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Efficacy of bio- pesticides and selected chemicals against okra shoot and fruit borer *Earias vittella* (fab.) on okra [*Abelmoschus esculentus* (L.) Moench] under field condition at Prayagraj

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Abstract
A field trial was conducted to evaluate Efficacy of Bio- pesticides and selected chemicals against Okra Shoot and fruit borer *Earias vittella* (fab.) on okra [*Abelmoschus esculentus* (L.) Moench] under field condition at Prayagraj in *Kharif* season 2023-2024 at Central Research Farm (CRF), SHUATS, Prayagraj, Uttar Pradesh, India. The experiment was laid in Randomised Block Design with eight treatments each replicated thrice using a variety of BS-267. The treatments were against *Earias vittella* i.e., (T_1) Karanj oil 2% EC @ 2 ml/lit., (T_2) Garlic bulb extract 3% @ 30 ml/lit., (T_3) Flubendiamide 90 SC + Deltamethrin 60 SC @ 5 ml/lit., (T_4) Imidacloprid 17.8% SL @ 2.0 ml/lit., (T_5) Spinosad 45% SC @ 0.5 ml/lit., (T_6) *Verticillium lecani* (1x10^8 CFU/g) @ 300 kg/ha and (T_7)*Metarhizium anisopliae*4% WSP (1 × 10^8 CFU/g) @ 2.5kg/ha and (T_8) control plot their influences on yield of okra. Every insecticide was applied twice, separated by 14 days interval. Every plant's shoot and fruit infection was observed the one day before, the 3rd, 7th, and the 14th day following each treatment. When compared to over the control plot, every insecticide that was tested greatly decreased the level of pest infestation. The fruit and shoot infestation percentage that was lowest was observed in 90 SC + Deltamethrin 60 SC (4.40% and 3.29%) and Spinosad 45% SC (4.90% and 3.83%) followed by Imidacloprid 17.8% SL (5.53% and 4.25%), Garlic bulb extract 3% (5.84% and 4.54%), *Verticillium lecani* (1x10^8 CFU/g) (6.32% and 5.01%), *Metarhizium anisopliae* 4% WSP (1 × 10^8 CFU/g) (6.65% and 5.46%), Karanj oil 2% EC (6.89% and 6.35%).

Keywords: Bio-pesticides, efficacy *Earias vittella* flubendiamide 90 SC + deltamethrin 60 SC

Introduction
One of the most well-known and useful plants in the Malvaceae family, "okra" (*Abelmoschus esculentus* L. Moench) is a vegetable crop that is grown in tropical and sub-tropical regions of the world and has a significant economic impact. The plant known as "okra" was formerly a member of the Hibiscus genus. Afterwards, it was given the name Abelmoschus, which is different from the Hibiscus genus. By the 12th century BC, "okra" had spread from Ethiopia to North Africa, the Mediterranean, Arabia, and India. Although its edible fruits are the primary reason for its cultivation, other components of the plant, such as leaves, flower petals, stems, and roots, are also utilized in various regions of the world for food, biofuel, and medicinal purposes. (Janu and Kumar, 2022) [4].

"Okra" has high levels of protein, carbs, and vitamin C [Water (%) 90, Energy (kcal) 38, Protein (g) 2.0, Fat (g) 0.1, Carbohydrate (g) 7.6, Fiber (g) 0.9, Ca (mg) 81, P (mg) 63, Fe (mg) 0.8, Na (mg) 8, K (mg) 303, Vitamin A (iU) 660, Thiamine (mg) 0.20, Riboflavin (mg) 0.06, Niacin (mg) 1.00, Ascorbic acid (mg) 21.1 and Vitamin B6 (mg) 0.22]. (Kaveri and Kumar 2020) [5].

According to reports, there are 1.26 million hectares and 22.29 million tons of okra produced worldwide. India, Nigeria, Sudan, Pakistan, Ghana, Egypt, Saudi Arabia, Mexico, and Cameroon are the principal growing regions for it. With an area of 1148.0 thousand hectares, an annual production of 6346 million tonnes, and a productivity of 11.9 million tonnes/ha, India leads the world in okra production, accounting for 5784.0 thousand tonnes (72% of total global production). Andhra Pradesh (20%), West Bengal (15%), Bihar (14%), Orissa (11%), Gujarat (10%), Jharkhand (7%), Maharashtra (4%), Assam (3%) and Haryana (3%)

are the main states in India that grow okra. (Madhuri and Kumar, 2022) [6].

At 509 thousand hectares, 6094.9 thousand tons of okra are produced year, and the yield per hectare is 12 million, making India the world leader in okra production. While the crop is planted all throughout India, Gujarat is the state that produces the most okra, with an output of about 921.72 thousand tons from an area of 75.27 thousand hectares and a productivity of 12.25 tons per hectare. West Bengal comes next, with 914.86 thousand tonnes from 77.5 thousand hectares with a productivity of 11.5 tonnes per hectare. The acreage, productivity, and production of okra in Uttar Pradesh are 22.93 hectares, 307.29 tonnes, and 13.40 metric tons/ha, respectively. (Manikanta and Kumar, 2022) [7].

Several insect pests harm okra crops: jassids (*Amrasca biguttula bigutulla*, Ishida); aphids (*Aphis gossypii* Glover); fruit borers (*Earias insulana* Boisduval and *Earias vittella* (Fab.); *Helicoverpa armigera* Hub.; whiteflies (*Bemisia tabaci* Genn.); and the red spider mite (*Tetranychus cinnabarinus*), which is occasionally seen. While immature larvae of *Earias vittella* (Fabricius) bore into fragile shoots during the early vegetative growth of plants, it is the most destructive pest of okra among all other pests that cause shoot and fruit borer damage. (Dash *et al.*, 2020) [3].

Affected fruits become unfit for human eating and lose value in the market as a result of the infested stalk dying and the premature dropping of buds, blooms, and fruits. In some parts of South East Asia, this bug may harm fruit by 40–50%. (Panbude, 2019) [10]. When mature larvae injure fruit, the output is reduced by 54.04% and the plant's vitality is diminished. According to reports, the borer damages okra shoots by 24.6 to 26.0 percent and ruins fruits by 40 to 100%. (Akolkar *et al.*, 2021) [1].

Materials and Methods

At the Central Research Farm of the Naini Agricultural Institute in Prayagraj, Uttar Pradesh, India, the experiment was conducted in the Kharif season of 2023–2024. The okra variety BS 267 was planted in a 2 m × 1 m plot with 45 cm x 30 cm spacing between each seed from August to November. Eight treatments, one of which was the control (a water spray), were triple-replicated using a Randomized Block Design. The experimental site's soil was medium-high and well-drained. A 15-day gap was seen between the two sprays. Five randomly chosen plants per plot were used to obtain data based on the infestation of shoots and fruits.

In order to determine the incidence of the borer on the shoots, observers counted both the total number of damaged shoots and the number of healthy shoots. Similarly, to record the observations of the infestation on the fruits, five randomly selected plants were examined for both healthy and damaged fruits. Observations were recorded one day before spray 3rd, 7th, 14th day after spraying. The extent of the damage was computed by using the formula;

Percent shoot infestation

The total number of shoots and the number of infested shoots of five randomly selected plants from each treatment were counted at each picking.

$$\text{Percent shoots damage} = \frac{\text{Number of infested shoots}}{\text{Total number of shoots}} \times 100$$

(Manikanta and Kumar, 2022) [7]

Percent fruit infestation

The total number of fruits and the number of infested fruits of five randomly selected plants from each treatment were counted at each picking.

$$\text{Percent fruits damage} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

(Manikanta and Kumar, 2022) [7]

Results and Discussion

The present study is entitled, "Comparative study of Bio-pesticides and selected chemicals against Okra Shoot and fruit borer *Earias vittella* (fab.) on okra [*Abelmoschus esculentus* (L.) Moench] under field condition at Prayagraj". The purpose of the current experiments was to assess the efficacy of various management strategies for both the fruit borer and the okra shoot individually and in various combinations. Chemical control demonstrated to be the least harmful to fruit and shoots when used alone, outperforming other methods in this regard. Additionally, mechanical control of damaged shoots and fruits continued to be more effective than other non-chemical treatments, indicating the value of this approach. When appropriate, statistical analysis was performed on the data that were gathered through observation on various aspects, and the results were then collated.

After the first spray (percent shoots infestation), thus obtained results are presented here, DBS (Day before spraying) per cent shoot infestation of was (T_1) Karanj oil 2% EC 6.89%, (T_2) Garlic bulb extract 3% 5.84%, (T_3) Flubendiamide 90 SC + Deltamethrin 60 SC 4.40%, (T_4) Imidacloprid 17.8% SL 5.53%, (T_5) Spinosad 45% SC 4.90%, (T_6) *Verticillium lecani* (1x10^8 CFU/g) 6.32%, (T_7) *Metarhizium anisopliae*4% WSP (1 × 10^8 CFU/g) 6.65% in (T_7) and (T_8) Control plot% 8.24%. Based on the percentage of shoot and fruit borer infestation on Okra on the3rd, 7th, and 14th day following the initial spray, all chemical treatments were shown to be significantly better than the control plot.

The lowest percentage of shoot infestation across all treatments was seen in (T_3) Flubendiamide 90 SC + Deltamethrin 60 SC (4.40) followed by (T_5) Spinosad 45% SC (4.90), (T_4) Imidacloprid 17.8% SL (5.53), (T_2) Garlic bulb extract 3% (5.84), (T_6) *Verticillium lecani* (1x10^8 CFU/g) (6.32), (T_7) *Metarhizium anisopliae*4% WSP (1 × 10^8 CFU/g) (6.65) and (T_1) Karanj oil 2% EC(6.89). The treatments (T_3) Flubendiamide 90 SC + Deltamethrin 60 SC (4.40) was most effective among all the treatments, and is significantly superior over the Control plot (T_8) (8.24) infestation.

The data on the percent infestation of fruit borer on okra 3rd, 7th and 14th day after second spray revealed that all the chemical treatments were significantly superior over control. (T_1) Karanj oil 2% EC 6.35%, (T_2) Garlic bulb extract 3% 4.54%, (T_3) Flubendiamide 90 SC + Deltamethrin 60 SC 3.29%, (T_4) Imidacloprid 17.8% SL 4.25%, T_5) Spinosad 45% SC 3.83%, (T_6) *Verticillium lecani* (1x10^8 CFU/g) 5.01%, (T_7) *Metarhizium anisopliae*4% WSP (1 × 10^8 CFU/g) 5.46% and (T_8) control plot% 8.39%. Based on the per centage of shoot and fruit borer infestation on Okra on the3rd, 7th, and 14th day following the initial spray, all chemical treatments were shown to be significantly better than the control plot. The lowest percentage of fruits infestation across all treatments was seen in (T_3) Flubendiamide 90 SC + Deltamethrin 60 SC (3.29) followed by (T_5) Spinosad 45% SC (3.83), (T_4) Imidacloprid 17.8% SL (4.25), (T_2) Garlic bulb extract 3% (4.54), (T_6) *Verticillium lecani* (1x10^8 CFU/g) (5.01), (T_7) *Metarhizium anisopliae*4% WSP (1 × 10^8 CFU/g) (5.46) and (T_1) Karanj oil 2% EC (6.35). The treatments (T_3) Flubendiamide 90 SC + Deltamethrin 60 SC (3.29) was most effective among all the treatments, and is significantly superior over the Control plot (T_8) (8.39).

Among all the treatments, Flubendiamide 90 SC + Deltamethrin 60 SC was found to be most efficient in controlling okra's infestation with fruit borer and shoots. The results from the first and second sprays were 4.40% and 3.29%. These results are supported by Akolkar *et al.*, (2021) [1] Spinosad 45% SC was also found to be very effective in reducing the infestation of shoot and fruit borer. The same results were observed by Kaveri and kumar (2022) [5] and Rakshith and Kumar (2017) [13], who reported that applying Spinosad 45% SC resulted in a lower percentage of shoot and fruit damage and decreased borer infestation. where the first and second spray observations were 3.90% and 3.83% infestation over the control plot, respectively.

In both the first and second sprays, imidacloprid 17.8% SL is effective against fruit borer and shoots. 5.53% and 4.25% respectively. These results are as per the findings of Manikanta and Kumar (2022) [7] and Dash *et al.*, (2020) [3]. The next best treatment was found to be Garlic bulb extract3% where in the first and second efficacious values spray were 5.84% and 4.54% respectively to the similar findings of Naidu and Kumar (2019) [8]. The next best treatment was found to be *Verticillium lecani* (1x10^8 CFU/g) in which the first and second spray's effectiveness values were 6.32% and 5.01% respectively, This results were corroborated by Janu and Kumar (2022) [4] and Pachole *et al.*, (2017) [9]. The least effective treatments were found to be *Metarhizium anisopliae* 4% WSP (1 × 10^8 CFU/g) and Karanj oil 2% EC in which efficacy values of first and second sprays were (6.65), (5.46) and (6.89), (6.35) respectively. The results obtained were as similar to Choudhury *et al.*, (2021) [2] and Patil *et al.*, (2021) [11].

Table 1: Treatments details

Tr.no.	Treatments	Dosage	Infestation of *Earias vittella* per five plants								
			% Shoot Infestation					% Fruit Infestation			
			1 DBS	3 DAS	7 DAS	14 DAS	Mean	3 DAS	7 DAS	14 DAS	Mean
T_1	Karanj oil 2% EC	2 ml/lit	7.12	7.00	5.46	8.22	6.89	6.73	5.87	6.46	6.35
T_2	Garlic bulb extract 3%	30 ml/lit	6.96	6.32	4.16	7.05	5.84	5.24	3.17	5.21	4.54
T_3	Flubendiamide 90 SC + Deltamethrin 60 SC	5 ml/lit	7.82	4.66	3.24	5.31	4.40	3.89	2.16	3.82	3.29
T_4	Imidacloprid 17.8% SL	2.0 ml/lit	7.51	5.53	4.14	6.92	5.53	5.06	2.84	4.86	4.25
T_5	Spinosad 45% SC	0.5 ml/lit	7.78	5.19	3.37	6.16	4.90	4.33	2.70	4.46	3.83
T_6	*Verticillium lecani* (1x10^8 CFU/g)	2.5 kg/ha	8.15	6.35	4.80	7.83	6.32	5.95	3.60	5.48	5.01
T_7	*Metarhizium anisopliae*4% WSP (1 × 10^8 CFU/g)	300 kg/ha	7.43	6.73	5.20	8.02	6.65	6.46	3.93	6.00	5.46
T_8	Control	-	8.06	8.12	8.27	8.35	8.24	8.28	8.53	8.37	8.39
	F- test	-	NS	S	S	S	S	S	S	S	S
	S.Ed(±)	-	0.50	0.22	0.23	0.58	0.53	0.26	0.39	0.23	0.42
	C.D.(0.05%)	-	-----	0.48	0.49	1.24	0.90	0.55	0.83	0.50	0.98

DBS = Day before spray; NS = Non significant; S = significant; *Figures are in parentheses of square root transformation.

Conclusion

The most successful treatments against the okra shoot and fruit borer (*Earias vittella*) were demonstrated by the current study's results, which revealed that flubendiamide 90 SC + Deltamethrin 60 SC and spinosad 45% SC reduced the maximum percent shoots and fruits infestation in comparison to other treatments. In contrast, average results were obtained using imidacloprid 17.8% SL, Garlic bulb extract 3%, and *Verticillium lecani* (1x108 CFU/g). *Earias vittella* was shown to be least responsive to biopesticides, such as Karanj oil 2% EC and *Metarhizium anisopliae 4*% WSP (1 × 108 CFU/g). Therefore, it is recommended that the efficient pesticides be switched out in accordance with the current Integrated Pest Management programs to prevent issues with insecticidal resistance, pest resurgence, etc. Integrated pest management includes bio-pesticides as a means of preventing.

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