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Efficacy of different chemical insecticides and biopesticides against *Helicoverpa armigera* and *Earias vittella* of okra, *Abelmoschus esculentus* (L.) Moench in western plain zone of UP

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Abstract
The present investigation was carried out on the efficacy of different chemical insecticides and biopesticides against *Helicoverpa armigera* and *Earias vittella* of okra, in Western Plain Zone of U.P. in randomized block design with three replications and nine treatments at Horticulture Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut. The shoot and fruit borer (*Earias vittella*) and fruit borer (*Helicoverpa armigera*) was recorded as major pest. All the treatments were found to be superior over untreated control. The results indicated that flubendiamide 0.0144% @ 60 g a.i./ha which was found to be most effective in managing the fruit borer, shoot and fruit borer infestation on okra followed by indoxacarb 14.05 SC @ 0.007% and the least effective were neem oil 1500 ppm @2.5ml/L and *Beauveria bassiana* CFU 2×10^9 @2 g/L respectively.

Keywords: Okra**,** shoot and fruit borer, fruit borer, insecticides, evaluation

Introduction
Among the vegetable crops grown in India, okra (*Abelmoschus esculentus* L. Moench), also known as lady's finger which is belongs to family Malvaceae and it is an important crop grown throughout the year. It is grown in many tropical and subtropical parts of the world. The immature fruits are used as vegetables or in culinary preparations as sliced and dried pieces. Tender fruits are used for thickening gravies and soups, because of its high mucilage content. The roots and stems of okra are used for cleaning cane juice (Chauhan, 1972) [2]**.** Tender fruits of okra are the rich sources of vitamins (A, B and C), iron, calcium, and magnesium and also other minerals and tender fruits are used as vegetables (Roseleen and Ramaraju, 2012) [6]. It has good quality of nutritional value, particularly the high content of, calcium (90 mg/100g), vitamin C (30mg/100 g), iron (1.5 mg/100 g) and other minerals like magnesium and potassium, fats and carbohydrates, vitamin A and B (Aykroud, 1963) [1]. Insect pests of 72 species have been noticed on okra (Srinivas Rao and Rajendran, 2003) [7] of which, the sucking pests comprising of leafhopper (*Amrasca biguttula biguttula* Ishida), Aphids (*Aphis gossypii* Glover), mite (*Tetranychus cinnabarinus* Boisduval) and whitefly (*Bemisia tabaci* Gennadius) causes more damage to the crop. At later stage, fruit borers like *Earias spp* and *Helicoverpa armigera* cause considerable losses to the crop to the tune of 91.6% (Pareek and Bhargava, 2003) [5]. Krishnaiah (1980) [3] reported about 40-56% losses in okra. It causes direct losses in yield of marketable fruits and vitality of plant resulting in 54.04% net yield loss (Sivakumar *et al.,* 2003) [8]. Okra shoot and fruit borer, *Earias vittella* (Fab.) is one of the key insect pest of okra. This pest causes 36-90 % loss in the fruit yield of okra (Misra *et al*., 2002) [4]. For the control of pod borers largely dependent on pesticides but now a days, in discriminant use of pesticide resulted environment, soil, micro-organism and human health hazard, diseases and bad effect on overall environment and living being. And also cause environment imbalances. Many new emerging bio pesticides are available in the market with good efficacy to pest control and safety to non-target organisms.

Materials and Methods
The experiment was conducted at Horticulture Research Centre (HRC) of the Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, (Uttar Pradesh) India during *Kharif* 2018. An okra variety Improved Bhendi Kiran-397 was sown in 2nd week of June 2018.

The experiment was laid out in Randomized Block Design (RBD) with three replications there were total 9 treatments including control. The plot size for each treatment was kept 4 x 3 m^2 and spacing between rows and plant was kept 45 and 30 cm. To determine the shoot and fruit borer, *Earias vittella* and fruit borer (*Helicoverpa armigera*) on okra, fruits from each of the plots were harvested separately and larval population of *E. vittella* has examined carefully. The larval population of *Earias vittella* per 5 plants in every plot was taken before one day of first spraying and next observations were taken after five and fifteen days of first spray and subsequently second and third spraying was worked out and average was estimated. Data on healthy and infested shoot and fruit were recorded one day before and first and second week after spraying. Similarly observations on the damage fruit due to shoots and fruits borer, *Earias vittella* were also recorded at weekly interval after first, second and third spraying. The total fruit and shoot infestation was converted into percentage.

Shoot infestation observation

The total number of shoots and the number of shoots infested by the okra shoot and fruit borer *Earias vittella* (Fab.) was recorded at weekly intervals from 5 plants of each plot.

$$\text{Shoot infestation} = \frac{\text{Number of infested shoots}}{Total\ number\ of\ shoots} \times 100$$

Fruit infestation observation

The fruits were harvested at weekly interval at fruiting stages after that number of healthy fruits and infested fruits per plot were counted separately. Fruiting stage in different treatments and its reduction over control were calculated. The weight of healthy and infested fruits at fruiting stage of okra plants were taken separately per plot for each treatment. The overall percent fruit infestations at fruiting stages were calculated using the following formula.

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

$$\text{\% Fruit infestation by weight} = \frac{\text{Weight of infested fruits}}{\text{Total weight of fruits}} \times 100$$

The stage wise per cent fruit infestation was calculated on the basis of the infestation occurred at fruiting stage of the crop.

Results & Discussions

The efficacy of different insecticides namely flubendiamide 0.144% @ 60 g a.i./ha which was found to be significantly effective among all the treatments as it recorded lowest in fruit and shoot borer of okra population. The next effective treatments was imidacloprid 17.8 SL @ 0.3 ml/L followed by indoxacarb 14.05 SC @ 0.007% and spinosad 45% SC @ 0.05%, profenofos 50% EC @ 2L/ha were next better treatment, while NSKE 5% @ 2 g/L, neem oil 1500 ppm @2.5ml/L and *Beauveria bassiana* CFU 2×10^9 @2 g/L was found to be least effective. Results revealed that all the insecticides showed their effectively against Shoot and fruit borer. In conformity to the present findings Wakil *et al.* (2009) who have reported imidacloprid 17.8 SL @ 0.3 ml/L most effective among all the treatments evaluated against fruit borer on okra.

Table 1: Details of treatments used for the management of Shoot & fruit borer *(Earias vittella)*, Fruit borer *(Helicoverpa armigera)* during *Kharif*-2018.

Treatments	Common name	Formulation	Dose/liter in water (gm/ml)
T1	Flubendiamide	0.0144%	60 g a.i./ha
T2	Imidacloprid	17.8% SL	0.3 ml/l,
T3	Profenofos	50%EC	2L/ha
T4	Indoxacarb	14.05 SC	0.007 %
T5	Spinosad	45% SC	0.05%,
T6	NSKE	5%	2 g/lit
T7	Neem oil	1500 ppm	2.5 ml/lit
T8	*Beauveria bassiana*	CFU $2x10^9$	2 g/lit
T9	Untreated control	-	-

Table 2: Cost: benefit ratio of insecticide application for the management of Shoot and fruit borer

Treatment	Name of treatment	Yield (q/ha)	Increase in yield over control (q/ha)	Additional income (Rs)	Cost of treatment+labour (Rs/ ha)	Net profit (Rs/ ha)	Cost benefit ratio
T_1	Flubendiamide	46.15	31.02	55380	3085	52295	1: 16.95
T_2	Imidacloprid	33.78	18.65	40536	3095	37441	1: 12.10
T_3	Profenofos	30.04	14.91	36048	2892	33156	1: 11.78
T_4	Indoxacarb	41.37	26.24	49644	2990	46654	1: 15.60
T_5	Spinosad	36.23	21.10	43476	2850	40626	1: 14.25
T_6	NSKE	28.13	13.00	33756	3410	30346	1: 8.90
T_7	Neem oil	27.13	12.00	32556	3310	29246	1: 8.84
T_8	*Beauveria bassiana*	25.13	10.00	30156	3410	26746	1:7.84
T_9	Untreated control	15.13	-	18156	-	-	-

Average price of okra Rs 1200/quintal Cost of labour @ Rs 150/labour/day, Charge of sprayer @ Rs 40/day

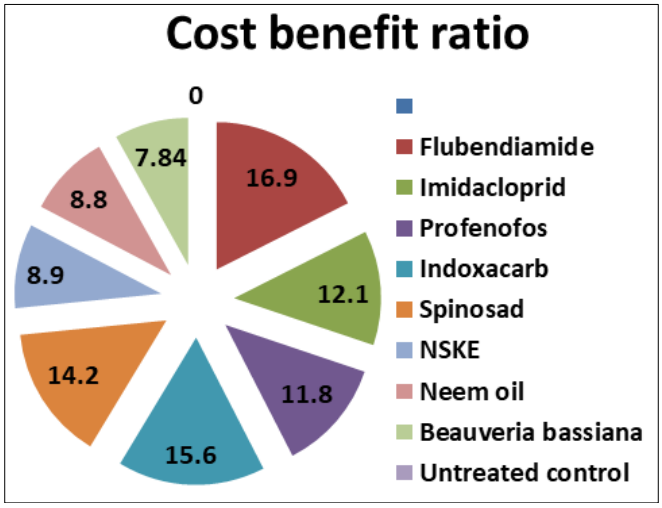

Fig 1: Economics of insecticides used for the management of shoot and fruit borer, *(Earias vittella)* on okra during *Kharif* 2018.

Table 3: Cost: benefit ratio of insecticides application for the management of Fruit borer

Treatment	Name of treatment	Yield (q/ha)	Increase in yield over control (q/ha)	Value of increase yield (Rs/ha)	Cost of treatment (Rs/ ha)	Net profit (Rs/ ha)	Cost benefit ratio
T_1	Flubendiamide	46.15	31.02	55380	3095	52285	1: 16.89
T_2	Imidacloprid	41.37	26.24	49644	2990	46654	1: 15.60
T_3	Profenofos	30.04	14.91	36048	2892	33156	1: 11.78
T_4	Indoxacarb	36.23	21.10	43476	2850	40626	1: 14.25
T_5	Spinosad	33.78	18.65	40536	3085	37451	1: 12.14
T_6	NSKE	28.13	13.00	33756	3410	30346	1: 8.90
T_7	Neem oil	27.13	12.00	32556	3310	29246	1: 8.84
T_8	*Beauveria bassiana*	25.13	10.00	30156	3410	26746	1: 7.84
T_9	Untreated control	15.13	-	18156	-	-	-

Average price of okra Rs 1200/quintal Cost of labour @ Rs 150/labour/day, Charge of sprayer @ Rs 40/day.

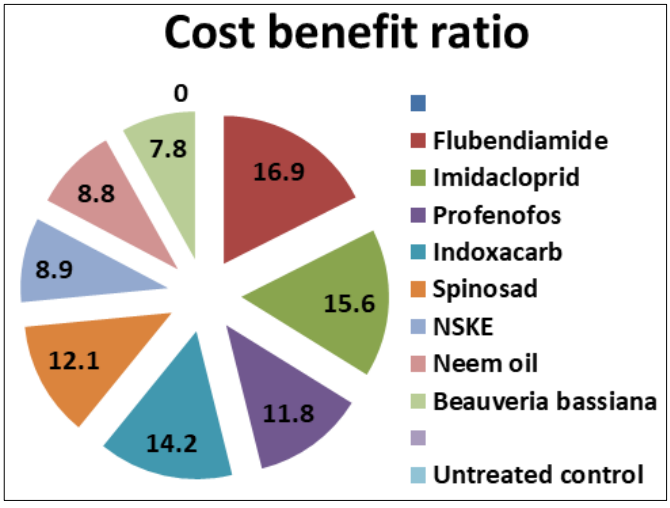

Fig 2: Economics of insecticides used for the management of fruit borer, *(Helicoverpa armigera)* on okra during *Kharif* 2018.

Conclusion

Finally the economics of each insecticide was studied to determine the best insecticide in controlling the shoot and fruit borer *(Earias vittella)* and fruit borer *(Helicoverpa armigera)* in okra. The shoot and fruit borer *(Earias vittella)* maximum net profit over control was recorded with flubendiamide 0.0144% recorded (Rs 52295) and the maximum benefit cost ratio(16.95) was also recorded with flubendiamide 0.0144 , whereas the minimum net profit was recorded with *Beauveria bassiana* CFU 2×10^9 (Rs26746) and benefit cost ratio (7.84) was recorded with *Beauveria bassiana* CFU 2×10^9.The fruit borer *(Helicoverpa armigera)* maximum net profit over control was recorded with flubendiamide 0.0144% @ 60 g a.i./ha recorded (Rs 52285) and the maximum benefit cost ratio (16.89) was also recorded with flubendiamide 0.0144% @ 60 g a.i./ha, whereas the minimum net profit was recorded with *Beauveria bassiana* CFU 2×10^9 (Rs26746) and benefit cost ratio (7.84) was recorded with *Beauveria bassiana* CFU 2×10^9.

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