: Experimental details

Sr. No.	Headings	Details
1	Crop	Tomato
2	Variety	Arka Vishesh
3	Design	RBD
4	Replication	Three
5	Treatment	Eleven
6	Total Plots	Thirty-three
7	Plant to plant Distance	40cm
8	Row to row distance	60cm
9	Plot size	3.60×3.60m
10	No. of row in each plot	05
11	No. of plot per row	08
12	Total No. of plant per plot	40
13	No. of plants for observation	05
14	Plot o plot distance	050m
15	Replication distance	01m
16	Manure & fertilizer	20 T FYM,100:50:60 (NPK)/ha
17	Season	Rabi

Result and Discussion

Across the two consecutive years of evaluation (2022-23 and 2023-24), the field experiments consistently demonstrated that among all tested insecticidal treatments, Chlorantraniliprole (T9) provided the most effective suppression of Helicoverpa armigera larval populations and fruit damage in tomato crops. Pre-treatment observations confirmed uniform pest pressure across plots, ensuring statistical reliability. Over three sprays per season, Chlorantraniliprole maintained the lowest larval counts, followed closely by Indoxacarb (T7) and Flubendiamide (T2), with Fluxametamide (T5) showing moderate yet consistent control. Conventional insecticides such as Cyantraniliprole (T1), Novaluron (T3), Quinalphos (T4), Phosalone (T8), and Lambda-cyhalothrin (T10) offered only partial suppression, while the botanical Azadirachtin (T6) remained largely ineffective, recording larval levels close to untreated control plots. The untreated control (T11) consistently showed the highest larval counts, confirming the necessity of chemical intervention for managing H. armigera in tomato cultivation.

The percentage of fruit damage data from successive pickings further substantiated the superiority of Chlorantraniliprole, which consistently recorded the lowest damage (around 6-8% mean across both years). Indoxacarb followed closely, with damage averaging around 10-11%, while Flubendiamide and Fluxametamide achieved moderate reductions (about 16-18%). Conventional insecticides generally showed higher fruit damage levels (24-26%), indicating limited field efficacy, and Azadirachtin consistently failed to reduce damage effectively, with values exceeding 34%. The untreated control plots reached critical infestation levels, with fruit damage surpassing 46-50%, highlighting the high pest pressure in the absence of management. Overall, the findings demonstrate that newer chemistries—particularly Chlorantraniliprole—offer superior and sustained protection against H. armigera, making them valuable candidates for inclusion in integrated pest management (IPM) programs to enhance tomato yield and quality under field conditions. Patil *et al.* (2018) [7] and Kumar *et al.* (2020) [8] identified Chlorantraniliprole as a highly potent insecticide, not only for its effectiveness but also for its environmental safety and compatibility with natural enemies. Similarly, Meena *et al.* (2016) [4] reported high larval mortality using Indoxacarb and Flubendiamide. Studies by Singh *et al.* (2011) and Kranthi *et al.* (2009) [9] have emphasized the challenges of resistance development due to over-reliance on synthetic pyrethroids, urging a shift to molecules with novel modes of action. Yadav *et al.* (2021) and Sharma and Singh (2016) confirmed the effectiveness of Spinosad and Emamectin benzoate, while Jain *et al.* (2019) and Verma and Meena (2016) [3] advocated for integrating biopesticides like neem oil for sustainable pest control. Gupta *et al.* (2017) and Panse *et al.* (2021) underlined that newer insecticides not only reduce infestation but also contribute to higher yield and quality. Chauhan *et al.* (2017) and Mishra *et al.* (2018) supported the use of Flubendiamide and Spinosad for their effectiveness and environmental safety. Verma and Meena (2016) highlighted that while neem oil is less effective, it is safer for pollinators and may complement chemical strategies. Panse *et al.* (2021) [2] and Dodia *et al.* (2020) [1] reinforced the value of combining molecules like Flubendiamide and Emamectin benzoate for enhanced, prolonged control.

Table 3: Efficacy of different insecticides on *Helicoverpa armigera* infesting tomato 2022-23

Treat. Symb.	Treatments	Formulation	Dose ml/ha	Pre treat-ment	Fruit borer larval population / plant									Overall mean of three sprays
					1st spray			2nd spray			3rd spray			
					Days after spraying									
					1	3	7	1	3	7	1	3	7	
T1	Cyantraniliprole	10.26 OD	900	4.26	3.35	3.37	3.77	3.79	3.59	3.55	3.52	3.52	3.51	3.54
T2	Flubendiamide	20 WG	100	3.95	2.70	2.65	3.37	2.70	2.56	2.93	2.37	1.95	1.32	2.50
T3	Novaluron	10 EC	750	4.13	3.88	3.83	3.85	3.84	3.84	3.69	3.72	3.56	3.48	3.73
T4	Quinalphos	25 EC	1000	3.84	3.53	3.83	3.84	3.84	3.75	3.66	3.53	3.50	3.39	3.64
T5	Fluxametamide	10EC	400	3.92	3.28	3.20	4.15	3.40	3.08	3.04	3.04	2.37	1.79	3.04
T6	Azadirachtin	01.00% EC (10000 PPM)	1000	4.18	3.88	3.86	3.97	3.97	4.00	4.06	4.01	4.02	4.00	3.97
T7	Indoxacarb	14.5SC	500	4.02	1.79	1.93	2.28	1.61	1.58	1.53	1.53	1.08	0.83	1.56
T8	Phosalone	35EC	1285	4.26	3.81	3.83	3.90	3.95	3.90	3.93	3.90	3.85	3.91	3.88
T9	Chlorantraniliprole	18.5 SC	150	3.86	1.38	1.25	1.76	1.36	1.18	1.37	1.10	0.86	0.59	1.22
T10	Lambda-cyhalothrin	5EC	300	3.34	3.42	3.25	3.50	3.55	3.50	3.53	3.50	3.57	3.47	3.47
T11	Control		---	4.65	4.92	5.09	5.29	5.34	5.57	5.64	5.70	6.07	6.01	5.50
	S.Em±			0.59	0.10	0.08	0.07	0.08	0.14	0.06	0.08	0.09	0.05	0.02
	C.D.at 5%			NS	0.30	0.25	0.22	0.23	0.42	0.20	0.23	0.28	0.16	0.08

Table 4: Evaluation of different insecticides against *Helicoverpa armigera* (%) on tomato 2022-23

Treat. Symb.	Treatments	Formulation	Dose ml/ha	Percentage of damaged fruits each picking						Overall mean
				Ist	IInd	IIIrd	IVth	Vth	VIth	
T1	Cyantraniliprole	10.26 OD	900	25.20 (29.98)	25.10 (29.90)	24.65 (29.54)	25.10 (30.05)	23.98 (29.09)	24.36 (29.35)	24.72 (29.78)
T2	Flubendiamide	20 WG	100	19.88 (26.39)	17.35 (24.53)	16.75 (24.06)	16.36 (23.78)	15.95 (23.45)	15.65 (23.20)	16.98 (24.30)
T3	Novaluron	10 EC	750	26.27 (30.82)	26.30 (30.84)	26.36 (30.84)	25.17 (29.95)	25.10 (29.90)	25.25 (30.01)	25.73 (30.43)
T4	Quinalphos	25 EC	1000	25.80 (30.40)	25.20 (29.98)	25.85 (30.44)	24.25 (29.28)	24.68 (29.56)	25.10 (29.90)	25.14 (30.05)

T5	Fluxametamide	10EC	400	22.90 (28.57)	19.60 (26.20)	17.23 (24.48)	16.70 (24.11)	15.40 (22.99)	15.23 (22.86)	17.83 (24.96)
T6	Azadirachtin	01.00% EC (10000 PPM)	1000	34.57 (35.99)	34.19 (35.77)	36.10 (36.91)	35.85 (36.72)	36.05 (36.88)	35.68 (36.62)	35.40 (36.50)
T7	Indoxacarb	14.5SC	500	14.00 (21.90)	12.46 (20.62)	10.50 (18.76)	9.75 (18.12)	8.95 (17.24)	10.15 (18.37)	10.96 (19.33)
T8	Phosalone	35EC	1285	26.85 (31.17)	26.90 (31.23)	25.75 (30.37)	25.45 (30.16)	25.55 (30.23)	24.85 (29.74)	25.88 (30.56)
T9	Chlorantraniliprole	18.5 SC	150	8.12 (16.55)	7.20 (15.47)	6.46 (14.66)	6.25 (14.44)	5.65 (13.69)	6.55 (14.76)	6.70 (14.96)
T10	Lambda-cyhalothrin	5EC	300	24.36 (29.35)	24.30 (29.31)	23.85 (29.00)	23.36 (28.70)	27.40 (31.42)	22.85 (28.41)	24.34 (29.41)
T11	Control	-	- -	42.65 (40.75)	42.25 (40.52)	45.15 (42.20)	48.80 (44.29)	50.30 (45.16)	52.65 (46.88)	46.96 (43.24)
	S.Em±		-	2.50 (1.67)	2.51 (1.71)	2.82 (1.92)	3.36 (2.18)	3.25 (2.13)	5.22 (3.30)	2.02 (1.27)
	C.D. at 5%		-	7.36 (4.93)	7.39 (5.04)	8.30 (5.68)	9.89 (6.44)	9.27 (6.29)	15.37 (9.75)	5.96 (3.75)

Table 5: Efficacy of different insecticides on *Helicoverpa armigera* infesting tomato 2023-24

Treat. Symb.	Treatments	Dose L./ha	Pre treat-ment	Fruit borer larval population / plant									Overall mean of three spray
				1st spray			2nd spray			3rd spray			
				Days after spraying									
				1	3	7	1	3	7	1	3	7	
T1	Cyantraniliprole	900 ml/ha.	5.12	3.35	3.37	3.77	3.79	3.69	3.55	3.52	3.52	3.51	3.58
T2	Flubendiamide	100 ml/ha.	4.00	2.72	2.67	3.37	2.76	2.56	2.96	2.37	1.95	1.32	2.50
T3	Novaluron	750 ml/ha.	4.13	3.88	3.83	3.85	3.84	3.84	3.60	3.72	3.56	3.48	3.73
T4	Quinalphos	1000 ml/ha.	4.12	3.53	3.72	3.81	3.88	3.75	3.66	3.53	3.50	3.39	3.64
T5	Fluxametamide	400 ml/ha.	3.92	3.28	3.20	4.15	3.40	3.08	3.04	3.04	2.37	1.79	3.04
T6	Azadirachtin	1000 ml/ha.	4.18	3.88	3.86	3.97	3.97	4.00	4.06	4.01	4.02	4.00	3.97
T7	Indoxacarb	500 ml/ha.	4.05	1.77	1.91	2.25	1.58	1.62	1.66	1.53	1.08	0.83	1.58
T8	Phosalone	1285 ml/ha.	4.26	3.81	3.83	3.96	3.95	3.94	3.93	3.90	3.85	3.91	3.88
T9	Chlorantraniliprole	150 ml/ha.	3.86	1.38	1.25	1.78	1.36	1.18	1.37	1.10	0.86	0.53	1.21
T10	Lambda-cyhalothrin	300 ml/ha.	3.34	3.42	3.25	3.50	3.55	3.50	3.53	3.50	3.57	3.47	3.47
T11	Control	---	4.70	4.92	5.09	5.29	5.34	5.57	5.64	5.70	6.07	6.01	5.56
S.Em±			0.60	0.10	0.08	0.07	0.08	0.14	0.06	0.08	0.09	0.05	0.03
C.D.at 5%			NS	0.30	0.25	0.22	0.23	0.42	0.20	0.23	0.28	0.16	0.08

Table 6: Evaluation of different insecticides against *Helicoverpa armigera* (%) on tomato 2023-24

Treat. Symb.	Treatments	Dose/ha	Percentage of damaged fruits each picking						Overall mean
			Ist	IInd	IIIrd	IVth	Vth	VIth	
T1	Cyantraniliprole	900 ml/ha.	25.26 (29.98)	25.10 (29.90)	24.65 (29.54)	25.18 (30.06)	24.12 (29.09)	24.38 (29.35)	25.24 (29.88)
T2	Flubendiamide	100 ml/ha.	19.90 (26.42)	17.35 (24.53)	16.75 (24.06)	16.36 (23.78)	15.95 (23.45)	15.65 (23.20)	16.99 (24.32)
T3	Novaluron	750 ml/ha.	26.27 (30.82)	26.30 (30.81)	26.36 (30.84)	25.17 (29.95)	25.12 (29.90)	25.25 (30.01)	25.74 (30.43)
T4	Quinalphos	1000 ml/ha.	25.82 (30.40)	25.20 (29.98)	25.85 (30.44)	24.52 (29.28)	24.68 (29.56)	25.10 (29.90)	25.46 (30.14)
T5	Fluxametamide	400 ml/ha.	23.12 (28.57)	19.62 (26.20)	17.23 (24.48)	16.70 (24.11)	15.40 (22.99)	15.23 (22.86)	17.85 (24.96)
T6	Azadirachtin	1000 ml/ha.	33.88 (35.99)	34.22 (35.77)	36.12 (36.91)	35.85 (36.72)	36.05 (36.88)	35.68 (36.62)	34.40 (35.50)
T7	Indoxacarb	500 ml/ha.	14.16 (21.92)	12.46 (20.62)	10.51 (18.76)	9.78 (18.12)	8.96 (17.26)	10.19 (18.37)	11.06 (19.33)
T8	Phosalone	1285 ml/ha.	26.88 (31.17)	26.92 (31.23)	25.75 (30.37)	25.45 (30.16)	25.55 (30.23)	24.85 (29.74)	25.88 (30.56)
T9	Chlorantraniliprole	150 ml/ha.	8.18 (16.58)	7.22 (15.47)	6.48 (14.66)	6.26 (14.44)	5.67 (13.69)	6.55 (14.76)	6.78 (14.98)
T10	Lambda-cyhalothrin	300 ml/ha.	24.42 (29.35)	24.30 (29.31)	23.85 (29.00)	23.36 (28.70)	27.41 (31.42)	22.85 (28.41)	24.34 (29.41)
T11	Control	- -	42.68 (39.88)	42.25 (40.52)	45.16 (42.20)	48.84 (44.29)	50.32 (45.16)	52.65 (46.88)	46.98 (43.24)
	S.Em±	-	2.58 (1.68)	2.54 (1.71)	2.84 (1.92)	3.36 (2.18)	3.25 (2.13)	5.22 (3.30)	2.08 (1.29)
	C.D. at 5%	-	6.92 (4.97)	7.42 (5.19)	8.32 (5.96)	9.90 (6.82)	9.27 (6.29)	15.37 (9.88)	6.06 (3.79)

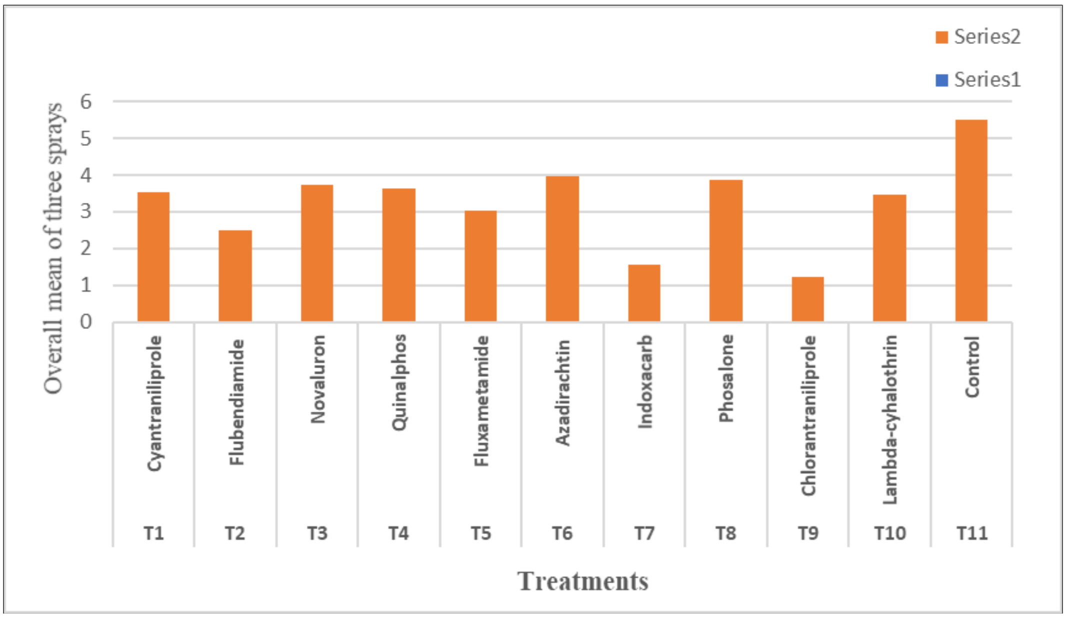

Fig 1: Efficacy of different insecticides on Helicoverpa armigera infesting tomato 2022-23 & 2023-24

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