Original Research Article

"Efficacy of selected insecticides against shoot and fruit borer, *Earias vittella* (Fabricius) on okra"

ABSTRACT

A field experiment was conducted in *Kharif* season of 2022 at Central Research Farm (CRF), SHUATS, Uttar Pradesh, India. The experiment was laid in Randomised Block Design with seven treatments each replicated thrice viz., Indoxacarb 14.5% SC (T1), Deltamethrin 2.8% EC (T2), Karanjin oil (T3), *Metarhizium anisopliae* $1*10^8$ CFU (T4), Neem oil 5% (T5), Emamectin benzoate 5% SG (T6), Spinosad 45% SC (T7) and control plot (T8). The data on percent infestation of *Earias vittella* after first and second spray revealed that all the treatments were significantly superior over control. Among all treatments, Deltamethrin 2.8% EC (17.745% & 13.608 %) recorded lowest percent infestation of *Earias vittella*, followed by Emamectin benzoate 5% SG (18.837% & 15.777%), Spinosad 45% SC (19.610% & 16.565%), Indoxacarb 14.5% SC (20.092% & 18.147%), Neem oil 5% (20.602% & 18.900%), Karanjin oil 5% (22.080% & 21.639%), and *Metarhizium anisopliae* $1*10^8$ CFU (22.710% & 21.837%) was the least effective among all treatments with percent shoot and fruit infestation respectively. While, the highest yield of 129 q/ha was obtained from the treatment- Deltamethrin 2.8% EC as well as B:C ratio (1:5.45) obtained high from this treatment. It was followed by Emamectin benzoate 5% SG (1:5.31), Spinosad 45% SC (1:5.19), Indoxacarb 14.5% SC(1:4.93), Neem oil 5% (1:4.76), Karanjin oil 5% (1:4.64) and *Metarhizium anisopliae* $1*10^8$CFU(1:4.58), as compared to control plot (1:3.01).

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Keywords: Botanicals, *Earias vittella*, Deltamethrin, Emamectin benzoate, Karanjin oil, *Metarhizium anisopliae* $1*10^8$ CFU , Okra.

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1.Introduction

Okra [*Abelmoschus esculentus* L.] a native of South-Africa and commonly known as 'Bhendi', is an annual malvaceous vegetable crop, especially grown in tropical and subtropical climates. It is very popular summer vegetable for home gardening while it is also grown commercially throughout the world especially in Indo-Pakistan sub- continent. It is cultivated a lost throughout the year except

one or two cold months, due to favorable climatic conditions for its cultivation, Particularly in states of Uttar Pradesh, Madhya Pradesh, Karnataka and Maharashtra. The production of okra is mostly taking out in all over in India. There are ~~a~~ nine species of okra which are cultivated in India *i.e. Abelmoschus angulosus, Abelmoschus cancellatus, Abelmoschus criniturs, Abelmoschus ficulneus, Abelmoschus manihot tetraphyllus, Abelmoschus manihot* spp., *tetraphyllus* var. ~~*Pungens*~~*pungens*, *Abelmoschus moschatus* spp. *moschatus, Abelmoschus moschatus* spp. *tuberosus*~~.~~**.**

India is the second largest producer of vegetables after China. Majority of Indians are vegetarian, with a per capita consumption 135 g per day as against the recommended 300 g per day. It is still very less than the recommended diet level **(Dhandapani *et al.*, 2003)[2].**

Vegetables possess high nutritive value, supply vitamins and minerals which are deficient in other food materials. Okra is rich source of vitamins, minerals and other nutritive ingredients. It's seeds containing good quality edible oil and high protein which are used to complement other protein. Okra pod contains mucilage, which is comprised of mixture of pectin and carbohydrates, which is used as thickener in food industries. The predominant elements found in this vegetable are K, Mg, Na, Ca, Fe, etc. Fresh fruits contain water (90.17 g), carbohydrate (703 g), protein (2 g), calcium (81 mg), sugars (1.20 g), phosphorus (0.04 mg), iron (0.0051mg), dietary ~~fiber~~ fibres (3.2 g), fats (0.10 g), vitamin A-58 IU, vitamin B-63 IU and vitamin C-16 mg/100g. **(~~source:~~ USDA National Nutrient data base, 2021)[21].** It also contains iodine and potash. In addition, mucilaginous extract of green stem of okra is used for clarifying sugarcane juice in jaggery preparation.

Globally India ranks first in okra production i.e. 5794 thousand tons (72% of total world production) having area of 564 thousand hectares with an annual production of 6371 thousand million tons and productivity of 12.9 million tons–/–ha. (Reference ???). The crop is grown throughout India~~,~~ Andhra Pradesh is the leading okra producing state which has production of around 884.2 thousand tons from an area of 79.9 thousand ~~ha~~hectares, with a productivity of 15 tons / ha. It is followed by west Bengal (862.1 thousand tons from 74 thousand hectares with 11.7 tons / ha productivity. In Uttar Pradesh, area, production and productivity of okra is 48.2 thousand ha, 177.26 thousand tones, 8 tons/ha respectively. **(NHB 2021-22)[13].**

Of the various reasons for low productivity, heavy damage inflicted by insect pests is a key limiting factor. **(Nayar *et al.*, 1976)[14]** reported more than three dozen insect pests ~~are~~ attacking okra. Among these pests~~,'s~~ fruit borer, *E. vittella* (Fab.) and ~~jassid~~ leah hopper *A biguttula biguttula* Ishida are major biotic constraints towards achieving the potential yield. Okra crop also suffers damage by other insect pests *viz.*, the aphid, *Aphis gossypii* Glover; the fruit borers. *Helicoverpa armigera*

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Hub.; whitefly, *Bemisia tabaci* Genn.; and red spider mite, *Tetranychus cinnabaris* that appears occasionally. Infestation by sucking insect pests hampers crop growth apart from transmitting pathogenic diseases.

Okra is grown during summer and *Kharif* seasons. Among insect pests infesting okra, shoot and fruit borer, [*Earias vittella* (Fabricius)] is one of the serious pests causing 40-50 percent damageto okra fruits during both seasons. *Earias* spp. alone causes damage ranging from 52.33 to 70.75 percent **(Pareek and Bhargava, 2009)[16].**

Kamble *et al*., (2014)[4] reported shoot and fruit borer infestation on okra as 32.14 percent on number basis and 31.31 percent on weight basis. *Earias vittella* lays eggs individually on leaves, floral buds and on tender fruits. Small brown caterpillars bore into the top shoot and feeds inside the shoot before fruit formation. The shoots wilt and dry, as a result the damaged plant develops branches. Later on caterpillars bore into the fruits and feed inside as a result the infested plant bears smaller and deformed pods. A larva attacks a number of stems and pods one after another. Damaged plant tissues serve as entrance for disease causing microorganisms such as fungi. The moth is yellow green and having a narrow light longitudinal green band in the middle of forewing. The damage due to fruit borer accounts nearly 22.5% in Uttar Pradesh; 25.93% to 40.91% in Madhya Pradesh, and 45% in Karnataka.

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OBJECTIVES

1.To evaluate the efficacy of selected insecticides against shoot and fruit borer, *Earias vittella* (Fabricius.) on okra during *kharif* season 2022.

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2.To ~~Calculate~~ calculate Cost – Benefit ratio [B: C ratio] of treatments

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2.MATERIALS AND METHODS

The experiment was conducted during *kharif* season, 2022 at Central Research Farm (CRF), Uttar Pradesh, India, in a randomized block design with eight treatments including control replicated three times using variety Arka Anamika in a plot size of (2m×1m) at a spacing of (45×30cm) with a recommended package of practices excluding plant protection. The soil of the experimental site is well drained and medium high. The climate of the experimental site is sub-tropical characterized by normal rainfall. The experiment was conducted at Central Research Farm (CRF), Uttar Pradesh, during the *kharif* season of 2022-23. Prayagraj is situated at an elevation of 78 meters above sea level at 25.87 North latitude and 81.15° E longitudes. This region has a sub-tropical climate prevailing in the South-East part of U.P. with both the extremes in temperature, i.e., the winter and the summer. In cold winters, the temperature sometimes is low as 32°F in December-January and very hot summer with temperature reaching up to 115°F in the months of May and June. During winter, frosts and during summer, hot scorching winds are also not uncommon. The average rainfall is around 1013.4(cm) with maximum concentration during July to September months with occasional showers in winters.

Comment [110]: What is this? Why repeating same lines. How can it be kharif 2022-23?

"The observations on infestation of *Earias vittella* were recorded visually per plant from five randomly selected plants and tagged plants in each plot. The insecticides were sprayed at recommended doses when percent infestation reaches ETL (5% of shoot damage and 10% fruit damage) level" (Shirale *et al.*,) Number of infested shoots and fruits from randomly selected plants per plot was counted and recorded at weekly interval after careful examination on the presence of borer and excreta at both vegetative and reproductive stage, which was further converted into percent infestation. Observations were recorded on the number of infested shoots and fruits in each plot a day on 7th and 14th days after spraying on selected plants in a plot.

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The following insecticides were used in this the field trail trial are : Indoxacarb 14.55 SC @ 0.25ml/L, Deltamethrin 2.8%EC @ 1.25ml/L, Karanjin oil 5% @ 5ml/L, *Metarhizium anisopliae* (1×10^{8} CFU) @ 4g/L, Neem oil 5% @ 5ml/L, Emamectin benzoate 5%SG @ 0.25g/L, and Spinosad 45%SC @ 0.4ml/L along with control plot. The basal application of fertilizers was done

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manually and insecticides were applied with the help of knapsack sprayer by considering ERTL level for making spray decisions.

The healthy marketable ~~yield~~ fruits obtained from different treatments ~~was~~ were collected separately ~~from different teretments was collected seperatwely~~ and weighed. The cost of insecticides used in this experiment was recorded during *kharif* season of 2022. The cost of botanicals used was obtained from near-by market. The total cost of plant protection consisted of cost of treatments, sprayer rent and labour charges for the spray. There were two sprays throughout the research period and the overall plant protection expenses were calculated. Total income was realized by multiplying the total yield per hectare by the prevailing market price, while the net benefit is obtained by subtracting the total cost of plant protection from total income. Benefit over the control for each sprayed treatment was obtained by subtracting the income of the control treatment from that of each sprayed treatment.

2.1 Data Analysis:

Percent shoot infestation:

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

Percent fruit infestation:

$$\text{Per cent fruit damage} = \frac{\text{Number of damaged fruits} \times 100}{\text{Total number of fruits}}$$

Benefit cost Ratio :

Benefit cost ratio = Gross Returns /Total cost incurred

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RESULTS AND DISCUSSION

Efficacy of different insecticides on the percent infestation of okra shoot and fruit borer showed that all the treatments were significantly superior over control in reducing the infestation of shoot and fruit borer resulting in increasing the yield~~, significantly as compared to control~~. On 7th and 14th day~~s~~ after first spray, lowest percent infestation was recorded in Deltamethrin 2.8% EC (17.300 and 18.190) followed by Emamectin benzoate 5%SG (18.333 and 19.340) and Spinosad 45%SC (19.597 and 19.623) treated plots respectively that differed significantly with other treatment plots but statistically at par with each other(Table 1).

Deltamethrin 2.8%EC treated plots recorded the lowest percent infestation in all observations on 7th and 14th day~~s~~ after second spray ~~with~~ (13.803 and 13.413) followed by Emamectin benzoate 5%SG (16.437 and 15.117) and Spinosad 45% SC (16.883 and 16.247). These results are supported by **Mane (2007)[9]** and **Shinde *et al.*, (2007)[19]**, **who** reported that Deltamethrin 2.8% EC proved superior over other insecticides in reducing ~~percent~~ percent infestation of okra shoot and fruit borer. **Govindan *et al.*, (2013)[3] and Shyamrao *et al.*, (2018)[20]**, found Emamectin benzoate5%SG as the most effective treatment.

The yields among the treatments were significant. The highest yield was recorded in Deltamethrin 2.8%EC (129 q/ha) followed by Emamectin benzoate 5%SG (126 q/ha), Spinosad 45% SC (123.33 q/ha), Spinosad 45%SC (123.33 q/ha), Indoxacarb 14.5%SC (117.5 q/ha), Neem oil 5% (113.33 q/ha), Karanjin oil 5%(110.17q/ha) and *Metarhizium anisopliae* $1*10^8$ CFU (106.91q/ha) as compared to the control ~~plot~~ (68.33 q/ha). These findings are supported by **Shinde *et al.*, (2011)[19], Sandip *et al.*, (2007)[18], Maurya *et al.*, (2014)[11], Madhuri and Kumar (2022)[8], Rani and Kumar (2022)[17].**

Among the treatments studied, the best and most economical treatment was Deltamethrin 2.8%EC (1:5.45), followed by Emamectin benzoate 5%SG (1:5.31), Spinosad 45%SC (1:5.19), Indoxacarb 14.5%SC (1:4.93), Neem oil 5% (1:4.76), Karanjin oil 5% (1:4.64) and *Metarhizium anisopliae* $1*10^8$ CFU (1:4.58), as compared to control ~~plot~~ (1:3.01). These findings are supported by **Shinde *et al.*, (2011)[19], Lachattiwar and Meena (2014)[7], Dhaka *et al.*, (2016)[1], Kaveri and Kumar (2020)[5], Kulkarni and Kumar (2022)[6] and Manikanta and Kumar (2022)[10].**

Comment [115]: Percent shoot or fruit….mention

Comment [116]: Give the values upto two decimal places only

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Comment [118]: Be specific while supporting results. Clarify what is supported and don't generalize it by saying that the the entire yield results are supported by so many authors

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Table 1: Efficacy of insecticides, NSKE and karanj oil on percent shoot and fruit i

S.No.	Treatments	Percent shoot and fruit infestation ~~of~~ by shoot and fruit borer on okra				Yield (q/ha)	B:C Ratio
		First spray		Second spray			
		7 DAS	14 DAS	7 DAS	14 DAS		
T_1	Indoxacarb 14.5% SC	20.173	20.010	18.747	17.547	117.5	1:4.93
T_2	Deltamethrin 2.8% EC	17.300	18.190	13.803	13.413	129	1:5.45
T_3	Karanjin oil 5%	21.567	22.593	21.890	21.387	110.17	1:4.64
T_4	*Metarhizium anisopliae* $1*10^8$ CFU	22.780	22.640	22.167	21.507	106.91	1:4.58
T_5	Neem oil 5%	20.467	20.737	19.573	18.227	113.33	1:4.76
T_6	Emamectin Benzoate 5% SG	18.333	19.340	16.437	15.117	126	1:5.31
T_7	Spinosad 45%SC	19.597	19.623	16.883	16.247	123.33	1:5.19
T_0	Control	25.810	26.153	34.600	36.817	68.33	1:3.01
	F-test	S	S	S	S	…..	…..
	S. Ed (±)	1.02	0.98	1.04	1.58	…..	…..
	C.D. (P = 0.5)	3.089	2.982	3.160	4.785	…..	…..

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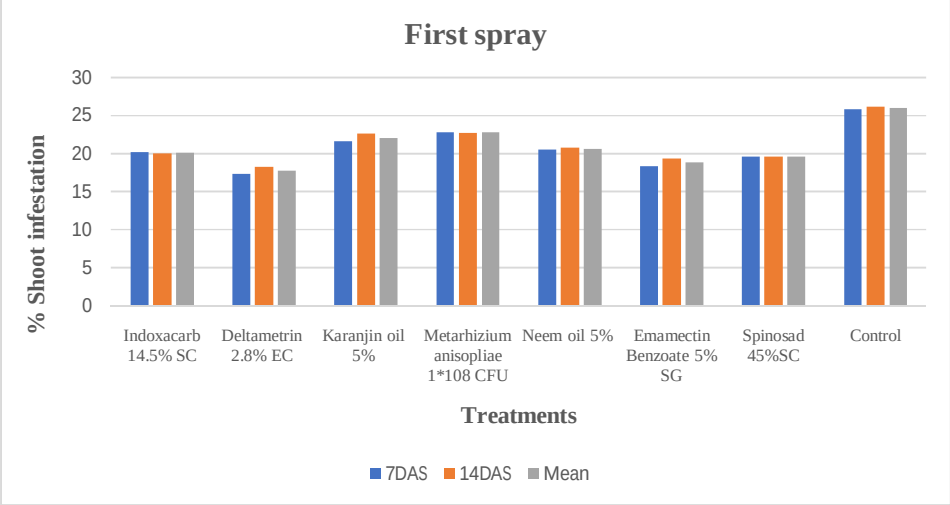

Fig. 1. Efficacy of selected insecticides on percent ~~infeststion~~ infestation of shoot and fruit borer, *Earias vittella* on okra (First spray)

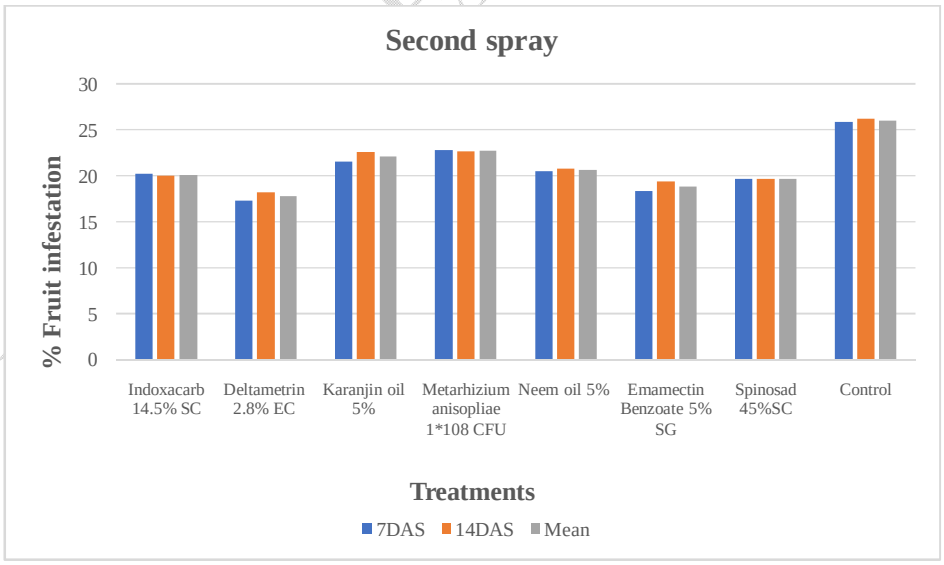

Fig. 2. Efficacy of selected insecticides on percent fruit infestation of shoot and fruit borer, *Earias vittella* on okra (Second spray)

CONCLUSION

From the ~~critical analysis of the~~ present findings, it can be concluded that, among all the ~~treatments~~ treatment, Deltamethrin 2.8%EC is more effective in controlling per cent infestation by okra shoot and fruit borer followed by Emamectin benzoate 5%SG,Spinosad 45%SC , Indoxacarb 14.5%SC , Neem oil 5%, Karanjin oil 5%, *Metarhizium anisopliae* $1*10^8$ CFU. Among the treatments studied, Deltamethrin 2.8%EC gave the highest cost benefit ratio (1:5.45) and ~~marketing~~ marketable yield (129 q/ha) followed by Emamectin benzoate 5%SG (1:5.31 and 126 q/ha), Spinosad 45%SC (1:5.19 and 123.33 q/ha), Indoxacarb 14.5%SC (1:4.93 and 117.5 q/ha), Neem oil 5% (1:4.76 and 113.33 q/ha), Karanjin oil 5% (1:4.64 and 110.17 q/ha) and *Metarhizium anisopliae* $1*10^8$ CFU(1:4.58 and 106.91 q/ha) respectively. ~~as such more~~ More such trials are required ~~in~~ to be conducted in future to validate the findings. Therefore, botanicals may be useful in devising proper IPM strategy as an effective tool against okra shoot and fruit borer.

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Comment [124]: How can you say that when from your findings, synthetic insecticide is proving to be the best treatment while botanicals are coming out to be the least effective???

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Comment [125]: Follow proper guidelines of the journal while citing references

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