Biological Forum – An International Journal 14(2a): 149-154(2022)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Efficacy and Economics of newer Insecticides for the Management of Brinjal Shoot and Fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae) in the Gwalior region of Madhya Pradesh

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(Received 22 April 2022, Accepted 20 June, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The present investigation was carried out at the entomological field of College of Agriculture, Gwalior during *rabi* 2018-19 to study the efficacy and economics of newer insecticides for the management of Brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee in the Gwalior region of M.P. The study was conducted because due to the frequent fruit pickings in brinjal, the use of harmful conventional pesticides to manage this pest started to pose concerns for the environment, natural enemies, development of resistance, and pest comeback in addition to being harmful to customers' health and environment due to residual effect of chemicals in the produce. The results revealed that all the newer insecticidal treatments were significantly superior in comparison to control. Among the treatments, flubendiamide 20% WG @ 300 g/ha was found to be most efficient as it was recorded with a minimum per cent shoot and fruit damage (0.31% and 11.77%, respectively) and thiacloprid 21.7% W/W @ 300 ml/ha with 2.87% shoot and 25.95% fruit damage, being the least effective. A similar trend was observed in per cent fruit damage where Flubendiamide 20% WG @ 300 g/ha was found to be most efficient as it recorded the highest fruit yield (583.70 q/ha) followed by emamectin benzoate 5% SG @ 150 g/ha (448.30 q/ha) and thiacloprid 21.7% W/W @ 300 ml/ha was recorded with least fruit yield (252.57 q/ha). The highest increase in fruit yield of brinjal among the different treatments during *rabi* 2019 over control was recorded in flubendiamide 20 WG @ 300 g/ml/ha (385.2 q/ha) and the lowest in thiacloprid 21.7 W/W @ 300 g/ml/ha (54.07 q/ha). Highest net profit per hectare among the different treatments, was recorded in flubendiamide 20 WG @ 300 g/ml/ha (Rs. 767656), followed by emamectin benzoate 5% SG @ 150 g/ml/ha (Rs. 496856) and lowest in thiacloprid 21.7 W/W @ 300 g/ml/ha (Rs. 105396). The highest cost-benefit ratio per hectare among the different treatments, was recorded in flubendiamide 20 WG @ 300 g/ml/ha (1:279.7) which was followed by emamectin benzoate 5% SG @ 150 g/ml/ha (1:181.06) and lowest cost-benefit ratio per hectare was recorded in thiacloprid 21.7 W/W @ 300 g/ml/ha (1:38.40). The study contributed that newer insecticides included in this study have best managed the brinjal shoot and fruit borer and hence produced the higher yields.

Keywords: *Solanum melongena* Linnaeus, *Leucinodes orbonalis* Guenee, newer insecticides, shoot damage, fruit damage, fruit yield, economics.

INTRODUCTION

Brinjal (*Solanum melongena* Linnaeus) also known as eggplant belongs to the family "Solanaceae" and is designated as the "King of vegetables", having the centre of origin in the Indian sub-continent, Omprakash and Raju (2014). Being local to India it is one of the foremost common vegetable crops developed all through the nation. China is the leading nation of brinjal within the area and production all over the world. India is second in area and production about 730.4 thousand hectare areas and 12800.8 metric tons production and 17.5 metric tons productivity. In India, brinjal is grown mainly in Bihar, Orissa, Karnataka, Andhra Pradesh, Maharashtra, West Bengal, Uttar Pradesh and states with coordinating climatic conditions within the tropics and subtropics. The area, production and productivity of brinjal are India- 7.1 Lakh ha, 135.58 Lakh MT, 19.1MT/ha; Bihar – 57,500 ha, 12.40 Lakh MT, 21.6 MT/ha. In Madhya Pradesh, it is grown in an area of 51.35 thousand hectares, with a production of 1073.63 metric tons (Anonymous 2018).

Owing to the accessibility of the brinjal produce all through the year, this crop suffers very significantly from insect-pests damage. Brinjal is attacked by 142 species of insect pests, four species of mites and three species of nematodes in different nations of the world (Prempong and Bauhim 1977; Sohi, 1996, Butani and Verma, 1976; Nayar *et al.*, 1976). Brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae) is the extremely severe, endemic pest of brinjal in India causing potential damage to the crop. Early instar larvae tunnel into petioles, midribs of big leaves, and delicate shoots; the usual symptom caused is a dead heart and plant falling. Later, they bore into developing unmarketable fruits. During its whole larval stage, one larva destroys four to six fruits. A fully developed larva makes an escape hole in the fruit before entering the pupal stage. According to Alam *et al*. (2003), the economic harm threshold in India corresponds to a shoot and fruit infestation of 6%. The caterpillar may be a profoundly damaging and cosmopolitan pest causing damage to 80-90% yield loss, Regupathy *et al.* (1997).

To combat the brinjal shoot and fruit borer, farmers are presently utilising a wide range of harmful chemical pesticides and spraying them more often. The foremost successful and cheapest strategy to manage this pest is to develop resistant varieties. Among the different strategies of pest management, the use of pesticides shapes the primary line of defence against insect pests. Due to the frequent picking, the use of pesticides to manage this pest started to pose concerns for the environment, natural enemies, the development of resistance, and pest comeback in addition to being harmful to customers' health due to chemical residue in the produce (Mehrotra, 1990). However, it has been asserted that the next-generation biorational pesticide compounds are both potent and safer for non-target creatures and the environment (Sontakke *et al.*, 2007; Misra, 2008). With a view on the climate change projections for India, an attempt has been made here to study the efficacy and economics of newer insecticides for the management of Brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee in the Gwalior region of M.P.

MATERIAL AND METHODS

A field experiment was conducted at the entomological field of the College of Agriculture, Gwalior during *rabi* 2018-19. An experiment was laid out in Randomized Block Design (RBD), with eight treatments including the untreated control and three replications. The plot size was taken as 4.2 m × 3.0 m. Thirty days old healthy seedlings of the *Deshi* variety of brinjal were transplanted in the main field with 60 cm spacing between the rows and 60 cm between plants. A standard agronomic package of practices was followed to raise and maintain a healthy crop. Insecticidal treatments mentioned in Table 1 were imposed when the pest population has reached its ETL. Further, the second and third sprays were done at 15 days intervals.

Table 1: Detail of Treatments.

S. No.	Treatments	Formulations	Dose/ha
1	Chlorantraniliprole	18.5 SC	55 gm/ha
2	Flubendiamide	20 WG	300 gm/ha
3	Thiacloprid	21.7 W/W	300 ml/ha
4	Carbosulfan	25 EC	1000 ml/ha
5	Indoxacarb	14.5 SC	500 ml/ha
6	Emamectin benzoate	5 SG	150 gm/ha
7	Spinosad	45 SC	180 ml/ha
8	Control	-	-

For the observations on the shoot and fruit borer, the total number of secondary shoots per plant and number of infested shoots per plant were recorded from 5 randomly selected plants in each replicated plot and per cent shoot damage was calculated by using the following formula. To avoid repetition in observations, the infected shoots were clipped off at each observation.

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

For observations on percent fruits infestation, the fruits were harvested at fruiting stages and weight of the total number of fruits and weight of infested fruits per plant were counted separately and per cent, of fruit infestation (by weight) was calculated by using the following formula

$$\text{Percentage fruit infestation (by weight)} = \frac{\text{Weight of infested fruits}}{\text{Weight of the total number of fruits}} \times 100$$

The weight of brinjal fruits at each picking was recorded individually for each treatment and the total yield was calculated by adding the yield from all pickings in each treatment. The yield was then converted into a per hectare basis.

$$\text{Yield (Kg/ha)} = \frac{\text{Yield / plot}}{\text{Plot size}} \times 10000$$

The data on pest infestation based on calculated percentage were arc sine transformed by the method as suggested by Gomez and Gomez (1984). The data were then subjected to statistical analysis by adopting the appropriate method of "Analysis of variance" as suggested by Fisher and Yates (1963).

RESULTS AND DISCUSSION

1. Efficacy of newer insecticides against Brinjal shoot and fruit borer

Brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee was observed in the field at varying levels and the damage symptoms and specimens are depicted in Plate 1.

(A) (B) (C)

Plate 1. Damage due to Brinjal Shoot and Fruit Borer, *Leucinodes orbonalis* Guenee (A) bore hole in brinjal fruit, (B) Fruit bored and damaged symptoms, and (C) larvae in stem of brinjal plant.

A. Percent shoot damage by Leucinodes orbonalis

Based on the data presented in Table 2 and depicted in Fig. 1, the mean per cent shoot damage in all the insecticidal treatments was recorded as significantly less damage in comparison to control (5.08%). Among the treatments, flubendiamide 20% WG @ 300g/ha was found to be most efficient as it was recorded with minimum per cent shoot damage (0.31%) followed by emamectin benzoate 5% SG @ 150g/ha (0.53%) and spinosad 45% EC @ 180ml/ha (0.79%). The following effective group of treatments included chlorantraniliprole 18.5% SC @ 55 gm/ha (1.23% shoot damage), Carbosulfan 25% EC @ 1000ml/ha (1.54% shoot damage), Indoxacarb 14.5% SC @ 500ml/ha (2.05% shoot damage), thiacloprid 21.7% W/W @ 300ml/ha (2.87% shoot damage) and found at par with each other but statistically significant superior to control.The results are in line with the findings of Reshma and Behera (2018) who reported that flubendiamide 480 SC @ 78.70 g a.i. /ha and spinosad 45% SC @ 10ml a.i. /ha were proved to be highly effective against shoot and fruit borer in brinjal.

B. Percent fruit damage by Leucinodes orbonalis

Based on the data presented in Table 2 and depicted in Fig. 1, the mean per cent fruit damage (by weight) in all the insecticidal treatments recorded significantly less damage in comparison to control (40.58%). Among the treatments, flubendiamide 20% WG @ 300g/ha was found to be most efficient as it was recorded with least fruit damage (11.77%) followed by emamectin benzoate 5% SG @ 150g/ha (16.03%) and spinosad 45% EC @ 180ml/ha (18.02%). The following effective group of treatments included chlorantraniliprole 18.5% SC @ 55 g/ha (20.29% fruit damage), Carbosulfan 25% EC @ 1000ml/ha (22.22% fruit damage).

Treatment indoxacarb 14.5% SC @ 500ml/ha with 24.38% fruit damage was found at par with thiacloprid 21.7% W/W @ 300ml/ha with 25.95% fruit damage but statistically significant superior to control.These results were strongly supported by previous studies by Singh and Sachan (2015) who reported that spinosad @ 200ml/ha was the most effective treatment for shoot and fruit damage in brinjal. Niranjan *et al.* (2017) reported chlorantraniliprole 18.5% SC was most effective. Besides these, Spinosad 2.5% SC and Flubendiamide 20 WG proved next to Chlorantraniliprole.

C. Fruit yield

Based on the data presented in Table 2 and depicted in Fig. 1, cumulative healthy marketable fruit yield in all the insecticidal treatments recorded significantly higher fruit yield as compared to control (198.50 q/ha).

Among the treatments flubendiamide 20% WG @ 300g/ha was found to be most efficient as it recorded highest fruit yield (583.70 q/ha) after by emamectin benzoate 5% SG @ 150g/ha (448.30 q/ha), spinosad 45% EC @ 180ml/ha (418.17 q/ha). The following effective group of treatments included chlorantraniliprole 18.5% SC @ 55 g/ha (328.50 q/ha), Carbosulfan 25% EC @ 1000ml/ha (322.27 q/ha), indoxacarb 14.5% SC @ 500ml/ha (322.17 q/ha), thiacloprid 21.7% W/W @ 300ml/ha (252.57 q/ha) fruit yield.

Table 2: Percent damage of shoot and fruit yield of brinjal during *rabi* 2019-20.

S. No.	Treatment Details	Dose /ha	Shoot damage (%)	Fruit damage (%)	Fruit yield (q/ ha)
T1	Chlorantraniliprole 18.5 SC	55 g/ha	1.23	20.29	328.50
T2	Flubendiamide 20 WG	300 g/ha	0.31	11.77	583.70
T3	Thiacloprid 21.7 W/W	300 ml/ha	2.87	25.95	252.57
T4	Carbosulfan 25 EC	1000 ml/ha	1.54	22.22	322.27
T5	Indoxacarb 14.5 SC	500 ml/ha	2.05	24.38	322.17
T6	Emamectin benzoate 5 SG	150 g/ha	0.53	16.03	448.30
T7	Spinosad 45 SC	180 ml/ha	0.79	18.02	418.17
T8	Control (Untreated)	-	5.08	40.58	198.50
SEm ±		-	**0.45**	**0.35**	**0.78**
C.D. at 5%		-	**0.64**	**1.08**	**2.38**

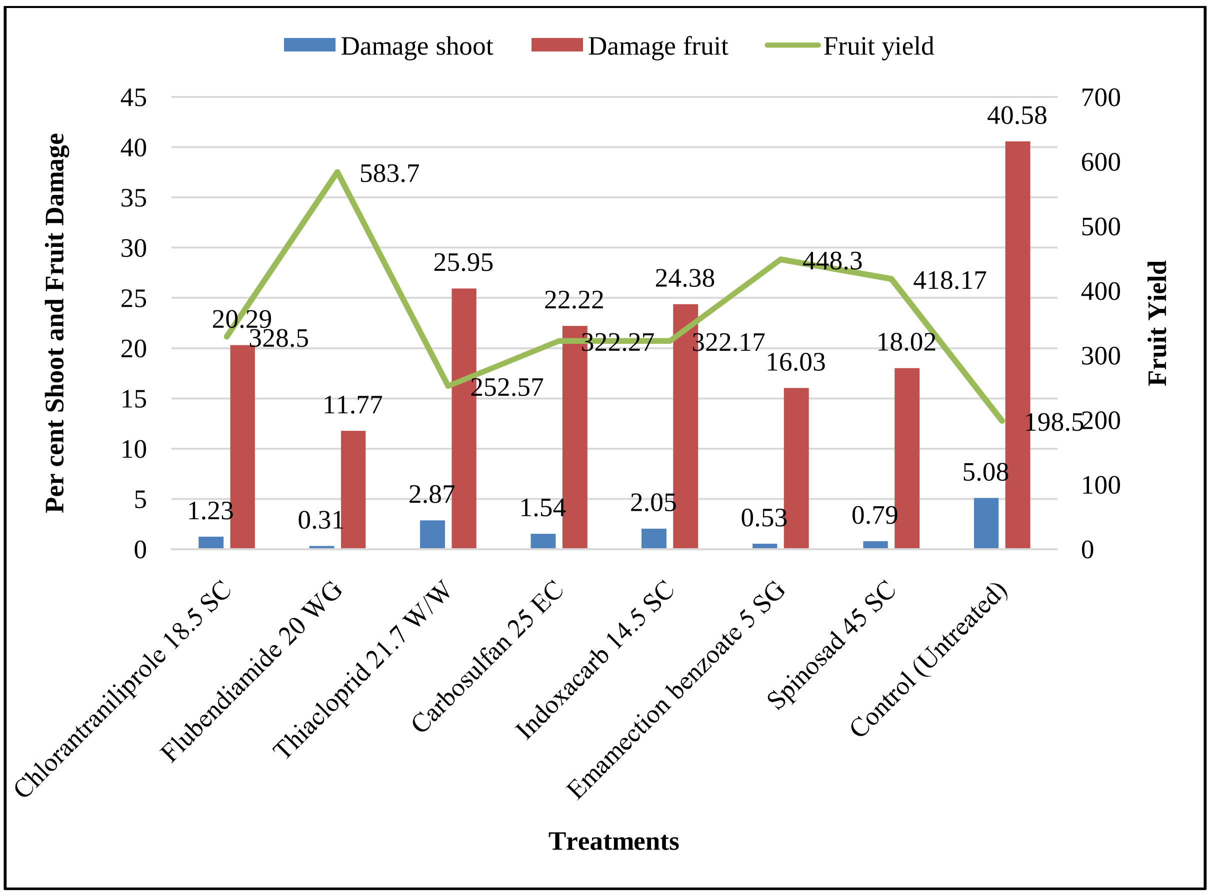

Fig. 1. Graphical representation of percent shoot and fruit damage by brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee and fruit yield during *rabi* 2018-19.

The present findings are in line with the findings of Khare and Sneha (2021) who reported that the brinjal crop was best protected against the brinjal shoot and fruit borer using Spinosad 45 percent SC with a fruit yield of 250 q/ha. Singh *et al*. (2021) reported spinosad 45SC @ 0.5 ml/l was the best with the least shoot (2.03%) and fruit damage (12.66%) with maximum yield (25.39 and 26.99 t/ ha), chlorantraniliprole and emamectin benzoate were the next best treatment. Shirale *et al*. (2012) reported Chlorantraniliprole 18.50% SC gave a significantly higher yield as compared to the plots (528.52 quintals/ha).

2. Economics of the insecticidal treatments

A. Increase in yield over control

Data indicated in Table 3 showed that, highest increase in fruit yield of brinjal among the different treatment during *rabi* 2019 over control was recorded in flubendiamide 20 WG @ 300 g/ml/ha (385.2 q/ha) which was followed by emamectin benzoate 5% SG @ 150 g/ml/ha (249.8 q/ha), spinosad 45% SC @ 180 g/ml/ha (219.67 q/ha), Chlorantraniliprole 18.5 SC @ 55 g/ml/ha (130 q/ha), Carbosulfan 25 EC @ 1000 g/ml/ha (123.77 q/ha), Indoxacarb 14.5 SC @ 500 g/ml/ha @ 123.67g/ml/ha and thiacloprid 21.7 W/W @ 300 g/ml/ha (54.07 q/ha).

B. Net profit

Highest net profit per hectare among the different treatments, was recorded in flubendiamide 20 WG @ 300 g/ml/ha (Rs. 767656), followed by emamectin benzoate 5% SG @ 150 g/ml/ha (Rs. 496856), spinosad 45% SC @ 180 g/ml/ha (Rs. 436596), Chlorantraniliprole 18.5 SC @ 55 g/ml/ha (Rs. 257256), Carbosulfan 25 EC @ 1000 g/ml/ha (Rs. 244796), Indoxacarb 14.5 SC @ 500 g/ml/ha @ 123.67g/ml/ha (Rs. 244596) and thiacloprid 21.7 W/W @ 300 g/ml/ha (Rs. 105396). The present findings got supported by Khare and Sneha (2021) who reported spinosad treated plot was Rs. 410000/ha. Shridhara *et al*. (2019) reported emamectin benzoate 5 SG higher net profit of Rs. 141884 ha^{-1}. This was followed by flubendiamide 39.5 SC, chlorantraniliprole 18.5 SC and spinosad 45 SC registered net profit of Rs. 125604, 108179.84 and 71937.58 ha^{-1}.

Table 3: Economics of newer insecticide on fruit yield of brinjal during *rabi* 2019-20.

S. No.	Treatment Details	Dose /ha	Fruit yield q/ha	Increase in yield over control	Cost of Treatments (Rs.)	Cost increased yield over Control @ Rs. 2000/- per quintal	Net profit (Rs. /ha)	Cost benefit ratio
T1	Chlorantraniliprole 18.5 SC	55 g/ha	328.50	130	2744	260000	257256	1:93.7
T2	Flubendiamide 20 WG	300 g/ha	583.70	385.2	3150	770400	767656	1:279.7
T3	Thiacloprid 21.7 W/W	300 ml/ha	252.57	54.07	2844	108140	105396	1:38.40
T4	Carbosulfan 25 EC	1000 ml/ha	322.27	123.77	3550	247540	244796	1:89.2
T5	Indoxacarb 14.5 SC	500 ml/ha	322.17	123.67	3200	247340	244596	1:89.1
T6	Emamectin benzoate 5 SG	150 g/ha	448.30	249.8	2737.5	499600	496856	1:181.06
T7	Spinosad 45 SC	180 ml/ha	418.17	219.67	2752.2	439340	436596	1:159.10
T8	Control (Untreated)	-	198.50	-	-	-	-	-

C. Cost-benefit ratio

Highest cost benefit ratio per hectare among the different treatments, was recorded in flubendiamide 20 WG @ 300 g/ml/ha (1:279.7) which was followed by emamectin benzoate 5% SG @ 150 g/ml/ha (1:181.06), spinosad 45% SC @ 180 g/ml/ha (1:159.10), Chlorantraniliprole 18.5 SC @ 55 g/ml/ha (1:93.7), Carbosulfan 25 EC @ 1000 g/ml/ha (1:89.2) Indoxacarb 14.5 SC @ 500 g/ml/ha @ 123.67g/ml/ha (1:89.1) and thiacloprid 21.7 W/W @ 300 g/ml/ha (1:38.40). The present results were supported by Kushwaha and Painkra (2016) who reported Chlorantraniliprole (1:5.48) had the highest B:C ratio, followed by flubendiamide (1:4.91), spinosad (1:4.65), and indoxacarb (1:4.65). (1:4.44). Kameshwaran and Kumar (2015) reported highest CBR with chlorantraniliprole 20 EC @ 40 g a.i./ha and lowest with indoxacarb 14.5 SC @ 75 g a.i./ha.

CONCLUSION

Among all the insecticidal treatments, flubendiamide 20% WG @ 300gm/ha was found to be most effective as it was recorded with minimum per cent shoot and fruit damage and maximum fruit yield followed by emamectin benzoate 5% SG @ 150gm/ha and spinosad 45% EC @ 180ml/ha. The next effective treatments included chlorantraniliprole 18.5% SC @ 55 gm/ha, Carbosulfan 25% EC @ 1000ml/ha, indoxacarb 14.5% SC @ 500ml/ha and thiacloprid 21.7% W/W @ 300ml/ha being the least effective.

FUTURE SCOPE

The use of newer insecticides or biorational pesticide compound-based management techniques may become more common in the future because they are effective and safer for the environment and natural enemies than the harmful chemical pesticides that the Indian government is currently banning that have a high residual effect on the environment. Insect pest control on a wide scale may benefit greatly from the use of these more advanced pesticides in the coming years, protecting crops from production losses.

Acknowledgements. The authors extend their sincere thanks to the Head, Department of Entomology and Dean, College of Agriculture, Gwalior, Madhya Pradesh for providing the necessary facilities and encouragement for conducting the research work.

Conflict of Interest. None.

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How to cite this article: Sheojat, N.K.S. Bhadauria, Salil Dwivedi, Neeraj Kumar, Naveen and Amar Chand (2022). Efficacy and Economics of newer Insecticides for the Management of Brinjal Shoot and Fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae) in the Gwalior region of Madhya Pradesh. *Biological Forum – An International Journal, 14*(2): 149-154.