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Evaluation of the bio-efficacy of novel insecticides against the shoot and fruit borer *Earias vitella* (Fabricius) in okra

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Abstract
Okra (*Abelmoschus esculentus* L.) is a nutritionally and economically important crop in India, but its productivity is severely constrained by the shoot and fruit borer, *Earias vitella* (Fabricius), which can cause yield losses exceeding 60%. The present field investigation was conducted during summer 2024 and summer 2025 at ICAR-IIVR, Varanasi, to evaluate the bio-efficacy and economics of different insecticidal treatments against *E. vitella*. Eight treatments, including azadirachtin, quinalphos, novaluron, lambda cyhalothrin, and varying doses of fipronil, were tested in a randomized block design. Results revealed that all insecticides significantly reduced fruit infestation compared to the untreated control, with fipronil @ 4 ml/l (T_6) showing the highest efficacy, reducing infestation to 2.96% and recording the maximum yield (126.37 q/ha). Fipronil @ 2 ml/l and 1 ml/l ranked second and third in effectiveness, while novaluron and lambda cyhalothrin provided moderate control. Economic analysis indicated that fipronil @ 1 ml/l achieved the highest cost-benefit ratio (1:23.56), followed by lambda cyhalothrin (1:20.04). Overall, fipronil, particularly at higher doses, proved most effective in minimizing borer damage and enhancing yield, while lower doses offered superior economic returns. The study underscores the potential of fipronil as a key component of integrated pest management strategies for sustainable okra cultivation.

Keywords: Okra, *Earias vitella*, Insect pest management, Yield, ICBR

Introduction

Okra (*Abelmoschus esculentus* L.), a prominent member of the Malvaceae family and commonly known as lady's finger, is extensively cultivated across the tropical and subtropical agro-climatic zones of India. It holds considerable nutritional significance due to its rich composition of essential macro- and micronutrients, including potassium, calcium, iron, magnesium, sodium, and phosphorus, as well as vitamins A, B-complex, and C, alongside fats and carbohydrates-key constituents of a well-balanced human diet (Aykroyd *et al.*, 1963) [2]. Notably, okra seeds possess a distinctive protein profile, characterized by a favourable balance of essential amino acids such as tryptophan and lysine, surpassing the amino acid composition typically found in cereals and pulses (Gemede *et al.*, 2016) [5]. The therapeutic potential of okra is attributed to its abundant bioactive compounds present in the mucilage, seeds, and fruit tissues.

India ranks as one of the leading producers of okra globally, with an annual production of 6,416.31 tonnes. The principal okra-producing states include Gujarat (15.89%), West Bengal (13.93%), Bihar (12.38%), Madhya Pradesh (11.75%), and Odisha (10.33%) (NHB, 2021-22). Despite its economic and nutritional value, okra cultivation is severely constrained by a broad spectrum of phytophagous insect pests that infest various plant organs-leaves, stems, floral buds, flowers, calyx, roots, and fruits-culminating in yield losses estimated at approximately 69% (Adja *et al.*, 2019) [1]. Among these, the shoot and fruit borer, *Earias vitella* (Fabricius), poses a particularly severe threat by inflicting direct damage to the tender shoots and developing fruits, leading to deformities, reduced fruit size, and compromised marketability (Rahman *et al.*, 2013) [11]. Infestations by *Earias* spp. have been reported to cause fruit yield losses ranging from 21.00% to as high as 91.58%, depending on the cultivar and environmental conditions (Kataria & Singh, 2021) [7]. The pest exerts its deleterious impact throughout all phenological stages of the crop, thereby diminishing both yield quantity and quality (Shah *et al.*, 2001) [14].

Conventional management practices predominantly depend on the application of chemical insecticides; however, the identification of efficacious, economically sustainable, and environmentally benign compounds remains a pressing challenge. In this context, the present investigation is undertaken to assess the field-level bio-efficacy of various novel insecticidal formulations against *Earias vitella*, with the ultimate objective of optimizing pest management strategies in okra cultivation.

Material and Methods

The experiments were conducted during Summer 2024 and Summer 2025 at ICAR - Indian Institute of Vegetable Research, Varanasi (India). The experiment was laid out in randomized complete block design (RBD) with four replications. The unit plot size was 4.0 × 3.6 m with maintaining spacing of 60 cm between row to row and 45 cm plant to plant. The land was ploughed 2-3 times, incorporating FYM before sowing. The recommended cultivation practices for growing okra were followed except for plant protection measures. Fertilizers were applied at the recommended rates as a basal application: 100 kg of Nitrogen (N), 40 kg of phosphate (P_2O_5), and 40 kg of potash (K_2O) per hectare. Irrigation was provided as needed, especially at the flowering and fruit formation stages. Weed control was done through hand weeding. The first harvest began 40 to 50 days after sowing, with tender pods of 7 to 10 cm picked regularly.

Materials

For conducting the present investigation, required material like okra seed (kashi pragati), fertilizers, agricultural implements, tractor, chemical insecticides Azadiractin, Quinalphos, Novaluron, Lambda Cyhalothrin and Fipronil, knapsack sprayer, measuring cylinder, labels and pegs were made available by ICAR- Indian Institute of Vegetable Research, Varanasi.

Details of Treatments

For estimating the comparative losses caused by the pests, eight treatments were compared with the control plots. Different treatments were as follows: T_1 (Azadiractin 5 ml/l), T_2 (Quinalphos 1.5 ml/l), T_3 (Novaluron 1.5 ml/l), T_4 (Lamda Cyhalothrin 1 ml/l), T_5 (Fipronil 2 ml/l), T_6 (Fipronil 4 ml/l), T_7 (Fipronil 1 ml/l) and T_8 (Control) no insecticide was sprayed on the crop and was exposed to natural infestation i.e. untreated control. The knapsack sprayer fitted with hollow cone nozzle was used for spray operation after mixing the required concentration of insecticides with water.

Table 1: Details of treatments

Sr. no.	Treatments	Formulations	Application Rate (ml/ liter of water)	Trade name	Company
T_1	Azadirachtin	300 ppm	5 ml/ l	Econeem	Margo Biocontrols Pvt. Ltd.
T_2	Quinalphos	25 EC	1.5 ml/l	Ekalux	Syngenta Pvt. Ltd.
T_3	Novaluron	10 EC	1.5 ml/l	Rimon	Indofil Industries Ltd.
T_4	Lambda Cyhalothrin	5 EC	1 ml/l	Karate	Syngenta Pvt. Ltd.
T_5	Fipronil (RD)	5 SC	2 ml/l	Regent	Bayer Pvt. Ltd.
T_6	Fipronil (DD)	5 SC	4 ml/l	Regent	Bayer Pvt. Ltd.
T_7	Fipronil (HD)	5 SC	1 ml/l	Regent	Bayer Pvt. Ltd.
T_8	Control	-	-	-	-

C) Method of Recording Observations

1. Percentage of infestation and yield

Larvae population of *E. vitella* to be observed, five plants were randomly selected from each treatment and count the number of numbers of infested fruits was recorded 24 hours before spray and after 1, 3, 5,7 and 14 days of each spray.

$$\text{Fruit infestation (\%)} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

Yield data for each treatment was meticulously recorded post-harvest. Subsequently, treatment-specific fruit yields were converted into quintals per hectare (q/ha). The data collected from both treated and untreated plots were then utilized to calculate the avoidable yield loss.

2. Percent increase in yield

Per cent increase in yield was computed by using the formula mentioned by Pradhan (1969) [10].

$$\text{Percent increase in yield} = \frac{\text{Yield in treated plots (q/ha)} - \text{Yield in utreated plots (q/ha)}}{\text{Yield in untreated plots (q/ha)}} \times 100$$

Total three spray were applied. The first spray was administered at the ETL of pest stage, with a follow-up application conducted 15 days later.

3. Incremental Cost Benefit Ratio (ICBR)

The economic evaluation of different treatments was carried out by considering the costs associated with insecticides, biopesticides, botanicals, their application, equipment charges, and other related expenses incurred during the study. The grain yield per hectare, along with the prevailing market price, was used to calculate the benefit derived from each treatment per hectare. The Incremental Cost Benefit Ratio (ICBR) was then determined based on the incremental yield benefit over the control and the costs involved, to rank the treatments economically. The following parameters were used to calculate the Incremental Cost Benefit Ratio:

- **Gross Monetary Benefits**

This was determined by multiplying the additional yield over the control with the prevailing minimum local market price of the commodity.

- **Treatment Costs**

This was calculated by summing up all the expenses related to each treatment, including labour and charges for any hired equipment.

- **Net Monetary Return**

This was calculated by subtracting the total cost of the treatment (B) from the gross monetary benefits (A), i.e., A - B.

- **Cost Benefit Ratio**

This was determined by dividing the net monetary return (C) by the total treatment cost (B), i.e., C/B.

Results and Discussion

Pooled data of Bio efficacy of different Insecticides against okra shoot and fruit borer *Earias vitella* (Fabricus).

The pooled analysis of the bio-efficacy of different insecticidal treatments against *Earias vitella* on okra revealed that all insecticidal treatments significantly reduced fruit infestation compared to the untreated control. Fipronil, particularly at 4 ml/l (T_6), consistently demonstrated the highest efficacy across all time intervals and spray schedules. In the first spray, infestation levels dropped significantly from 35.07% pretreatment to just 10.00% at 7 days after spray (DAS) in T_6. This trend continued in the second spray, where T_6 recorded only 6.13% infestation at 7 DAS, compared to 47.26% in the control. Similarly, in the third spray, fruit infestation was further minimized to just 2.96% at 7 DAS in T_6, as opposed to 55.29% in untreated plots. Fipronil @ 2 ml/l (T_5) and 1 ml/l (T_7) also showed excellent control, ranking second and third in efficacy across most observations. Novaluron (T_3) and lambda cyhalothrin (T_4) provided moderate control and were often statistically at par, while quinalphos (T_2) and azadirachtin (T_1) showed comparatively lower, yet still significant, reduction in infestation. The consistent reduction in fruit damage across sprays, particularly with higher doses of fipronil, underscores its superior efficacy. Overall, the study confirmed that all treatments outperformed the control significantly, with fipronil at 4 ml/l emerging as the most effective insecticide for managing *E. vitella* in okra (Table 2.0). The findings of the present study on the efficacy of various insecticides against *Earias* spp. in okra align partially with previous research, particularly regarding the performance of fipronil. While Yadav *et al.*, (2017) [18] reported slightly lower infestation levels with other insecticides like indoxacarb and spinosad, the current study recorded higher percent reductions over control, reaffirming the strong efficacy of fipronil. Similar trends were observed by Chauhan *et al.*, (2021) [4], Naidu and Kumar (2019) [9], and Umrao *et al.*, (2013) [17], all of whom reported significant reductions in fruit and shoot borer infestation following fipronil application. Additionally, studies by Gosalwad and Kawathekar (2009) [6], Singh *et al.*, (2002) [15], and Sinha *et al.*, (2007) [16] further highlighted the dual benefits of fipronil, not only in pest suppression but also in enhancing marketable yield. Collectively, these findings support the current study's results and emphasize fipronil's consistent and effective role in managing *Earias vitella*, validating its integration into pest management programs for okra cultivation

Table 2: Pooled data of Bio efficacy of different Insecticides against okra shoot and fruit borer *Earias vitella* (Fabricus).

Treatment	Pre-treatment	1 DAS	3 DAS	5 DAS	7 DAS	Pre-treatment	1 DAS	3 DAS	5 DAS	7 DAS	Pre-treatment	1 DAS	3 DAS	5 DAS	7 DAS
T_1	33.33	32.04	26.42	24.94	22.81	26.15	24.80	22.42	19.67	16.53	19.78	18.83	16.64	12.78	11.66
T_2	34.45	31.43	27.01	24.39	20.88	23.38	22.18	20.80	18.08	14.79	17.86	17.16	13.97	11.71	10.58
T_3	34.39	32.51	26.76	23.48	17.34	19.46	18.08	16.18	14.43	12.40	14.39	13.54	12.04	9.51	8.99
T_4	34.61	32.81	27.28	22.81	19.83	21.81	21.25	18.58	15.48	13.69	16.19	15.00	12.91	10.53	9.84
T_5	34.54	31.00	22.46	18.49	12.04	14.74	13.68	11.46	10.10	8.93	9.69	8.76	8.12	6.45	4.87
T_6	35.07	31.65	19.79	16.49	10.00	12.36	11.16	9.70	8.19	6.13	8.11	7.43	6.37	5.05	2.96
T_7	34.22	33.54	25.70	22.12	15.83	17.27	15.68	13.75	12.00	10.64	12.14	11.10	9.79	8.69	7.76
T_8	34.68	37.91	39.39	40.05	40.55	42.82	43.74	45.02	46.09	47.26	50.94	51.70	53.05	53.79	55.29
CD	N/A	1.54	1.77	1.47	1.95	1.63	1.86	1.59	1.51	1.54	2.21	1.76	1.62	1.25	1.10
SE (m)	0.54	0.52	0.59	0.49	0.65	0.55	0.62	0.53	0.51	0.52	-	-	-	-	-

Pooled data of Yield and ICBR of different Insecticides against okra shoot and fruit borer *Earias vitella* (Fabricus).

The highest yield was recorded in the T_6 (fipronil @ 4 ml/l) (126.37 q/ha) followed by T_5 (fipronil @ 2 ml/l) (120.45 q/ha), T_7 (fipronil @ 1 ml/l) (113.09 q/ha), T_3 (novaluron @ 1.5 ml/l) (104.00 q/ha), T_4 (lambda cyhalothrin @ 1 ml/l) (96.86 q/ha), T_2 (quinalphos @ 1.5 ml/l) (90.53 q/ha), T_1 (azadirachtin @ 5 ml/l) (84.31 q/ha) and lowest fruit yield was recorded in in T_8 (Control) (65.93 q/ha). Fipronil @ 4 ml/l was found significantly superior over all the treatments followed by fipronil @ 2 ml/l and fipronil @ 1 ml/l. All the treatments were found significantly superior over control. The yield percent was maximum increased in fipronil @ 4 ml/l (91.68%) followed by fipronil @ 2 ml/l (82.70%), fipronil @ 1 ml/l (71.54%), novaluron @ 1.5 ml/l (57.76%), lambda cyhalothrin @ 1 ml/l (46.92%), quinalphos @ 1.5 ml/l (37.32%), azadirachtin @ 5 ml/l (27.88%) as compare to control. The cost of crop protection was highest T_3 (novaluron @ 1.5ml/l) (11,670 Rs./ha), T_6 (fipronil @ 4 ml/l) (9,240 Rs./ha) followed by T_1 (azadirachtin 5 ml/l) (7,740 Rs./ha)**,** T_5 (fipronil @ 2 ml/l) (5,640 Rs./ha), T_2 (quinalphos @ 1.5 ml/l) (4,290 Rs./ha), T_7 (fipronil @ 1 ml/l) (3,840 Rs./ha) and T_4 (lambda cyhalothrin @ 1 ml/l) (2,940 Rs,/ha). However highest cost benefit ratio was recorded in fipronil @ 1 ml/l (1: 23.56) followed by lambda cyhalothrin @ 1 ml/l (1: 20.04), fipronil @ 2 ml/l (1: 18.33), fipronil @ 4 ml/l (1: 12.08), quinalphos @ 1.5ml/l (1: 10.47), novaluron @ 1.5 ml/l (1: 5.53) and azadirachtin @ 5 ml/l (1: 3.75) (Table 3.0). Laichattiwar and Meena (2014) [8] evaluated the efficacy of various insecticides against okra shoot and fruit borer, *Earias vitella* and found maximum cost:benefit ratio was obtained from okra plots treated with fipronil with (1:11.76) followed by spinosad (1:8.77). Bharpoda *et al.*, (2014) [3] reported that the highest seed cotton yield of 30.81 q/ha was obtained from the crop treated with imidacloprid, followed by treatments with thiamethoxam (26.01 q/ha), acetamiprid (25.68 q/ha), and fipronil (23.44 q/ha). Imidacloprid recorded the highest insecticidal cost-benefit ratio (1:16.54), followed by acetamiprid (1:11.06), thiamethoxam (1:7.05), and fipronil (1:5.93). Saichand and Kumar (2024) [12] reported 149.2q/ha by using fipronil 5% SC in okra crop. Zanwar *et al.*, (2012) [19] reported that the significantly highest seed cotton yield (14.35 q/ha) was recorded in fipronil 40 per cent + imidacloprid 40 per cent at the rate of 100 ml/ha, followed by fipronil 5% SC (12.58q/ha) and imidacloprid 200 SL (11.84 q/ha). Zanwar *et al.*, (2012) [19] observed that the combination of fipronil 40% + imidacloprid 40% applied at 100 ml/ha resulted in a significantly higher seed cotton yield of 14.35 q/ha. This was followed by fipronil 5% SC, which yielded 12.58 q/ha, and imidacloprid 200 SL, with a yield of 11.84 q/ha.

Table 3: Pooled data of Yield and ICBR of different Insecticides against okra shoot and fruit borer *Earias vitella* (Fabricus)

Treatments	Yield q/ha	Yield increases over control (%)	Total return Rs/ ha	Cost of Treatments Rs/ ha (labour + sprayer charge + insecticides cost)	Net income Rs/ha	Realization over control Rs/ha	ICBR ratio
T_1	84.31	27.88	168610	7740	160870	29020	3.75
T_2	90.53	37.32	181050	4290	176760	44910	10.47
T_3	104.00	57.76	208000	11670	196330	64480	5.53
T_4	96.86	46.92	193710	2940	190770	58920	20.04
T_5	120.45	82.70	240890	5640	235250	103400	18.33
T_6	126.37	91.68	252730	9240	243490	111640	12.08
T_7	113.09	71.54	226170	3840	222330	90480	23.56
T_8	65.93	-	131850	-	131850	-	-
C.D.	3.613	-	-	-	-	-	-
SE(m)	1.21	-	-	-	-	-	-

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