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Eco-friendly management of okra shoot and fruit borer *Earias vittella* (Fab.)

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Abstract
A field trial was carried out during the *Rabi* season of 2020-2021 to evaluate eco-friendly approaches for managing the okra shoot and fruit borer, *Earias vittella* (Fab.). The study was designed using a Randomized Block Design (RBD) with three replications, involving two applications of eight treatments: Karanj oil (2 ml/L), Illupai oil (2 ml/L), Neem oil (3 ml/L), Cypermethrin 25% EC (2 ml/L), Spinosad 45% SC (0.5 ml/L), Mahogany oil (5 ml/L), Panchagavya (30 ml/L), and an untreated control. Among the treatments, the lowest shoot infestation percentage, fruit infestation percentage, and the highest benefit-cost (B:C) ratio were recorded in T_5 (Spinosad 45% SC) at 3.83%, 7.20%, and 1:3.20, respectively. This was followed by T_4 (Cypermethrin 25% EC) with 6.64%, 10.92%, and 1:3.09; T_3 (Neem oil) with 11.85%, 14.89%, and 1:2.27; T_1 (Karanj oil) with 13.78%, 18.77%, and 1:2.09; T_2 (Illupai oil) with 15.49%, 21.85%, and 1:1.87; T_6 (Mahogany oil) with 17.12%, 25.04%, and 1:1.59; T_7 (Panchagavya) with 20.63%, 27.80%, and 1:1.59; and the untreated control (T_8) with 25.97%, 33.20%, and 1:1.17, respectively.

Keywords: Efficacy, *Earias vittella*, botanical oils, insecticides, cost benefit ratio

Introduction
Okra (*Abelmoschus esculentus* L.), a member of the Malvaceae family, is an economically important vegetable crop believed to have originated in Ethiopia. It is now cultivated extensively across tropical, subtropical, and warm temperate regions worldwide. Okra contributes significantly to human nutrition, supplying protein, carbohydrates, vitamins, calcium, potassium, and other essential minerals that are frequently deficient in diets of developing nations. It also possesses medicinal properties, including the ability to help treat gastric ulcers and alleviate hemorrhoids.

In India, okra is grown throughout the country, with major production concentrated in states such as Andhra Pradesh, Telangana, West Bengal, Jharkhand, Odisha, Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat, and Maharashtra. The tender pods are highly valued for their rich nutritional profile, containing approximately 90% water, 38 kcal energy, 2.0 g protein, 0.1 g fat, 7.6 g carbohydrates, 0.9 g fiber, 81 mg calcium, 63 mg phosphorus, 303 mg potassium, 660 IU vitamin A, and 21.1 mg vitamin C per 100 g of edible portion, along with notable amounts of B-vitamins. The mucilage present in immature pods makes them ideal for thickening soups and curries. Additionally, okra roots and stems are traditionally used to clarify sugarcane juice (Chauhan, 1972), while its high iodine content helps prevent goitre. Mature dry seeds yield 18-22% edible oil and 20-30% protein.

Despite its importance, okra suffers heavy damage from various insect pests at different growth stages. Among them, the okra shoot and fruit borer (*Earias vittella* Fabricius), along with whitefly and jassids, are the most destructive. Approximately 13 serious insect and mite pests have been recorded on this crop. The shoot and fruit borer is particularly devastating, as larvae bore into tender shoots and developing fruits, often causing yield losses of up to 69% in marketable produce (Rawat and Sahu, 1973) [36].

In recent years, plant-derived (botanical) pesticides have gained prominence as safer alternatives for crop protection. These natural products break down quickly in the environment, pose lower risks to non-target organisms and beneficial insects, and reduce the ecological hazards associated with persistent synthetic chemicals. The present study was therefore undertaken to assess the effectiveness of selected botanical treatments in managing the okra shoot and fruit borer.

Materials and Methods

The field trial was carried out during the Rabi season of 2020-2021 at a farmer's field in Nizamabad, Telangana, located at 18°40′40.80″ N latitude, 78°06′7.20″ E longitude, and an elevation of 395 m above mean sea level. The region experiences a typical semi-arid subtropical climate, with summer temperatures rising up to 45 °C and winter temperatures falling to around 15 °C. The experimental site was level, uniformly fertile, and consisted of well-drained sandy loam soil. The trial included eight treatments along with an untreated control, and each treatment was replicated thrice. The okra variety "Samantha" was selected, and the crop was grown following all recommended agronomic practices to ensure uniform and healthy plant stand. Each experimental plot measured 2 m × 2 m, with row-to-row and plant-to-plant spacing maintained at 25 cm × 25 cm. The eight treatments evaluated were: T_1-Karanj oil @ 2 ml/L, T_2-Illupai oil @ 2 ml/L, T_3-Neem oil 3% @ 3 ml/L, T_4-Cypermethrin 25% EC @ 2 ml/L, T_5-Spinosad 45% SC @ 0.5 ml/L, T_6-Mahogany oil @ 5 ml/L, T_7-Panchagavya @ 30 ml/L and T_8-Untreated/control.

Table 1: Details of Treatments

S. No.	Botanicals oils and insecticide formulations for treatments	Group	Waiting period	Dosage (ml or gm/lit & kg/ha)	Reference
T_1	Karanj oil 2%	Botanical	-	2 ml/L	Panbude *et al.* (2019) [29]
T_2	Illupai oil 2%	Botanical	-	2 ml/L	Kumar and Thakur (2017) [28, 38]
T_3	Neem oil 3%	Botanical	07	3 ml/L	Rakshith and kumar (2017) [35]
T_4	Cypermethrin 25% EC	Synthetic pyrethroid	03	2 ml/L	Padwal and kumar (2014) [18]
T_5	Spinosad 45% SC	Spinosyn A & Spinosyn D/Naturalyte	03	0.5 ml/lit	Nalini and kumar (2016) [25]
T_6	Mahogany oil 5%	Botanical	-	5 ml/lit	Rahman *et al.* (2016) [32]
T_7	Panchagavya 3%	Organic	-	30 ml/lit	Pazhanisamy and Archunan (2020) [2]
T_8	Control (Untreated)	--	--	--	--

Method of recording observations

Infestation by the shoot and fruit borer was assessed on five randomly tagged plants per plot. Shoot damage was determined by counting the total number of infested shoots against the total shoots available, while fruit infestation was evaluated by recording the number of damaged (bore-affected) fruits in relation to healthy ones. Observations were taken one day prior to each spray and subsequently on the 3rd, 7th, and 14th day after every application. The percentage of shoot and fruit infestation was calculated using the following standard formula:

$$\text{Percent Shoot infestation} = \frac{\text{Number of infested shoots}}{\text{Number of total shoots}} \times 100$$

$$\text{Percent Fruit infestation} = \frac{\text{Number of infested fruits}}{\text{Number of total fruits}} \times 100$$

Cost Benefit Ratio

The economic viability of each treatment was evaluated through the benefit-cost ratio. Net returns were calculated by subtracting the total cost of plant protection from the additional gross income obtained over the untreated control. The total cost of production comprised standard cultivation expenses plus treatment-specific plant protection costs. The BCR was then expressed as the ratio of additional net returns to the additional cost incurred.

$$\text{Cost benefit ratio} = \frac{\text{Gross returns}}{\text{Total cost of production}}$$

Statistical analysis

The recorded data for each parameter were averaged and, where necessary, subjected to appropriate transformations (arcsine or square-root) to meet the assumptions of normality and homogeneity of variance. The transformed data were then analyzed using analysis of variance (ANOVA) following the standard procedures for Randomized Block Design as outlined by Gomez and Gomez (1984) [14]. Mean values were presented in tables to facilitate result interpretation. Treatment means were compared using the Critical Difference (CD) at a 5% level of significance ($p \leq 0.05$). The F-test was used to determine the significant difference.

Results and Discussion

First spray percent shoot infestation:

The mean percent shoot infestation recorded on the 3rd, 7th, and 14th day after the first spray revealed that all treatments were significantly superior to the untreated control (Table 2). The lowest shoot infestation by okra shoot and fruit borer was recorded in T_5-Spinosad 45% SC (3.83%), followed by T_4-Cypermethrin 25% EC (6.64%), T_3-Neem oil 3% (11.85%), T_1-Karanj oil (13.78%), T_2-Illupai oil (15.49%), T_6-Mahogany oil (17.12%), and T_7-Panchagavya (20.63%). Among the treatments, Panchagavya was the least effective but still significantly better than the untreated control T_8 (25.97%).

Second spray percent fruit infestation

The Mean percent fruit infestation recorded on the 3rd, 7th, and 14th day after the second spray showed that all treatments were significantly superior to the untreated control (Table 3). The lowest shoot infestation by the okra shoot and fruit borer was observed in T_5-Spinosad 45% SC (7.20%), followed by T_4-Cypermethrin 25% EC (10.92%), T_3-Neem oil 3% (14.89%), T_1-Karanj oil (18.77%), T_2-Illupai oil (21.82%), T_6-Mahogany oil (25.04%), and T_7-Panchagavya (27.80%). Among the treatments, Panchagavya was the least effective but remained significantly better than the untreated control T_8 (33.20%).

Among the evaluated treatments, T_5 (Spinosad 45% SC) demonstrated the highest efficacy in suppressing the shoot and fruit borer infestation in okra. The mortality values recorded after the first and second sprays were 3.83 percent and 7.20 percent, respectively, indicating superior performance. Similar effectiveness of Spinosad 45% SC against shoot and fruit borer has been previously documented by Pachole *et al.* (2017) [28]. The next most effective treatment was T_4 (Cypermethrin 25% EC), which recorded 6.64 percent and 10.92 percent mortality following the first and second sprays, a trend consistent with the findings of Rakshith and Kumar (2017) [35]. T_3 (Neem oil 3%) showed moderate efficacy, with corresponding values of 11.85 percent and 14.89 percent in the first and second applications. These results align with the observations of Padwal and Kumar (2013) [18] and Pachole *et al.* (2017) [28], who reported similar performance of neem-based formulations. T_1 (Karanj oil 2%) emerged as the subsequent effective bio-pesticide, yielding 13.78 percent and 18.77 percent reduction in pest population across two sprays, corroborating the findings of Pachole *et al.* (2017) [28]. This was followed by T_2 (Illupai oil 2%), which exhibited efficacy levels of 15.49 percent and 21.85 percent, supported by the reports of Kumar and Thakur (2017) [28, 38]. The least effective treatments were T_6 (Mahogany oil 5%) and T_7 (Panchgavya 3%), a conclusion that is in line with earlier studies by Rahaman *et al.* (2016) [32] and Pazhanismy and Archunan (2019) [31].

Fruit yield and cost benefit ratio

All treatments produced significantly higher marketable fruit yield than the untreated control during the Rabi 2020-21 season (Table 4). The highest yield was recorded in T_5-Spinosad 45% SC (108.28 q/ha), followed by T_4-Cypermethrin 25% EC (96.22 q/ha), T_3-Neem oil 3% (70.44 q/ha), T_1-Karanj oil (65.12 q/ha), T_2-Illupai oil (57.87 q/ha), T_6-Mahogany oil (50.45 q/ha), and T_7-Panchagavya (45.93 q/ha). The untreated control recorded the lowest yield of 35.45 q/ha. The highest cost-benefit ratio (1:3.20) was achieved with T_5 (Spinosad 45% SC), indicating its superior economic viability. These results are consistent with the observations of Gosalwad and Kawathekar (2006) [15], who reported enhanced yield performance with Spinosad 45% SC. The next most economical treatment was T_4 (Cypermethrin 25% EC), which recorded a cost-benefit ratio of 1:3.09, a finding supported by the work of Kushwaha and Painkra (2016). Moderate economic returns were obtained from the botanical treatments, with T_3 (Neem oil 3%) yielding a ratio of 1:2.27, followed by T_1 (Karanj oil 2%) at 1:2.09 and T_2 (Illupai oil 2%) at 1:1.87. These results correspond with earlier reports by Nalini and Kumar (2016) [25], Kumar and Thakur (2017) [28, 38], and Kushwaha and Painkra (2016), who noted comparable economic efficiency of these botanical formulations. The lowest cost-benefit ratios were observed in T_6 (Mahogany oil 5%), which recorded 1:1.59, and T_7 (Panchagavya 3%), which recorded 1:1.46. These findings are in agreement with the results reported by Sultana *et al.* Thus, Spinosad 45% SC emerged as the most effective and economically viable option for managing okra shoot and fruit borer.

Table 2: Efficacy of selected botanical oils and insecticides to control shoot and fruit borer (*Earias vittella*) in okra (First spray): Percent shoot infestation

Treatments		% Shoot infestation				
		Before Spraying	3 DAS	7 DAS	14 DAS	Mean
T_1	Karanj oil	19.26	13.48	14.41	13.47	13.78
T_2	Illupai oil	22.17	15.22	15.64	15.61	15.49
T_3	Neem oil	20.06	11.40	12.09	12.08	11.85
T_4	Cypermethrin 25% EC	22.42	6.75	5.36	7.82	6.64
T_5	Spinosad 45% SC	15.28	3.98	2.78	4.74	3.83
T_6	Mahogany oil	19.09	16.90	17.59	16.87	17.12
T_7	Panchagavya	17.86	19.87	20.76	21.27	20.63
T_8	Control (water spray)	21.31	24.67	25.94	27.30	25.97
F-test		NS	S	S	S	S
S. Ed. (±)		3.93	1.75	2.01	1.52	0.55
C. D. (P = 0.05)		NS	2.32	2.48	2.16	1.29

Table 3: Efficacy of selected botanical oils and insecticides to control shoot and fruit borer (*Earias vittella*) in okra (Second spray): Percent fruit infestation.

Treatments		% Fruit infestation				
		Before Spraying	3 DAS	7 DAS	14 DAS	Mean
T_1	Karanj oil	22.01	18.13	18.82	19.36	18.77
T_2	Illupai oil	23.75	20.87	22.48	22.26	21.85
T_3	Neem oil	22.81	13.80	14.82	16.07	14.89
T_4	Cypermethrin 25% EC	21.87	11.31	9.09	12.38	10.92
T_5	Spinosad 45% SC	21.98	7.63	5.38	8.61	7.20
T_6	Mahogany oil	22.58	24.14	25.09	25.85	25.04
T_7	Panchagavya	24.17	27.14	27.75	28.52	27.80
T_8	Control (water spray)	27.75	32.15	32.44	35.02	33.20
F-test		NS	S	S	S	S
S. Ed. (±)		4.07	1.30	1.65	2.25	0.72
C. D. (P = 0.05)		NS	2	2.25	2.63	1.48

Table 4: Economics of cultivation (Cost-benefit ratio):

S. No	Treatments	Yield q/ha	Cost of yield/Rs/q	Total cost of yield (Rs.)	Common cost (Rs.)	Treatment cost (Rs.)	Total cost (Rs.)	C:B ratio
1	Karanj oil	65.12	1800	117216	54474	1425	55899	1:2.09
2	Illupai oil	57.87	1800	104166	54474	1180	55654	1:1.87
3	Neem oil	70.44	1800	126792	54474	1285	55759	1:2.27
4	Cypermethrin 25% EC	96.22	1800	173196	54474	1450	55924	1:3.09
5	Spinosad 45% SC	102.28	1800	184104	54474	2975	57449	1:3.20
6	Mahogany oil	50.45	1800	90810	54474	2325	56799	1:1.59
7	Panchagavya	45.93	1800	82674	54474	2125	56599	1:1.46
8	Control	35.45	1800	63810	54474	-	54474	1:1.17

Conclusion

The present investigation concluded that Spinosad 45% SC is the most effective treatment among the eight evaluated for managing okra shoot and fruit borer (*Earias vittella* Fab.). It recorded the lowest infestation levels, delivered the highest marketable yield, and provided the best benefit-cost ratio. Cypermethrin 25% EC ranked second in efficacy, followed by Neem oil, Karanj oil, Illupai oil, and Mahogany oil, all of which significantly reduced borer damage compared to the untreated control. Panchagavya exhibited the lowest efficacy among the treatments under the agro-climatic conditions of Nizamabad. Nevertheless, the botanical oils and bio-organic products tested offer valuable eco-friendly alternatives for insect pest management. They can be effectively integrated into Integrated Pest Management (IPM) programmes for sustainable okra cultivation. Further studies are recommended to optimise their application schedules and dosages for enhanced control of *Earias vittella*.

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