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Efficacy of certain insecticides and bio-pesticides against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee)

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Abstract
The field trial was conducted at the Central field, Department of Entomology, SHUATS, Allahabad during *Kharif* from August to November 2017 investigation entitled "Efficacy of certain insecticides and bio-pesticides against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee)". The efficacy result showed that the T_5 Emamectin benzoate 5SG @ 50gm/lit was found most effective and showed (8.71%) shoot infestation and per cent fruit infestation (7.22%) followed by T_2 Spinosad 45 SC @ 0.02ml/lit (10.13) and (7.69), T_1 Cypermethrin 25 EC @ 2ml/lit (11.51) and (8.56), T_6 Chlorpyriphos 20EC @ 4gm/lit (12.23) and (9.47), T_3 Neem Oil 2% @ 2ml/lit (13.55) and (10.00), T_7 NSKE 5% @ 2ml/lit (13.72) and (10.57) and T_4 *Bacillus thuringiensis* @ 5gm/lit (15.31) and (11.48) respectively.

Keywords: Bio-pesticides, insecticide, *Leucinodes orbonalis*

1. Introduction
Vegetable cultivation is one of the most profitable and dynamic branches of agriculture. It has become an important source of income for both farmers and field labours, serving as a vehicle for reducing poverty in rural areas. Brinjal (*Solanum melongena* Linnaeus) also known as eggplant is referred as the "King of vegetables" originated from India and now grown as a vegetable throughout the tropical, sub-tropical and warm temperate areas of the world. It is a most important vegetable in the Indian Subcontinent that accounts for almost 50% of the world's area under its cultivation area under its cultivation. However, in India, the area is estimated as 7.5% of the total area of vegetables with 8% of the total production of vegetables [21].

It is an important vegetable grown in all the seasons. It is an important vegetable grown in all the seasons. Due to its nutritive value, consisting of minerals like iron, phosphorous, calcium and vitamins like A, B and C, unripe fruits are used primarily as vegetable in the country. It is also used as a raw material in pickle making and as an excellent remedy for those suffering from liver complaints. It has been reported as Ayurvedic medicine for curing the diabetes. In addition, it is used as a good appetizer, good aphrodisiac, cardio tonic, laxative and reliever of inflammation. [8]

Area with a production and productivity of 2.81 million tonnes and 12.0 t/ha. The major brinjal growing states in India are Andhra Pradesh, Karnataka, West Bengal, Tamil Nadu, Maharashtra, Orissa, Uttar Pradesh, Bihar and Rajasthan. Globally, India ranks second and China ranks first in the production of brinjal (57.9% of world output). In India, this crop occupies 71.13 lakh hectare area along with annual production of 135.57 (lakh tone) and productivity 19.1 MT per hectare. In Uttar Pradesh, the area under cultivation of brinjal is 3430 hectare producing 111.70 MT and the productivity is 8 MT/ha [23].

Brinjal shoot and fruit borer is the most destructive pest of brinjal considered the main constraint as it damages the crop throughout the year. This pest is reported from all brinjal growing areas of the world including Germany, Burma, USA, Srilanka and India. It is known to damage shoot and fruit of brinjal in all stages of its growth. The yield loss due to the pest is to the extent of 70-92 per cent. The infested fruits become unfit for consumption due to loss of quality and hence, lose their market value [8].

Larval feeds inside the fruit which results in destruction of the fruits tissue. The feeding tunnels are often clogged with fress. This makes even slightly damaged fruit unfit for marketing. The yield loss varies from season to season and from location to location.

Damage to fruits particularly in autumn, is very severe and the whole crop can be destroyed [2].

It alone causes damage as high as 85.90% and even up to 100% damage is also recorded. The larvae bore into tender shoots and cause wilting and dead heart and in later stage, they bore the tender fruits rendering them unfit for human consumption. So far, *L. orbonalis* is considered as a major pest of brinjal as shoot and fruit borer in established crop in main field [7].

It is also reported that there will be reduction in vitamin C content to an extent of 68 per cent in the infested fruits. It was reported that the shoot and fruit borer (on shoot) were more prevalent during vegetative phase of crop. The yield loss by this pest varied from 0.08-1.11 q/ha on the basis of inconsumable pest of damaged fruits and 0.46- 3.80 q/ha when whole of the damaged fruits were taken into consideration. It was reported that the borer infestation was 78.66% on top shoots in vegetative phase and then shifted to flowers and fruits with infestation reaching 66.66% in fruiting phase [23].

2. Materials and Methods

The present investigation was conducted at the Central Research field of Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh during *Kharif* season 2017. The research farm is situated on the right side of Allahabad Rewa road at 20 degrees and 15° North, 60° east longitude city and is about 129.2 cm above sea level. The site selected was uniform, cultivable with typical sandy loam soil having good drainage.

The seeds of 'Banaras purple round' variety were sown to raise the seedling in nursery. Regular watering and weeding were done up to transplanting of seedling to the main field. The seedlings were transplanted approximately after 5 weeks, in the main field and gap filling was done to maintain the plant population, keeping one plant per hill.

The spraying was done after the population reaching its ETL. The incidence of the borer on the shoot and the fruit were recorded from the five randomly selected plants. Observations were recorded one day before spray, 3rd, 7th, 14th days after spraying. The assessment of the shoot damage was done by calculating the number of damaged shoots and total number of the healthy shoots observed from five randomly selected plants per plot and expressed in percentage.

The percent fruit damage was total number of affected fruits from each plot. The total yield of the marketable fruits obtained from different treatments was calculated and converted by considering the additional cost (cost of insecticides and operational charges) and benefit (compared to untreated control) in the respective treatments.

2.1 Data collection

The population of brinjal shoot and fruit borer was recorded before 1day spraying and on 3, 7th day and 14th day after insecticidal application. The populations of brinjal shoot and fruit borer was recorded on 5 randomly selected and tagged plants from each plot and then it will be converted into per cent of infestation by following formulas,

2.2 On Shoot

2.2.1 Number Basis: The total number of shoots and number of shoots infested of five selected plants from each treatment replication wise were recorded.

$$\% \text{ Shoot infestation} = \frac{\text{No. of shoot infested}}{\text{Total no. of shoot}} \times 100$$

2.3 On Fruit

2.3.1 Number Basis: At each picking the total number of fruits and number of fruits infested of five selected plants from each treatment replication wise were recorded.

$$\% \text{ Fruit infestation} = \frac{\text{No. of fruit infested}}{\text{Total no. of fruit}} \times 100$$

3. Results

3.1 First spray- per cent shoot infestation

The data on the percent infestation of shoot borer on third, seventh and fourteenth day after spray revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest percent shoot, infestation was recorded in Emamectin benzoate (8.71%) followed by Spinosad (10.13%), Cypermethrin (11.51%) Next treatments were Chlorpyriphos (12.23) Neem oil (13.55%) NSKE (13.72%). *Bacillus thuringiensis* (15.31%) was found to be least effective but significantly superior over the control. (Table 1).

Table 1: To evaluate the efficacy of insecticides and bio-pesticides against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee). (First Spray): (% shoot infestation).

Treatments		Percent shoots infestation of *Leucinodes orbonalis*				
		One day before spray	After spray			
			3rd Day	7th Day	14th Day	Mean
T_1	Cypermethrin 25EC	13.57 (21.61)	11.66 (19.92)	11.28 (19.62)	11.61 (19.90)	11.51 (19.83)
T_2	Spinosad 45SC	13.39 (21.39)	10.97 (19.30)	9.85 (18.28)	9.57 (18.00)	10.13 (18.55)
T_3	Neem oil 2%	14.06 (21.99)	14.64 (22.45)	12.15 (20.38)	13.87 (21.85)	13.55 (21.58)
T_4	*Bacillus thuringiensis*	13.26 (21.35)	16.13 (23.63)	15.18 (22.91)	14.44 (22.33)	15.31 (23.03)
T_5	Emamectin benzoate 5%	13.39 (21.45)	9.48 (17.88)	8.05 (16.43)	8.61 (16.95)	8.71 (17.15)
T_6	Chlorpyriphos 20EC	15.33 (22.99)	11.84 (20.12)	12.01 (20.26)	12.85 (20.98)	12.23 (20.46)
T_7	NSKE 5%	14.50 (22.32)	14.66 (22.48)	12.57 (20.76)	13.94 (21.91)	13.72 (21.73)

T_0	Control	13.976 (21.91)	16.66 (24.07)	16.70 (24.11)	18.29 (25.31)	17.21 (24.50)
Overall Mean		13.94	13.26	12.23	12.90	12.79
F- test		NS	S	S	S	S
S. Ed. (±)		1.68	1.67	0.98	1.07	0.58
C. D. (P = 0.05)		3.61	3.57	2.10	2.30	1.25

Figures in parenthesis are arc sin transformed values.

3.2 Second spray- per cent fruit infestation

The data on the percent infestation of fruit borer on third, seventh and fourteenth day after spray revealed that all the chemical treatments were significantly superior over control.

Among all the treatments lowest percent infestation of shoot and fruit borer was recorded in Emamectin benzoate (7.22%) followed by Spinosad (7.69%) followed by Cypermethrin (8.56%). Chlorpyriphos (9.47%) and Neem oil (10.00) were statistically at par with each other. Treatments NSKE (10.57%), followed by *Bacillus thuringiensis* (11.48%) is found be least effective but significantly superior over the control (Table 2).

Table 2: Efficacy of insecticides and bio-pesticides against brinjal shoot and fruit borer (*Leucinodes orbonalis*, Guenee). (Second Spray): (% fruit infestation).

Treatments		Percent fruit infestation of *Leucinodes orbonalis*				
		One day before spray	After spray			
			3rd Day	7th Day	14th Day	Mean
T_1	Cypermethrin 25EC	10.13 (18.52)	9.13 (17.41)	7.75 (16.17)	8.80 (20.44)	8.56 (17.00)
T_2	Spinosad 45SC	11.42 (19.71)	8.66 (17.02)	6.64 (14.84)	7.79 (20.44)	7.69 (16.08)
T_3	Neem oil 2%	11.37 (19.71)	10.59 (18.93)	9.13 (17.58)	10.28 (20.44)	10.00 (18.42)
T_4	*Bacillus thuringiensis*	10.98 (19.27)	12.81 (20.93)	10.36 (18.77)	11.69 (20.44)	11.48 (19.79)
T_5	Emamectin benzoate 5%	10.52 (18.91)	7.52 (15.90)	6.60 (14.87)	7.56 (20.44)	7.22 (15.58)
T_6	Chlorpyriphos 20EC	10.51 (18.91)	10.40 (18.71)	7.86 (16.25)	10.16 (20.44)	9.47 (17.89)
T_7	NSKE 5%	10.38 (18.72)	11.50 (19.77)	9.66 (18.07)	10.55 (20.44)	10.57 (18.96)
T_0	Control	11.87 (20.13)	14.66 (22.48)	15.66 (23.30)	16.22 (23.74)	12.88 (21.01)
Overall Mean		10.91	10.66	9.21	10.39	9.74
F- test		NS	S	S	S	S
S. Ed. (±)		1.10	1.95	0.78	0.70	0.40
C. D. (P = 0.05)		2.35	4.18	1.68	1.53	0.85

Figures in parenthesis are arc sin transformed values.

4. Discussion

These results are in support with [9, 22, 8] who reported that Emamectin benzoate was found to be superior in reducing the population of shoot and fruit borer [18, 3, 5] found that spinosad was best in controlling shoot and fruit borer [4], also reported that cypermethrin is best in controlling the pest population of shoot and fruit borer. Chloropyriphos is found to the next best treatments which is in line with the findings of [17]. Neem oil found to the next best treatments, which is in line with the findings which is supported by [23]. Next treatment was NSKE which was in line with the findings supported by [10]. *Bacillus thurengiensis* resulted maximum shoot and fruit infestation, less effective and more expensive in controlling the pest. The results are supported by [16, 15].

These results are in support with [1, 6], who reported that Emamectin benzoate was superior in reducing the population of shoot and fruit borer [12, 5, 13] found that spinosad was best in controlling shoot and fruit borer [19, 10] also reported that cypermethrin is best in controlling the pest population of shoot and fruit borer. Chloropyriphos is found the next best treatments which is in line with the findings of [17, 16] reported as chlorpyriphos was most effective in the reduction of damage of shoot and fruit infestation. [11]. Among botanicals the highest reduction of brinjal shoot and fruit borer infestation was found in the plots treated by neem oil and it was most effective and these results were supported by [20]. The NSKE was next effective treatment which is in line with the finding and supported by [10, 8]. Among all the treatments *Bacillus thurengiensis* found to be least effective but comparatively superior over the control these findings are supported by [17, 15].

5. Conclusion

From the critical analysis Emamectin benzoate and selected insecticide and bio-pesticides like Spinosad 45 SC followed by Cypermethrin 25 EC, Chlorpyriphos 20 EC, Neem oil, NSKE and *Bacillus thuringiensis* are showing good result against *Leucinodes orbonalis* and can be a part of integrated pest management in order to avoid indiscriminate use of pesticides causing pollution in the environment and not much harmful to beneficial insects and in increasing cost effectiveness.

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