The Pharma Innovation Journal 2023; 12(5): 2747-2750

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 2747-2750

www.thepharmajournal.com
Received: 12-02-2023
Accepted: 22-04-2023

Comparative field efficacy of biorationals and chemical insecticides against shoot and fruit borer, *Earias vittella* in okra

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Abstract
An investigation was conducted to evaluate comparative field efficacy of biorantionals and chemical insecticides against shoot and fruit borer in Okra during *Kharif* 2022-23. All the biorationals and chemical insecticides tested were significantly reduced the infestation of okra shoot and fruit borer (OSFB) compared to control. The lowest 9.22% shoot and 8.66% fruit infestation of OSFB was observed in treatment Chlorantraniliprole 18.5% SC and found to be the best superior treatment followed by Emamectin benzoate 5% SC recorded 10.20% and 13.46% shoot and fruit damage. The next effective treatment was Imidacloprid 17.8% SL recorded 11.09% shoot and 14.97% fruit damage. Among the biorationals, NSKE 5% found to be most effective treatment recorded 12.25% shoot and 15.81% fruit damage followed by Azadirachtin 1500 ppm 13.84% and 16.64%, shoot and fruit damage respectively. Among the myco-insecticides *Metarhizium anisopliae* $1x10^8$ CFU/gm was found to be most effective treatment and recorded 14.46% shoot and 17.59% fruit damage and least effective treatment was *Verticillium lecanii* $1x10^8$ CFU/gm recorded highest (15.28%) shoot and (18.19%) fruit damage in okra. However, when cost benefit ratio was worked out, the highest yield (154.28q/ha) with C:B ratio of 1:7.21 was recorded in T_6 Chlorantraniliprole 18.5% SC and found to be best superior treatment followed by T_5 Emamectin benzoate 5% SG recorded 135.15 q/ha yield with 1:6.95 C: B ratio followed by T_7 Imidacloprid 17.8 SL recorded (129.51 q/ha and 1:6.67), T_3 NSKE 5% (97.69 q/ha and 1:4.83), T_4 Azadiractin 1500 ppm (91.71 q/ha and 1:4.58), T_1 *Metarhizium anisopliae* $1x10^8$ CFU/gm (75.64 q/ha and 1:3.89), T_2 *Verticillium lecanii* $1x10^8$ CFU/gm (64.87 q/ha and 1:3.34) and recorded lowest yield 50.14 q/ha and C:B ratio 1:2.68 in T_8 control.

Keywords: Biorational**,** Chemical, Insecticide, *Earias vittella*, okra, fruit, shoot. Borer

Introduction
Okra [*Abelmoschus esculentus* (L.) Moench] is an annual vegetable belonging to Malvaceae family; it is also known by different names *viz*., ladies' finger, bhindi, bamia, okro or gumbo in different parts of the world. Okra is known as "Queen of vegetables". Okra is valued for its tender green fruits. It is cooked in variety of ways and used as an ingredient in a wide variety of dishes. Its medicinal value has also been reported in curing ulcers and relief from haemorrhoids. Okra is a very useful plant. It is mainly cultivated for edible fruits but its other parts like leaves, flower petals, stems and roots are also being used as a food, biofuel and as a medicine in different parts of the world (Janu and Kumar 2022) [3].

The total area and production under okra in the world is reported to be 1.26 million ha and 22.29 million tonnes, respectively. It is mainly grown in India, Nigeria, Sudan, Pakistan, Ghana, Egypt, Saudi Arabia, Mexico and Cameroon. India ranks first in okra production 5784.0 thousand tonnes (72% of total world production) having area of 1148.0 thousand hectares with an annual production of 6346 million tonnes and productivity of 11.9 million tonnes/ha. The major okra growing states in India includes Andhra Pradesh (20%), West Bengal (15%), Bihar (14%), Orissa (11%), Gujarat (10%), Jharkhand (7%), Maharashtra (4%), Assam (3%) and Haryana (3%) (Madhuri and Kumar, 2022) [7].

In India, more than 13 species of insect pests have been reported to infest okra crop reported 15 arthropod species in okra ecosystem. Among all, shoot and fruit borer (*Earias spp*.) is considered as the most important pest in okra which causes both quantitative and qualitative losses of the crop. Okra Shoot and fruit borer (OSFB) is active throughout the year and prefers high temperature. During the rainy season borer damage is relatively less. Several overlapping generations are completed in a year (Vastav *et al*., 2019) [18].

The larvae bore into the terminal growing shoots, floral buds, flowers and fruits of okra, resulting in cessation, withering and drying of infested shoots, tender leaves and heavy shedding of floral buds and flowers. The infested fruits become malformed and are rendered unfit for human consumption as well as for procurement of the seeds. Grown up larva damages many fruits results in 54.04% yield loss and reduces the vitality of the plant. The borer has been reported to cause 24.6 to 26.0 percent damage to okra shoots and 40 to 100% loss to fruits (Akolkar *et al*., 2021) [1]. Chemicals belonging to various groups are recommended for the management of okra shoot and fruit borer *Earias vittella* (Fabricius). Due to continuous and indiscriminate use of chemicals pesticides leads to problems in the natural ecosystem, environmental pollution, pest resistance and health hazards and suppress the population of natural enemies, etc. Hence, an investigation was planned to evaluate the comparative field efficacy of biorationals and chemical insecticides against shoot and fruit borer, *Earias vittella* in okra.

Material and Methods

The experiment was conducted on comparative filed efficacy of biorationals and chemical insecticides against shoot and fruit borer, *Earias vittella* in okra at the research plot of the Department of Agricultural Entomology at Central Research Field, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj during the *Kharif* season of 2022. Research field situated at 25°27′ North latitude 80°50′ East longitudes and at an altitude of 98 meter above sea level. The climate is typically semi-arid and sub-tropical. The maximum temperature reaches up to 47 °C in summer and drops down to 2.5 °C in winter.

The experiment was conducted in randomized block design with three replications. Sowing was done by dibbling following similar recommended agronomic practices to all the treatments from sowing to the harvesting.

Experimental Details

Table 1: Details of experiment

Design	Random Block Design	Gross cultivated area	105.6m²
Replication	3	Net cultivated area	48 m²
Treatment	8	Crop	Okra
Plot size	2mx 1m	Variety	"Arka Anamika"
Total no of plots	24	Seed rate	7 kg ha^{-1}
Total length of area	12m	Row to row distance	45 cm
Total width of area	8.8m	Plant to plant distance	30 cm

Table 2: Particulars of Treatments

Treatments	Selected Insecticides	Formula-tions	Trade name	Dosages Gm\ml\lit	Group
T_1	*Metarhizium anisopliae*	1×10^8 CFU/gm	Metarhoz- P	5gm/lit	Biopesticide
T_2	*Verticillium lecanii*	1×10^8 CFU/gm	Verticoz- P	5gm/lit	Biopesticide
T_3	NSKE	5%	--	50g/lit	Botanicals
T_4	Azadirachtin	1500 ppm	Neem Aura	5ml/lit	Botanicals
T_5	Emmamectin benzoate	5% SG	Proclaim	0.3gm/lit	Diamide
T_6	Chlorantraniliprole	18.5% SC	Coragen	0.5ml/lit	Anthranilic Diamide
T_7	Imidacloprid	17.8% SL	Confidence 555	0.4ml/lit	Neonicotinoids
T_8	Control	-	-	-	-

Method of recording observation and filed efficacy of treatments

The spraying was done after the population level reaches ETL. The observations was recorded one day before spraying, 3rd, 7th and 14th days after spraying. The assessment of the shoot damage was done by calculating the number of damaged shoots and total numbers of healthy shoots observed from five randomly selected plants per plot and was expressed in percentage. The percentage of fruit damage was assessed at each picking by counting the total number of affected fruits from each plot.

Shoot and fruit Infestation

The total number of shoots and fruits, as well as the number of infested shoots and fruits, were visually observed and recorded at weekly intervals from five selected plants in each plot. Shoot and fruit infestation was determined by percent using the following formula given by (Choudhury *et al.*, 2021) [2].

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

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

Statistical Analysis

The observations and data obtained were subjected to Randomized Block Design for their significance and were statistically analyzed.

Results and Discussion

Comparative field efficacy of biorationals and chemical insecticides on shoot infestation against Okra Shoot and fruit borer

From data presented in Table 3, it was revealed that after First Spray, lowest percent shoot infestation was recorded in T_6 Chlorantraniliprole 18.5% SC (9.22) and was most effective in shoot borer management, followed by T_5 Emamectin benzoate 5% SC (10.20), T_7 Imidacloprid 17.8 SL (11.09), T_3 NSKE 5% (12.25), T_4 Azadirachtin 1500 ppm (13.84) and T_1 *Metarhizium anisopliae* $1\text{x}10^8$ CFU/gm (14.46). However, T_2 *Verticillium lecanii* $1\text{x}10^8$ CFU/gm (15.28), is found to be least effective than all the treatments and is significantly superior over the Untreated control T_8 (24.40).

Comparative field efficacy of biorationals and chemical insecticides on fruit infestation against Okra Shoot and fruit borer

From data depicted in Table 4 revealed that after Second spraying, lowest percent of fruit infestation was recorded in T_6 Chlorantraniliprole 18.5% SC (8.66) was most effective, followed by T_5 Emamectin benzoate 5% SC (13.46), T_7 Imidacloprid 17.8 SL (14.97), T_3 NSKE 5% (15.81), T_4 Azadirachtin 1500ppm (16.64) and T_1 *Metarhizium anisopliae* 1x10^8 CFU/gm (17.59). However, T_2 *Verticillium lecanii* 1x10^8 CFU/gm (18.19), is found to be least effective than all the treatments and is significantly superior over the untreated control T_8 (25.71).

Shrivastava *et al*., (2017) and Patil *et al*., (2022) [15] reported similar results pertaining to Chlorantraniliprole 18.5% SC and was found to be most effective in managing the shoot and fruit borer infestation on okra. Manikanta and Kumar (2022) and Madhuri and Kumar (2022) [7], Janu and Kumar (2022) [3] and Kulkarni and Kumar (2022) [5] reported similar findings Yadav *et al*., (2017) [19] and Rakshith and Kumar (2017) [16], Mulani *et al*., (2022) [9] and Kumar *et al*., (2017) [16] Kaveri and Kumar (2020) [4] and Panbude *et al*., (2019) [13] reported similar results pertaining to the biorationals and other chemical insecticides.

Comparative field efficacy of biorationals and chemical insecticides on yield of Okra

From table 5 it was revealed that the highest yield of okra fruits was recorded in T_6 Chlorantraniliprole 18.5% SC (154.28q/ha) followed by T_5 Emamectin benzoate 5% SG (135.15 q/ha), T_7 Imidacloprid 17.8 SL (129.51 q/ha), T_3 NSKE 5% (97.69 q/ha), T_4 Azadiractin 1500 ppm (91.71q/ha), T_1 *Metarhizium anisopliae* 1x10^8 CFU/gm (75.64 q/ha), T_2 *Verticillium lecanii* 1x10^8 CFU/gm (64.87 q/ha) and T_8 (50.14 q/ha). However, T_2 *Verticillium lecanii* 1x10^8 CFU/gm (64.87 q/ha) was found to be least effective among all the treatments over the untreated Control plot T_8 (50.14 q/ha) yield.

When cost benefit ratio worked out, interesting result was revealed in table 5, the most superior and economical treatment was found to be Chlorantraniliprole 18.5% SC having highest Benefit Cost ratio of 1:7.21 followed by T_5 Emamectin benzoate 5% SG (1:6.95), T_7 Imidacloprid 17.8 SL (1:6.67), T_3 NSKE 5% (1:4.83), T_4 Azadiractin 1500 ppm (1:4.58), T_1 *Metarhizium anisopliae* 1x10^8 CFU/gm (1:3.89), T_2 *Verticillium lecanii* 1x10^8 CFU/gm (1:3.34) and T_8 untreaed control (1:2.68). Kumar *et al*., (2017) [6], Naidu and Kumar (2017) [10], Srivastava *et al*., (2014) [17], Patel *et al*., (2021) [14], Janu and Kumar (2022) [3], Pachole *et al*., (2017) [12], Patil *et al* (2021), Nalini and Kumar (2016) [11] and Kaveri and Kumar (2020) [4] reported the similar findings and are in close conformity with the present investigation.

Table 3: Comparative field efficacy of biorationals and chemical insecticides on shoot infestation against Okra Shoot and fruit borer

Treatments		Percent Shoot infestation				
		1DBS	3DAS	7DAS	14DAS	MEAN
T_1	*Metarhizium anisopliae* (1x10^8 CFU/gm)	16.39	14.01	14.37	15.01	14.46
T_2	*Verticillium lecanii* (1x10^8 CFU/gm)	16.73	14.39	15.55	15.89	15.28
T_3	NSKE 5%	16.53	13.07	11.30	12.37	12.25
T_4	Azadirachtin 1500 ppm	15.64	13.66	13.85	14.00	13.84
T_5	Emamectin benzoate 5% SG	16.93	10.75	8.92	10.94	10.20
T_6	Chlorantraniliprole 18.5% SC	16.66	9.88	8.07	9.73	9.22
T_7	Imidacloprid 17.8 SL	17.26	11.54	9.59	12.12	11.09
T_8	Untreated Control	16.76	21.15	24.58	27.47	24.40
	Overall mean	16.61	13.55	13.27	14.69	13.84
F - test		NS	S	S	S	S
C.D.at 0.05%		-	0.58	0.65	0.45	0.44
S.Ed A (+)		0.47207	3.469631	5.31905	5.554899	4.760795

*DBS- Days before spraying #DAS- Days after spraying

Table 4: Comparative filed efficacy of biorationals and chemical insecticides on fruit infestation against Okra Shoot and fruit borer

Treatments		Percent Fruit infestation				
		1DBS	3DAS	7DAS	14DAS	MEAN
T_1	*Metarhizium anisopliae* (1x10^8 CFU/gm)	18.61	17.14	17.78	17.86	17.59
T_2	Verticillium lecanii (1x10^8 CFU/gm)	18.50	17.85	18.33	18.39	18.19
T_3	NSKE 5%	18.94	16.49	15.53	15.42	15.81
T_4	Azadirachtin 1500 ppm	18.15	16.95	16.51	16.46	16.64
T_5	Emamectin benzoate 5% SG	19.05	14.28	12.13	13.96	13.46
T_6	Chlorantraniliprole 18.5% SC	18.97	10.45	7.99	7.56	8.66
T_7	Imidacloprid 17.8 SL	19.31	15.96	13.90	15.04	14.97
T_8	Untreated Control	20.95	23.66	25.89	27.58	25.71
	Overall mean	19.06	16.59	16.00	16.53	16.37
F - test		NS	S	S	S	S
C.D.at 0.05%		-	0.42	0.46	0.56	0.34
S.Ed A (+)		0.845273	3.692594	5.215868	5.578707	4.815073

*DBS- Days before spraying #DAS- Days after spraying

Table 5: Economics of Okra Cultivation and production

Sr. No:	Treatment	Yield q/ha	Price (Rs/q)	Gross return (Rs/ha)	Common cost (Rs/ha)	Treatment cost (Rs/ha)	Total cost (Rs/ha)	B:C ratio
T_1	*Metarhizium anisopliae* 1x10^8 CFU/gm	75.64	2500	189100	46746	1796	48542	1:3.89
T_2	*Verticillium lecanii* 1x10^8 CFU/gm	64.87	2500	162175	46746	1796	48542	1:3.34
T_3	NSKE 5%	97.69	2500	244225	46746	3800	50546	1:4.83
T_4	Azadirachtin 1500 ppm	91.71	2500	229275	46746	3260	50006	1:4.58
T_5	Emamectin benzoate 5% SG	135.15	2500	337875	46746	1815	48561	1:6.95
T_6	Chlorantraniliprole 18.5% SC	154.28	2500	385700	46746	6710	53456	1:7.21
T_7	Imidacloprid 17.8 SL	129.51	2500	323775	46746	1760	48506	1:6.67
T_8	Control	50.14	2500	125350	46746	-	46746	1:2.68

Conclusion

From the present study, the results showed that Chlorantraniliprole 18.5% SC (T6), is the most effective treatment against Shoot and Fruit borer (*Earias vittella*) and produces maximum yield and recorded highest Cost-Benefit ratio compared to other treatments. While Emamectin benzoate 5% SG (T5), Imidacloprid 17.8% SL (T7) and NSKE 5% (T_3) has shown average results. Azadirachtin 1500ppm (T4), *Metarrhizium anisopliae* 1x10^8 CFU/gm (T1) and *Verticillium lecanii* 1x10^8 CFU/gm found to be least effective in managing *Earias vittella.* Hence, it is suggested that the effective insecticides may be alternated in harmony with the existing Integrated pest management programs to avoid the problems associated with insecticidal resistance, pest resurgence etc.

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