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Field efficacy of cypermethrin and certain biopesticides against brinjal shoot and fruit borer, (*Leucinodes orbonalis* Guenee) on Brinjal (*Solanum melongena* L.)

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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 2016 investigation entitled "Field efficacy of Cypermethrin and certain biopesticides against shoot and fruit borer (*Leucinodes orbonalis* Guenee) on brinjal (*Solanum melongena* L.). Seven treatments were evaluated against *Leucinodes orbonalis* i.e., T_1 Cypermethrin 25 EC@ 2ml/lit, T_2 Spinosad 45 SC @ 0.01%, T_3 Neem Oil 2%, T_4 NSKE 5%, T_5 *Beauveria bassiana*, T_6 *Verticilium lecanii*, T_7 Neem leaf extract 5% were evaluated against shoot and fruit borer *Leucinodes orbonalis.* Cypermethrin 25 EC, Spinosad 45 SC, and Neem oil recorded the minimum shoot infestation by 5.90, 7.33, and 9.83 percent respectively. In fruit infestation Cypermethrin 25 EC, Spinosad 45 SC, and neem oil recorded by 3.69, 4.06, and 5.17 percent, respectively. The best and most economical treatment was T1 Cypermethrin 25 EC (1:8.05), followed by T2 (1:7.60), T3 (1:6.04), T4 (1:4.79), T5 (1:5.03), T6 (1:4.95), T7 (1:4.00), as compared to control T0 (1:3.73). The highest yield was noticed in Cypermethrin 25 EC (204.16 q/ha) followed by Spinosad 45 SC (197.22 q/ha).

Keywords: Cost- benefit ratio**,** biopesticides, cypermethrin, *Leucinodes orbonalis*

Introduction
Brinjal or eggplant (*Solanum melongena* Linn.) is worldwide known as aubergine or guinea squash which is most popular and principle vegetable crop hence regarded as "King of vegetables belonging to the family "Solanaceae", is one of the common and popular vegetables grown throughout the world. Brinjal is a versatile and economically important vegetable among small-scale farmers and low-income consumers of the entire universe. It is the leading vegetable in the country and ranks first among summer and winter vegetables in terms of total acreage. Asia has the largest brinjal production which comprises about 90% of the total production area and 87% of the world production. Mannan *et al.* (2015) [4].
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. Kalawate and Dethe (2012) [3] 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. Yadav *et al.* (2015) [6]. 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. Kalawate and Dethe (2012) [3]. 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 (Anwar *et al*. 2015) [1]. 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. Halder *et al.* (2015) [2].

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 Yadav *et al*. (2015) [6].

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 2016. The research farm is situated on the right side of Allahabad Rewa road at 20 degrees and 15^0 North, 60^0-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.

Results and discussion

In case of shoot and fruit borer, all the three sprays revealed that among the Chemical insecticides and biopesticides cypermethrin 25 EC was found to be more effective, next to which Spinosad 45 SC (Spinosyns group) was most effective among all other treatments followed by Neem oil. Treatments *Beauveria bassiana, Verticilium lecanii* were at par with each other were next effective treatments. NSKE and Neem leaf extract recorded as least effective among the treatments but significant and superior over control.

Cypermethrin 25 EC, Spinosad 45SC, Neem oil, *Beauveria bassiana*, and *Verticilium lecanii* recorded the minimum shoot infestation by 5.90, 7.33, 9.83, 11.37 and 11.98 percent respectively. In fruit infestation Cypermethrin 25 EC, Spinosad 45 SC, neem oil and *Beauveria bassiana* recorded by 3.69, 4.06, 5.17 and 6.14 percent, respectively. The highest yield was noticed in Cypermethrin (204.16 q/ha) followed by Spinosad 45 SC (197.22 q/ha). Maximum net returns of ₹.38035 were obtained in Cypermethrin 25 EC and Spinosad 45 SC ₹. 38900. The yields among the treatment were significant. The highest yield was recorded in Cypermethrin 25 EC (204.16 q / ha), followed by spinosad 45SC (197.22 q / ha), Neem oil (163.83 q/ha), *Beauveria bassiana* (126.38 q/ha), *Verticilium lecanii* (124.22 q/ha), NSKE (120.25 q / ha), Neem leaf extract (100.2 q / ha) as compared to control (90.4 q / h). When cost benefit ratio was worked out, interesting result was achieved. Among the treatment studied, the best and most economical treatment was Cypermethrin 25 EC (1:8.05) followed by spinosad 45 SC (1:7.60), followed by Neem oil (1:6.04), Beauveria bassiana (1:5.03), Verticilium lecanii (1:4.95), NSKE (1:4.79), Neem leaf extract (1:4.00) as compared to control (1:3.73).From the critical analysis of the present findings, it can concluded that shoot and fruit borer population increased with maximum temperature and decreased with decline in minimum temperature. Cypermethrin 25 EC and selected Biopesticides like Spinosad 45 SC followed by Neem oil, *Beauveria bassiana* and *Verticilium lecanii* 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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Table 1: Efficacy of Cypermethrin and biopesticides against shoot and fruit borer *Leucinodes orbonalis* on brinjal (First Spray): (% shoot infestation)

Treatments		Percent fruit infestation of *Leucinodes orbonalis*				
		One day before spray	After spray			
			3rd Day	7th Day	14th Day	Mean
T_0	Control	14.65	16.37	18.75	23.44	19.52
T_1	Cypermethrin 25 EC	14.05	5.36	4.76	7.59	5.90
T_2	Spinosad 45SC	15.12	6.98	5.77	9.23	7.33
T_3	Neem oil 2%	14.28	9.23	8.57	11.69	9.83
T_4	NSKE 5%	15.01	11.76	12.68	14.12	12.85
T_5	*Beauveria bassiana*	15.07	10.35	11.39	12.37	11.37
T_6	*Verticilium lecanii*	15.55	10.91	11.84	13.18	11.98
T_7	Neem Leaf extract 5%	14.33	12.00	13.09	15.19	13.43
F- test		NS	S	S	S	S
S. Ed. (±)		0.58	0.18	0.24	0.14	0.13
C. D. (P = 0.05)		1.75	0.54	0.71	0.43	0.38

Figures in parenthesis are arc sin transformed values.

Table 2: Efficacy of Cypermethrin and biopesticides against shoot and fruit borer *Leucinodes orbonalis* on brinjal (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_0	Control	10.80	13.96	18.38	27.93	20.09
T_1	Cypermethrin 25 EC	7.06	3.09	2.52	5.66	3.76
T_2	Spinosad 45 SC	7.37	3.48	3.06	5.89	4.14
T_3	Neem oil 2%	8.31	4.47	4.84	6.98	5.43
T_4	NSKE 5%	9.78	6.12	5.08	10.35	7.18
T_5	*Beauveria bassiana*	8.94	5.36	6.00	7.50	6.29
T_6	*Verticilium lecanii*	8.52	5.17	5.66	8.11	6.31
T_7	Neem Leaf extract 5%	10.02	7.32	8.58	11.32	9.08
F- test		NS	S	S	S	S
S. Ed. (±)		3.73	0.14	0.16	0.24	0.14
C. D. (P = 0.05)		11.30	0.44	0.49	0.73	0.44

Figures in parenthesis are arc sin transformed values.

Table 3: Efficacy of Cypermethrin and biopesticides against shoot and fruit borer *Leucinodes orbonalis* on brinjal (Third Spray) (% Fruit infestation)

Treatments		Percent fruit infestation of *Leucinodes orbonalis*				
		One day before spray	After spray			
			3rd Day	7th Day	14th Day	Mean
T_0	Control	33.03	35.71	40.59	28.18	34.83
T_1	Cypermethrin 25 EC	6.33	2.75	4.61	3.53	3.63
T_2	Spinosad 45SC	6.81	3.00	5.17	3.79	3.99
T_3	Neem oil 2%	7.16	3.89	6.00	4.84	4.91
T_4	NSKE 5%	16.84	5.66	9.39	7.32	7.46
T_5	*Beauveria bassiana*	15.39	4.22	7.32	6.38	5.98
T_6	*Verticilium lecanii*	15.53	4.41	7.50	6.52	6.15
T_7	Neem Leaf extract 5%	20.00	6.52	11.57	8.83	8.98
F- test		NS	S	S	S	S
S. Ed. (±)		4.30	0.10	0.33	0.25	0.10
C. D. (P = 0.05)		13.04	0.30	1.01	0.76	0.31

Figures in parenthesis are arc sin transformed values.

Table 4: Efficacy of Cypermethrin and biopesticides against shoot and fruit borer *Leucinodes orbonalis* on brinjal (second and third spray over all mean) (% fruit infestation).

Treatments		Percent fruit infestation of *Leucinodes orbonalis*		
		IInd Spray	III rd Spray	Overall Mean
T_0	Control	20.09	34.83	27.46
T_1	Cypermethrin 25 EC	3.76	3.63	3.69
T_2	Spinosad 45SC	4.14	3.99	4.06
T_3	Neem oil 2%	5.43	4.91	5.17
T_4	NSKE 5%	7.18	7.46	7.32
T_5	*Beauveria bassiana*	6.31	5.98	6.14
T_6	*Verticilium lecanii*	6.29	6.15	6.22
T_7	Neem Leaf extract 5%	9.08	8.98	9.03
F- test		S	S	S
S. Ed. (±)		0.14	0.10	0.08
C. D. (P = 0.05)		0.44	0.31	0.24

Figures in parenthesis are arc sin transformed values.

Table 5: Economics of Cultivation

S. No:	Treatment	Yield of q/ha	Total cost of yield (□)	Common cost (□)	Treatment cost (□)	Total cost (□)	B:C ratio
T1	Cypermethrin25 EC	204.16	306240	36285	1750	38035	1:8.05
T2	Spinosad 45 SC	197.22	295830	36285	2615	38900	1:7.60
T3	Neem oil 2%	163.83	245745	36285	4350	40635	1:6.04
T4	NSKE 5%	120.25	180375	36285	3450	39735	1:4.79
T5	*Beauveria bassiana*	126.38	189570	36285	1350	37635	1:5.03
T6	*Verticillium lecanii*	124.22	186330	36285	1350	37635	1:4.95
T7	Neem leaf extract 5%	100.2	150300	36285	1200	37485	1:4.00
T8	Untreated	90.4	135600	36285	------	36285	1:3.73

Cost of yield per quintal ₹ 1500

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