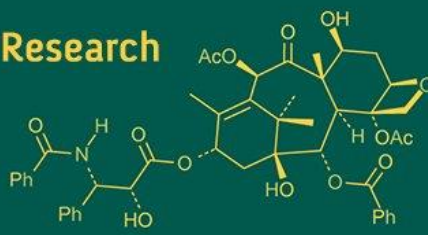


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Teresa Mary Agastian
M.Sc. Scholar, Department of
Agricultural Entomology, Pandit
Jawaharlal Nehru College of
Agriculture and Research Institute,
Karaikal, Puducherry, India

Swapnil Kumar Pandey
Assistant Professor, Faculty of
Agriculture, JNCT Professional
University, Bhopal, Madhya
Pradesh, India

Nandeesh J
Ph.D. Scholar, Department of
Horticulture, University of
Agricultural Sciences, Bangalore,
Karnataka, India

Vishwambhar Hanmant Jadhav
Programme Assistant (Lab
Technician), Shri Siddhagiri Krishi
Vigyan Kendra, Kaneri Math,
Kolhapur, Maharashtra, India

Ektedar
M.Sc. Scholar, Department of Plant
Pathology, Chaudhary Charan
Singh University, Meerut, Uttar
Pradesh

Rohit Rohan Dahiya
Ph.D. Scholar, Department of
Vegetable Science, Maharana
Pratap Horticulture University,
Karnal, Haryana, India

Moge Lollen
M.Sc. Scholar, Department of
Entomology, Rajiv Gandhi
University, Doimukh, Itanagar,
Arunachal Pradesh, India

Jyoti Gawaria
Ph.D. Scholar, Department of
Entomology, Chaudhary Charan
Singh Haryana Agricultural
University, Hisar, Haryana, India

Dharampal Yadav
M.Sc. Scholar, Department of
Entomology, Institute of
Agricultural Sciences, Bundelkhand
University, Jhansi, Uttar Pradesh,
India

Corresponding Author:
Dharampal Yadav
M.Sc. Scholar, Department of
Entomology, Institute of
Agricultural Sciences, Bundelkhand
University, Jhansi, Uttar Pradesh,
India

Efficacy of different bio-pesticides for the management of okra shoot and fruit borer (*Earias vitella* Fab.)

Teresa Mary Agastian, Swapnil Kumar Pandey, Nandeesh J, Vishwambhar Hanmant Jadhav, Ektedar, Rohit Rohan Dahiya, Moge Lollen, Jyoti Gawaria and Dharampal Yadav

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Abstract

All the treatments were found effective and significantly superior to the control. Based on per cent fruit infestation on okra, T₁ *Beauveria bassiana* 2.0 kg/ha, T₃ *Bacillus thuringiensis* 2.0 kg/ha, T₈ Neem oil 5%, T₄ *Metarhizium anisopliae* 2.0 kg/ha, T₆ NSKE 5%, T₂ *Verticillium lecanii* 2.0 kg/ha, T₇ Karanj oil 10% and T₅ Garlic extract 10% were compared to T₉ control. All the treatments were found effective and significantly superior to the control. The same trend of effectiveness of treatments was found in both cases, i.e., in shoot infestation as well as in fruit infestation. Among the treatments studied, the best and most economical treatment was T₁ *Beauveria bassiana* (1:3.10), followed by T₃ (1:3.05), T₈ (1:3.02), T₄ (1:2.93), T₆ (1:2.74), T₂ (1:2.65), T₇ (1:2.61), T₅ (1:2.48), as compared to control T₉ (1:1.90).

Keywords: Okra, *Beauveria bassiana*, infestation, shoot and fruit borer, yield

Introduction

Lady's finger (*Abelmoschus esculentus* L.), commonly known as okra or bhindi, is one of the most important vegetable crops grown in tropical and subtropical regions of the world because of its taste, flavour, and nutritional value. Okra is one of the widely consumed and commercially cultivated vegetable crops and forms an important component of the human diet due to its nutritional and medicinal properties. It is a very popular summer vegetable for home gardening, and it is also grown commercially throughout the world, especially in the Indo-Pakistan subcontinent (Yadav *et al.*, 2024a) ^[17]

A total of 204.61 million metric tons of vegetables are produced in India. India is the largest producer of okra in the world, producing 6,371,000 tonnes of okra during 2021–2022. Nigeria is the second-largest okra-producing country in the world, with a production of 1,837,904 tonnes. India, which ranks first, contributed approximately 62 percent of the world's total okra production. In 2022, the top three producing countries accounted for an 85.5 percent share, while the top ten countries accounted for 95.0 percent of global production. The major okra-producing states in India include Uttar Pradesh, Bihar, Odisha, West Bengal, Andhra Pradesh, and Karnataka (Anonymous, 2022) ^[2].

Okra is an important component of the human diet and is a good source of protein, carbohydrates, vitamins, calcium, potassium, enzymes, and total minerals, which are often deficient in the diets of developing countries. Okra is also good for health and the mucilage of okra has great medicinal properties: antioxidant, antidiabetic, antitumor, antimicrobial, and antiulcer capacities, and it also has the properties to control cholesterol in the human body (Yadav *et al.*, 2024b) ^[14]. Its medicinal properties have been associated with the relief of haemorrhoids and ulcers. Okra has also been used medicinally as a blood volume expander and plasma replacement, and in the treatment of chronic dysentery, spermatorrhoea, and genito-urinary disorders. Its seeds are rich in unsaturated fatty acids and rich in fibre, which is good for digestion and cures ulcers of the digestive system (Yadav *et al.*, 2024c) ^[13]. The nutritional and medicinal importance of okra fruits has increased interest in its commercial cultivation.

The composition of okra pods per 100 g of edible portion is as follows: water 88.6 g, energy 144.00 kJ (36 kcal), protein 2.10 g, carbohydrate 8.20 g, fat 0.20 g, fibre 1.70 g, Ca 84.00 mg, P 90.00 mg, Fe 1.20 mg, β -carotene 185.00 μ g, riboflavin 0.08 mg, thiamin 0.04 mg, niacin 0.60 mg, and ascorbic acid 47.00 mg. It is crucial for human nutrition and a good source of total minerals, vitamins, calcium, potassium, enzymes and other nutrients that are frequently lacking in the diets of developing countries (Yadav *et al.*, 2025a) [15]. Biopesticides, including entomopathogenic fungi and bacteria, offer promising, eco-friendly pest management options (Yadav *et al.*, 2025b) [16].

Materials and Methods

The present investigation on okra shoot & fruit borer (*Earias vitella* Fab.) using different bio-pesticides was carried out at the experiment, Organic Research Farm Kargua Ji, Department of Entomology, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (Uttar Pradesh) during the *Kharif* season of 2022-2023. The experiment was laid out in a simple Randomized Block Design (RBD) with nine treatments, including the untreated control, *Beauveria bassiana* 2.0 kg/ha, *Bacillus thuringiensis* 2.0 kg/ha, Neem oil 5%, *Metarhizium anisopliae* 2.0 kg/ha, NSKE 5%, *Verticillium lecanii* 2.0 kg/ha, Karanj oil 10% and Garlic extract 10%. The individual plot size was 3.20 $\times$ 2.15 m, with row-to-row and plant-to-plant distances of 60 $\times$ 45 cm, respectively. Okra variety Kashi Lalima was sown on 25 July, 2022. All the biopesticides were applied as foliar sprays. The recommended package of practices was adhered to for cultivating the crop. Records were maintained regarding the percentage of shoots infested and the total damaged fruits, with shoot infestation computed at weekly intervals from five randomly selected plants in each plot. Fruit infestation data were collected from each picking, and marketable fruit yield was recorded. Data were recorded one day before spraying and on the 3rd, 7th, and 14th days following each application. The collected data on different parameters were analyzed using analysis of variance (ANOVA) as per the method of Gomez and Gomez (1984). The results were analyzed using the 'F' test, and the critical difference (CD) was determined at a 5% significance level. The prevailing market price of okra, the cost of biopesticides, and labour charges were considered to calculate the cost-benefit ratio, evaluating the economics based on the net income obtained from the additional yield over the control. The percentage of shoot and fruit infestation was determined using the formula below:

$$\text{Per cent shoot infestation} = \frac{\text{Number of infested shoots}}{\text{Number of total shoots}} \times 100$$

$$\text{Per cent fruit infestation} = \frac{\text{Number of infested fruit's}}{\text{Number of total fruit's}} \times 100$$

Results and Discussion

The minimum shoot infestation (Table 1) after 1st spray 6.83, 4.75, and 1.82 per cent was recorded in *Beauveria bassiana* @ 2 kg/ha treated plot at 3rd, 7th and 14th days after spraying respectively followed by *Bacillus thuringiensis* 2 kg/ha (7.15, 4.93 and 3.96) < Neem oil 5% (7.88, 6.79 and 4.96) < *Metarhizium anisopliae* 2 kg/ha (8.55, 7.46 and 6.92) < NSKE 5% (9.6, 8.32 and 7.58) < *Verticillium lecanii* 2 kg/ha (9.99, 9.28 and 8.24) < Karanj oil 10 % (10.89,

10.37 and 9.94) < Garlic extract 10% (12.08, 11.90 and 11.11) compared to control (15.95, 17.54 and 18.75), all the treatments were found effective and significantly superior over the control.

The minimum fruit infestation (Table 2) after 2nd spray was recorded in per cent was recorded in *Beauveria bassiana* 2 kg/ha treated plot *i.e.* 13.59, 11.86 and 7.68 per cent fruit infestation followed by *Bacillus thuringiensis* 2 kg/ha (14.30, 12.70 and 8.95) < Neem oil 5% (15.36, 14.90 and 12.32) < *Metarhizium anisopliae* 2 kg/ha (16.13, 15.32 and 14.13) < NSKE 5 % (17.42, 17.07 and 14.48) < *Verticillium lecanii* 2 kg/ha (18.21, 17.74 and 15.35) < Karanj oil 10 % (19.93, 18.04 and 17.30) < Garlic extract 10% (20.91, 19.76 and 19.61) compared to control (17.67, 20.04 and 23.10), all the treatments were found effective and significantly superior over the control at 3rd, 7th, and 14th days after spraying respectively.

The minimum fruit infestation (Table 3) after 3rd spray was recorded in percent was recorded in *Beauveria bassiana* 2 kg/ha treated plot *i.e.* 7.78, 5.91 and 4.69 percent fruit infestation followed by *Bacillus thuringiensis* 2 kg/ha (9.16, 7.21 and 5.90) < Neem oil 5% (10.27, 8.50 and 6.72) < *Metarhizium anisopliae* 2 kg/ha (11.10, 9.41 and 7.64) < NSKE 5 % (11.87, 10.35 and 9.25) < *Verticillium lecanii* 2 kg/ha (13.20, 12.86 and 10.07) < Karanj oil 10 % (15.33, 13.39 and 12.25) < Garlic extract 10% (15.96, 14.87 and 13.81) compared to control (19.90, 23.95 and 25.86), all the treatments were found effective and significantly superior over the control at 3rd, 7th, and 14th days after spraying respectively. This study substantiates with the findings of Ghosal *et al.* (2013), who reported that the biorational insecticide spinetoram 50 g a.i./ha has been found superior to other treatments against *Earias vitella* (Fab.) okra. It recorded 4.01 % mean shoot and fruit infestation in okra. The next effective treatment was emamectin benzoate @ 18 g a.i./ha (5.61 % mean shoot and fruit infestation in okra), followed by spinosad @ 75 g a.i./ha (5.87 %), chlorfenapyr @ 125 g a.i./ha (7.42 %), *Bacillus thuringiensis* (9.47 %) and azadirachtin (1 0.68 %). The results of the present study were in accordance with the findings of several workers (Mandal *et al.*, 2007; Panbude *et al.*, 2019) [6, 8].

The yields among the treatments were significant. The highest yield (Table 4) was recorded in T₁ *Beauveria bassiana* (150.20 q/ha), followed by T₃ *Bacillus thuringiensis* (148.6 q/ha), T₈ Neem oil (143.11 q/ha), T₄ *Metarhizium anisopliae* (142.5 q/ha), T₆ NSKE (139.84 q/ha), T₂ *Verticillium lecanii* (128.4 q/ha), T₇ Karanj oil (123.29 q/ha) and T₅ Garlic extract (117.40 q/ha) as compare to T₉ (87 q/ha). When the cost-benefit ratio was worked out, a good result was achieved. Among the treatment studied, the best and most economical treatment was T₁ *Beauveria bassiana* (1:3.10), followed by T₃ (1:3.05), T₈ (1:3.02), T₄ (1:2.93), T₆ (1:2.74), T₂ (1:2.65), T₇ (1:2.61), T₅ (1:2.48), as compared to control T₉ (1:1.90). The result of present study was according with the finding of Kaveri and Kumar (2020) observed that the Two applications of seven insecticides viz; Spinosad 45% SC, *Metarhizium anisopliae*, *Verticillium lecanii*, *Beauveria bassiana*, Neem oil 3%, karanjin 2% EC, Alovera extract 1%, were evaluated against shoot and fruit borer, *Earias vittella*. Minimum per cent of shoot infestation, percent fruit infestation and B:C ratio were observed in Spinosad 45% SC (5.22%, 5.86% and 1:11.1), respectively, which was

followed by *Beauveria bassiana* (11.63%, 12.33%, and 1:8.43) < untreated control (water spray) (24.37%, 24.35% and 1:4.22), respectively. Chandravanshi *et al.* (2018) observed that *Beauveria bassiana* @ 10 g/lit., *Bacillus thuringiensis* @ 2 g/lit., *Metarhizium anisopliae* @ 10 g/lit. Fipronil 0.3 G soil application after germination, followed

by spray with *Metarhizium anisopliae*, was found to be most effective against okra shoot and fruit borer, as it was recorded overall less fruit infestation percentage (8.30%) highest fruit yield (89.89 q/ha), with a benefit-cost ratio of 1.38:1.00.

Table 1: Effect of bio-pesticides against shoot damage by okra shoot and fruit borer in the first spray.

T. No.	Treatments	Dose (%)	Before spray	Percent shoot damage (no. basis)			Over All mean
				3 DAS	7 DAS	14 DAS	
T ₁	<i>Beauveria bassiana</i> .	2.0 kg/ha	10.13	6.83	4.75	1.82	4.47
T ₂	<i>Verticillium lecanii</i>	2.0 kg/ha	14.12	9.99	9.28	8.24	9.17
T ₃	<i>Bacillus thuringiensis</i>	2.0 kg/ha	10.88	7.15	4.93	3.96	5.35
T ₄	<i>Metarhizium anisopliae</i>	2.0 kg/ha	12.49	8.55	7.46	6.92	7.64
T ₅	Garlic extract	10 %	16.18	12.08	11.90	11.11	11.70
T ₆	NSKE	5%	13.71	9.06	8.32	7.58	8.32
T ₇	Karanj oil	10%	15.24	10.89	10.37	9.94	10.40
T ₈	Neem Oil	5%	11.87	7.88	6.69	4.96	6.51
T ₉	Water control	-----	15.12	15.95	17.54	18.75	17.41
	CD		2.476	2.274	2.356	2.323	1.883
	SE(m)		0.819	0.752	0.779	0.768	0.623

Table-2: Effect of bio-pesticides against fruit damage by okra shoot and fruit borer in the second spray.

T. No.	Treatments	Dose (%)	Before spray	Percent fruit damage (no. basis)			Over All mean
				3 DAS	7 DAS	14 DAS	
T ₁	<i>Beauveria bassiana</i> .	2.0 kg/ha	16.76	13.59	11.86	7.68	11.04
T ₂	<i>Verticillium lecanii</i>	2.0 kg/ha	20.28	18.21	17.74	15.35	17.10
T ₃	<i>Bacillus thuringiensis</i>	2.0 kg/ha	17.36	14.30	12.70	8.95	11.98
T ₄	<i>Metarhizium anisopliae</i>	2.0 kg/ha	18.44	16.13	15.32	14.13	15.19
T ₅	Garlic extract	10 %	22.64	20.91	19.76	19.61	20.09
T ₆	NSKE	5%	19.56	17.42	17.07	14.48	16.32
T ₇	Karanj oil	10%	21.29	19.93	18.04	17.30	18.42
T ₈	Neem Oil	5%	17.66	15.36	14.90	12.32	14.19
T ₉	Water control	-----	15.46	17.67	20.04	23.10	20.27
	CD		2.866	2.010	4.935	4.167	2.942
	SE(m)		0.948	0.665	1.632	1.378	0.973

Table-3: Effect of bio-pesticides against fruit damage by okra shoot and fruit borer in the third spray.

T. No.	Treatments	Dose (%)	Before spray	Percent fruit damage (no. basis)			Over All mean
				3 DAS	7 DAS	14 DAS	
T ₁	<i>Beauveria bassiana</i> .	2.0 kg/ha	11.81	7.78	5.91	4.69	6.13
T ₂	<i>Verticillium lecanii</i>	2.0 kg/ha	14.21	13.20	12.86	10.07	12.04
T ₃	<i>Bacillus thuringiensis</i>	2.0 kg/ha	12.42	9.16	7.21	5.90	7.42
T ₄	<i>Metarhizium anisopliae</i>	2.0 kg/ha	13.08	11.10	9.41	7.64	9.38
T ₅	Garlic extract	10 %	16.23	15.96	14.87	13.81	14.88
T ₆	NSKE	5%	13.88	11.87	10.35	9.25	10.49
T ₇	Karanj oil	10%	15.73	15.33	13.39	12.25	13.66
T ₈	Neem oil	5%	12.93	10.27	8.50	6.72	8.50
T ₉	Water control	-----	17.25	19.90	23.95	25.86	23.24
	CD		2.836	4.508	3.142	2.795	2.715
	SE(m)		0.938	14.91	1.04	0.924	0.898

Table 4: Comparative economics of different bio-pesticide treatments.

S. No.	Treatments	Yield (q/ha)	Cost of yield	Total cost of yield	Common cost	Treatment cost	Total cost	C:B ratio
01.	<i>Beauveria bassiana</i> .	150.20	1600 Rs/q	240320	73000	4500	77500	1:3.10
02.	<i>Verticillium lecanii</i>	128.4	1600 Rs/q	205440	73000	4200	77300	1:2.65
03.	<i>Bacillus thuringiensis</i>	148.6	1600 Rs/q	237760	73000	4800	77800	1:3.05
04.	<i>Metarhizium anisopliae</i>	142.5	1600 Rs/q	228000	73000	4800	77800	1:2.93
05.	Garlic extract	117.40	1600 Rs/q	187840	73000	2550	75550	1:2.48
06.	NSKE	139.84	1600 Rs/q	223744	73000	8400	81400	1:2.74
07.	Karanj oil	123.29	1600 Rs/q	197264	73000	2400	75400	1:2.61
08.	Neem oil	143.11	1600 Rs/q	228976	73000	2700	75700	1:3.02
09.	Water control	87	1600 Rs/q	139200	73000		73000	1:1.90

Conclusion

The present study demonstrated that all the tested bio-pesticides were effective and significantly superior to the control in reducing the infestation of okra shoot and fruit borer, *Earias vitella*. Among the treatments, *Beauveria bassiana* 2.0 kg/ha was found to be the most effective treatment, recording the lowest shoot and fruit infestation throughout the observations. It also resulted in the highest yield of 150.20 q/ha, followed by *Bacillus thuringiensis* 2.0 kg/ha (148.6 q/ha) and Neem oil 5% (143.11 q/ha). The economic analysis further indicated that *B. bassiana* 2.0 kg/ha was the most economical treatment, with the highest cost-benefit ratio of 1:3.10, followed by *B. thuringiensis* 2.0 kg/ha (1:3.05), Neem oil 5% (1:3.02), and *Metarhizium anisopliae* 2.0 kg/ha (1:2.93). In comparison, the control recorded a lower yield of 87 q/ha and a cost-benefit ratio of 1:1.90. Therefore, *Beauveria bassiana* 2.0 kg/ha can be considered the most effective and economical bio-pesticide among the treatments evaluated under the conditions of the present study.

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