Journal of Advances in Biology & Biotechnology

Volume 27, Issue 7, Page 59-65, 2024; Article no.JABB.117159
ISSN: 2394-1081

Bio Efficacy and Economics of Selected Biopesticides against Shoot and Fruit Borer [*Leucinodes orbonalis* (G.)] on Brinjal [*Solanum melongena* (L.)]

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jabb/2024/v27i7966

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/117159

Original Research Article

Received: 09/03/2024
Accepted: 13/05/2024
Published: 03/06/2024

ABSTRACT

The present investigation was carried out in a Randomized Block Design having 3 replications and 8 treatments (seven insecticides and one control) during *kharif* season 2023 conducted at the Central Research Farm, NAINI, SHUATS, Prayagraj (U.P). The order of effectiveness was observed in Chlorantraniliprole 18.5 EC (11.79), (8.01) > Spinosad 45 SC (13.52), (10.52) >

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Cite as: *Panwar, C., Yadav, U., Meena, A., & Bhati, M. S. (2024). Bio Efficacy and Economics of Selected Biopesticides against Shoot and Fruit Borer [Leucinodes orbonalis (G.)] on Brinjal [Solanum melongena (L.)]. Journal of Advances in Biology & Biotechnology, 27(7), 59–65. https://doi.org/10.9734/jabb/2024/v27i7966*

Emamectin benzoate 5% SG (14.91), (11.41) > *Beauveria bassiana* 1% WP (16.00), (12.39) > *Metarhizium anisopliae* 1x10^8 CFU/gm (16.71), (13.46) > Neem oil 0.4% + Pongamia oil 0.1% (17.84), (14.79) > Neem oil 2% (20.03), (17.77) > untreated control plot (27.22), (32.12) based on percentage shoot and fruit infestation. While highest yield and benefit cost ratio was obtained in Chlorantraniliprole 18.5 EC (220.95 q/ha), (1:6.48) followed by Spinosad 45 SC (198.20 q/ha), (1:5.68), Emamectin benzoate 5% SG (170.87 q/ha), (1:4.98), *Beauveria bassiana* 1% WP (160.00 q/ha), (1:4.75), *Metarhizium anisopliae* 1x10^8 CFU/gm (140.69 q/ha), (1:4.13), Neem oil 0.4% + Pongamia oil 0.1% (125.50 q/ha), (1:3.68), Neem oil 2% (99.85 q/ha), (1:2.96). Lest monetary returns was obtained with untreated control plot (55.16 q/ha), (1:1.70).

Keywords: Leucinodes orbonalis; bio-pesticides; chlorantraniliprole; spinosad; neem oil.

1. INRTODUCTION

“Brinjal or eggplant (*Solanum melongena* Linn.) is worldwide known as aubergine or guinea squash which is most popular and principal vegetable crop hence regarded as King of vegetables belonging to the family Solanaceae. 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”. Danish and Alexander, [1].

“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 hectares producing 111.70 MT and the productivity is 8 MT/ha”. Kolhe *et al.,* [2].

“A general view of the pest problem in brinjal in India reveals that this crop is attacked severely by number of pests, shoot and fruit borer (*Leucinodes orbonalis)*, Epilachna beetle (*Epilachna vigintioctopunctata* Fab.), jassid *(Amrasca biguttula biguttula* Ishida), aphid, thrips and white flies (*Bemicia tabaci* Gennadius). Out of these pests, shoot and fruit borer, *Leucinodes orbonalis* G. is considered to be the most destructive. The infestation on brinjal can be as high as 75 to 92% Brinjal crop is attacked regularly or sporadically by at least 50 insect pests and Aphid, Jassids, Whitefly and shoot and fruit borer are categorized as major pests of regular occurrence”. Pooja and Kumar, [3].

“Shoot and fruit borer, *Leucinodes orbonalis* Guenee of brinjal causing enormous damage in all brinjal growing areas. It is an internal borer which damages the tender shoots and fruits. The damaged shoots and the flowers droop down, and the damaged fruits get rotten from inside. This reduces plant growth, which in turn, reduces fruit number and size. The entry hole on the fruits is not visible as they get smaller due to increase in size of fruits while a small depression can be often observed. Only the large and more round exit holes are visible on the fruits. Such fruits lose their market value”. Verma *et al.,* [4].

“Bio-pesticides play an important role in insect pest management by their various inhibitory actions on insect physiology and behavior. They are the best alternative to chemical insecticides against *Leucinodes orbonalis* on brinjal. They are locally available, relatively cheap, biodegradable, and easy to handle. They are bringing about the balance back to the ecosystem. As agriculture shift toward organic farming the organic farming, they have much better scope in the management tactics”. Warghat *et al.,* [5].

2. MATERIALS AND METHODS

The present investigation was conducted at the experimental research plot of Department of Entomology, Central Research Farm, Sam Higginbottom University of Agriculture Technology and Science, Prayagraj, during *Kharif* season 2023 in a Randomized Block Design (RBD) with 8 treatment and 3 replication using variety, Indam Supriya seeds in plot size of 2m X 1m at a spacing of 60 cm x 45 cm with a recommended package of practices excluding plant protection. The spraying was done after the population reached its ETL.

The population of brinjal shoot and fruit borer was recorded 1 day before spraying and on 3rd, 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.

On Shoot:

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

$$\% \, shoot \, infestation = \frac{No. of \, shoot \, infestation}{Total \, no. of \, shoots} \times 100$$

Shyamrao *et al.,* [6]

On Fruit:

Number Basis: At each picking the total number of fruit and number of fruits infestation five selected plants from each treatment replication wise was recorded.

$$\% \, fruit \, infestation = \frac{No. of \, fruit \, infestation}{Total \, no. of \, fruits} \times 100$$

Shyamrao *et al.,* [6]

Based on the yield data, the gross returns and net returns were calculated for each treatment. Gross returns were calculated by multiplying total yield with the market price of the produce. The ratio of gross return and cost of cultivation will be work for each treatment and was used as benefit: cost ratio (BCR) to compare the performance of different treatments. Benefit cost ratio was calculated by using the following equation.

$$Gross \, return = Total \, yield \times Market \, price$$

$$BCR = \frac{Gross \, returns}{Total \, cost}$$

Reddy and Yadav [7].

3. RESULTS

3.1 First Spray- Per Cent Shoot Infestation

The data on the mean (3rd, 7th, and 14th DAS) of first spray for shoot infestation of *Leucinodes orbonalis* revealed that among all the treatments lowest percent shoot infestation was recorded in T_7 Chlorantraniliprole 18.5 SC (11.79), followed by T_6 Spinosad 45 SC (13.52), T_2 Emamectin benzoate 5% SG (14.91), T_3 *Beauveria bassiana* 1 % WP (16.00), T_5 *Metarhizium anisopliae* 1x10^8 CFU/gm (16.71), T_4 Neem oil 0.4% + Pongamia oil 0.1% (17.84) and T_1 Neem oil 2% (20.03) was least effective among all the treatments. Shoot infestation in Control plot T_0 was (27.22) recorded (Table 1).

3.2 Second Spray- Per Cent Fruit Infestation

The data on the mean (3rd, 7th and 14th DAS) of second spray for fruit infestation of *Leucinodes orbonalis* revealed that among all the treatments lowest percent fruit infestation was recorded in T_7 Chlorantraniliprole 18.5 SC (8.01), followed by T_6 Spinosad 45 SC (10.52), T_2 Emamectin benzoate 5% SG (11.41), T_3 *Beauveria bassiana* 1% WP (12.39), T_5 *Metarhizium anisopliae* 1x10^8 CFU/gm (13.46), T_4 Neem oil 0.4% + Pongamia oil 0.1% (14.79) and treatment T_1 Neem oil 2% (17.77) was least effective among all the treatments. Fruit infestation in Control plot T_0 was (32.12) recorded (Table 1).

The yields among all the treatments was significant as compared to control. The highest yield was obtained in T_7 Chlorantraniliprole 18.5 SC (220.95 q/ha), followed by T_6 Spinosad 45 SC (198.20 q/ha), T_2 Emamectin benzoate 5% SG (170.87 q/ha), T_3 *Beauveria bassiana* 1% WP (160.00 q/ha), T_5 *Metarhizium anisopliae* 1x10^8 CFU/gm (140.69 q/ha), T_4 Neem oil 0.4% + Pongamia oil 0.1% (125.50 q/ha) and treatment T_1 Neem oil 2% (99.85 q/ha). Control plot T_0 (55.16 q/ha) (Table 1).

When cost benefit ratio worked out, interesting result was achieved, among the treatments, the best and most economical treatment was found T_7 Chlorantraniliprole 18.5 SC (1:6.48), followed by T_6 Spinosad 45 SC (1:5.68), T_2 Emamectin benzoate 5% SG (1:4.98),T_3*Beauveria bassiana* 1% WP (1:4.75), T_5 *Metarhizium anisopliae* 1x10^8 CFU/gm (1:4.13), T_4 Neem oil 0.4% + Pongamia oil 0.1% (1:3.68) and T_1 Neem oil 2% (1:2.96) was found least effective among all the treatments. Control plot T_0 (1:1.70) (Table 1).

4. DISCUSSION

In the present research work lowest percent shoot infestation was recorded in T_7

Chlorantraniliprole 18.5 SC treated plot (11.79%) as similar findings were also reported by Pooja and Kumar [3] and Reddy and Yaday [7]. T_6 Spinosad 45 SC was found the next effective treatment with (13.52%) similar finding was reported by Shyamrao *et al.,* [6]. T_2 Emamectin benzoate 5 % SG was found the next best effective treatment with (14.91%) similar finding was reported by Sharma and Tayde [8]. Mean percentage of shoot infestation of T_3 *Beauveria bassiana* 1 % WP and T_5 *Metarhizium anisopliae* 1x10^8 CFU/gm with treated plot was (16.00%) and (16.71%) respectively which is similar finding was reported by Naik and Kumar [9]. Mean percentage infestation of T_4 Neem oil (0.4%) + Pongamia oil (0.1%) treated plot was (17.84%) which is also similar reported by Kumar *et al.,* [10]. Mean percentage infestation of T_1 Neem oil 2% treated plot was (20.03%) which is similar reported by Chandar *et al.*, [11] while shoot infestation in control plot T_0 was (27.22%) recorded.

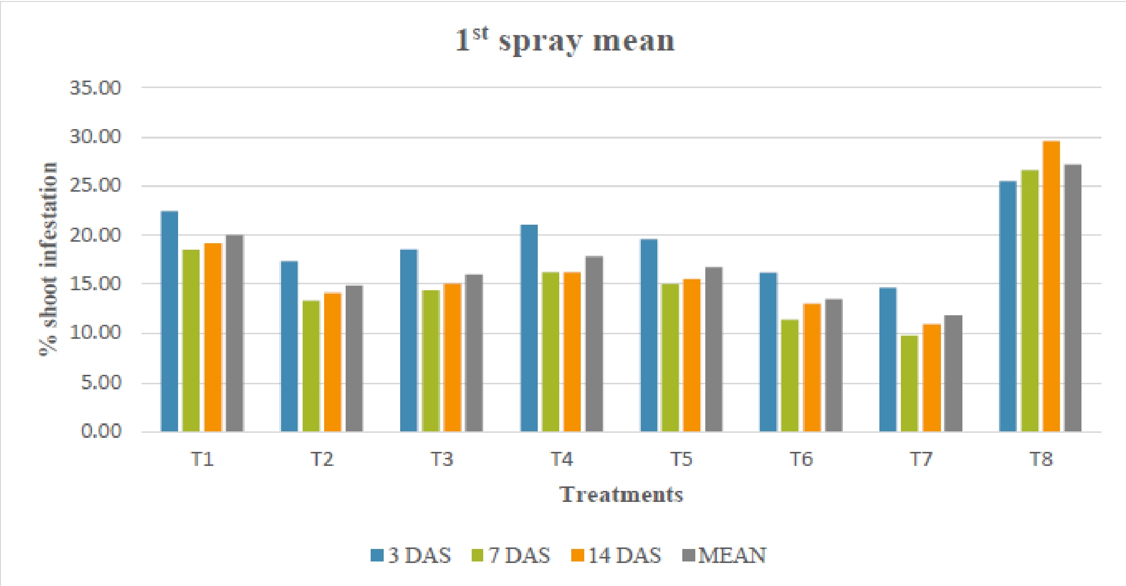

Fig. 1. Effect of different treatments on brinjal shoot and fruit borer after 1st spray.(% shoot infestation)

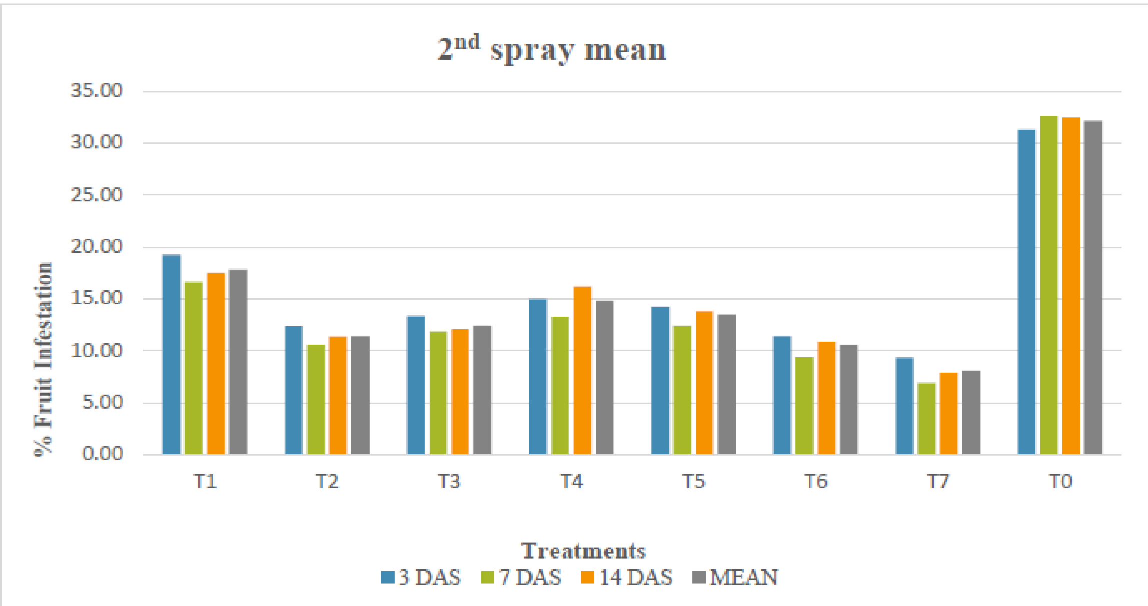

Fig. 2. Effect of different treatments on brinjal shoot and fruit borer after 2nd spray(% fruit infestation)

Table 1. Bio efficacy and economics of selected biopesticides against shoot and fruit borer [*Leucinodes orbonalis* (G.)] on brinjal

S. No.	Treatments	Doses	Percent shoot and fruit infestation of *Leucinodes orbonalis*										Yield (q/ha)	B:C ratio
			First spray (Shoot infestation)					Second spray (Fruit infestation)						
			1 DBS	3 DAS	7 DAS	14 DAS	Mean	1 DBS	3 DAS	7DAS	14 DAS	Mean		
T_1	Neem oil 2%	5 ml/l	23.10	22.45	18.47	19.18	20.03	21.72	19.17	16.63	17.50	17.77	99.85	1:2.96
T_2	Emamectin benzoate 5% SG	0.4 gm/l	20.42	17.32	13.31	14.08	14.90	16.92	12.32	10.56	11.35	11.41	170.87	1:4.98
T_3	*Beauveria bassiana 1%* WP	2.5 gm/l	20.23	18.56	14.36	15.08	16.00	15.39	13.32	11.84	12.01	12.39	160.00	1:4.75
T_4	Neem oil (0.4%)+ Pongamia oil (0.1%)	2.5 ml/l + 2.5ml/l	21.26	21.05	16.23	16.25	17.84	16.40	14.97	13.26	16.15	14.79	125.50	1:3.68
T_5	*Metarhizium anisopliae 1X10^8 CFU/gm*	4 gm/l	21.51	19.60	15.04	15.49	16.71	18.73	14.15	12.39	13.83	13.46	140.69	1:4.13
T_6	Spinosad 45% SC	0.5 ml/l	21.07	16.16	11.41	12.99	13.52	16.43	11.39	9.35	10.82	10.52	198.20	1:5.68
T_7	Chlorantraniliprole 18.5 SC	0.4 gm/l	20.01	14.65	9.77	10.95	11.79	15.95	9.30	6.89	7.83	8.01	220.95	1:6.48
T_8	Control		21.69	25.51	26.57	29.58	27.22	27.59	31.31	32.60	32.45	32.12	55.16	1:1.70
	F- test		NS	S	S	S	S	NS	S	S	S	S		
	CD.at 0.05%			1.14	1.52	1.19	2.54		1.67	1.82	2.70	1.35		
	S. Ed. (+)			0.53	0.71	0.56	1.18		0.78	0.85	1.26	0.63		

DBS- Day Before Spraying; DAS- Day After Spraying; BCR-Benefit Cost Ratio

In the present research work lowest percentage fruit infestation was recorded in T_7 Chlorantraniliprole 18.5 SC treated plot (8.01%) similar findings were also reported by Shirale *et al.,* [12]. T_6 Spinosad 45 SC (10.52%) is found next effective treatment which is similar reported by Verma *et al.,* [4]. T_2 Emamectin benzoate 5% SG treated plot showed (11.41%) percentage infestation similar findings were also reported by Jat and Shrisvastva [13]. Mean percentage of fruit infestation in T_3 *Beauveria bassiana* 1% WP treated plot was (12.39%) and T_5 *Metarhizium anisopliae* $1x10^8$ CFU/gm (13.46) which was similar to findings of to Abirami *et al.,* [14]. Mean percentage fruit infestation in T_4 Neem oil (0.4%) + Pongamia oil (14.79) which is similar findings were also reported by Kumar *et al.,* [10]. Mean percentage infestation of T_1 Neem oil 2% treated plot is (17.77%) which is similar findings were also reported by Mahajan *et al.,* [15].

When the benefit cost ratio worked out, an interesting result was achieved. Among all the treatments the higher cost benefit ratio was obtained from T_7 Chlorantraniliprole 18.5 SC (1:6.48) as the similar findings was done Reddy and Yadav [7] followed by, T6 Spinosad 45 SC exhibited a cost benefit ratio of (1:5.68) as the similar finding was done Bhagwan and Kumar [16] T_2 Emamectin benzoate 5% SG with a cost benefit ratio of (1:4.98), T_3 *Beauveria bassiana* 1% (1:4.75) and T_5 *Metarhizium anisopliae* $1x10^8$ CFU/gm exhibited cost benefit ratio of (1:4.13) as the similar finding was done by Sharma and Tayde [8] T_4 Neem oil (0.4%) + Pongamia oil (0.1%) with a cost benefit ratio of (1:3.68) as the similar finding was done by Kumar *at el.,* [10]. T_1 Neem oil 2% was the least effective against *Leucinodes orbonalis* which obtained a cost benefit ratio of (1:2.96) which was supported by Sanjana and Tayde [17]. Cost benefit ratio of Controlplot T_0 (1:1.70) obtained.

5. CONCLUSION

From the critical analysis it can be concluded that among biopesticides, combination and chemicals Chlorantraniliprole 18.5 SC was found to be most superior in managing brinjal shoot and fruit borer, as it recorded lowest percentage of shoot and fruit infestation (11.79%), (8.01%) respectively and highest marketable fruit yield (220.95 q/ha) with B:C ratio (1:6.48). which was followed by Spinosad 45 SC, Emamectin benzoate 5 SG. Among biopesticides *Beauveria bassiana* 1% WP followed by *Metarhizium anisopliae* $1x10^8$ CFU/gm found effective against *Leucinodes orbonalis*. While Neem oil 2% was found to be the least effective in managing *Leucinodes orbonalis.* Bio-pesticides and combination of botanicals Neem oil + Pongamia oil can be a part of integrated pest management in order to avoid indiscriminate use of pesticides causing pollution in the environment and not harmful to beneficial insects and Human beings. On the basis of reduced borer infestation and high yield, Chlorantraniliprole could be recommended in successful management of shoot and fruit borer.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/117159