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Management of Fruit and Shoot Borer, *Leucinodes orbonalis* (Guenee) in Brinjal through Sequential Application of Selected Insecticides and Biorationals

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ABSTRACT

Leucinodes orbonalis Guenee (Lepidoptera: Crambidae), commonly known as brinjal shoot and fruit borer is a dreaded pest in India. The bio efficacy of insecticides and biorationals has been test verified in managing fruit and shoot borer through logical sequential schedules. The results of the present field experiment conducted during *Summer* 2023 in Agricultural and Horticultural research Station (AHRS), Bavikere revealed the most effective insecticidal schedule among the tested sequences. The sequence containing Chlorantraniliprole 18.5 SC @ 0.3 ml/L - Spinosad 45 SC @ 0.4 ml/L - Lufenuron 5 EC @ 1.0 ml/L - *Bacillus thuringiensis* var. kurstaki @ 2.0 g/L demonstrated remarkable success in reducing the damage caused by *L. orbonalis* along with economic viability and high cost-benefit ratio.

Keywords: Brinjal; Leucinodes; insecticides; damage; management.

1. INTRODUCTION

Brinjal (*Solanum melongena* Linn.) (2n =24) is the most popular vegetable which is also known as eggplant or aubergine or guinea squash, belongs to the nightshade family Solanaceae, and principally regarded as “King of the Vegetables”. It has high yielding potential and can be grown throughout the year under diverse agro climatic conditions, especially in tropical and sub-tropical environment. Brinjal has its centre of origin in the Indian sub-continent [1].

In India, brinjal is grown over an area of 0.743 million hectares of agricultural land, with a production of 12.77 million tonnes per year and productivity of nearly 17.17 MT/ha [2]. The major brinjal growing states in India are Bihar, Orissa, Karnataka, Andra Pradesh, Maharashtra, West Bengal, Uttar Pradesh and states with coordinating climatic conditions within the tropics and subtropics. In Karnataka, brinjal is being grown in an area of 1.58 lakh ha with a production of 402.5 MT (3.13% share) and a productivity of 25.4 MT/ha [3]. Brinjal has been recognized as an Ayurvedic medicine for managing diabetes. The brinjal is also valued for its diverse medicinal properties serving as a good appetizer, aphrodisiac, cardiac tonic, laxative and reliever of inflammation and found as an excellent remedy for liver related health issue [4].

Due to year-round availability of brinjal, the crop is affected by range of biotic and abiotic factors. Among thease factors, insect pests play a pivotal role for lowering the yield of brinjal by attacking the crop right from nursery stage till harvesting. Brinjal is attacked by almost 142 species of insect pests, four species of mites and nematodes in different parts of the world [5]. Several insect pests attack brinjal crop, of which aphid (*Aphis gossypii* Glover), whitefly (*Bemisia tabaci* Lind.), jassid (*Amrasca biguttula biguttula* Ishida), spotted leaf beetle (*Epilachna vigintioctopunctata* Fab.), brinjal shoot and fruit borer (BSFB) (*Leucinodes orbonalis* Guenee), brinjal leaf beetle (*Psylliodes bali* Jacoby) and leaf folder (*Eublemma oleracea* Walk.) are common pests [6].

Among these pests, brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guenée) (Lepidoptera: Crambidae) is one of the significant and destructive threats to the brinjal production. At early stage of the crop growth, adult female moth lays eggs mostly on lower side of the young leaves near the midrib occasionally or even on the tender shoots itself. Upon hatching, young larvae bore into the young leaves near midrib or tender shoot and close the opening with frass and feed within the shoot or midrib of the leaves. Drooping, wilting, or withering of shoots are the typical symptoms of shoot damage during early stage of crop growth. After fruit formation, larvae generally enter from underside of the calyx or bud or fruit. The entry hole is closed with frass. Infestation to the buds results in flower drop. The holes seen on the fruits are actually the exit holes of the larvae. Such infested fruits are partially unfit for human consumption and fetch less price in the market [7]. This pest damages brinjal crop with the yield loss up to 60-80 per cent or can even cause 100% damage if no control measures are taken [8].

The profitable cultivation of brinjal makes farmers inevitable to protect the crop from shoot and fruit borer damage using synthetic insecticides heavily. But the overuse or exclusive use of a single class of insecticide can lead to the development of insecticide resistance. This can lead reduced effectiveness of the insecticides leading to an increased use of the insecticide or need to switch to a more potent and often more toxic insecticide.

Given this scenario, sequential scheduling of insecticides plays an important role in delaying or completely preventing build-up of resistance to insecticides and offers effective management of brinjal shoot and fruit borer. Sequential scheduling of insecticides involves rotating different classes of insecticides over a period of time to reduce likelihood of resistance development and to improve control. Furthermore, different insecticides have varying modes of action, which means that they target various stages of the life cycle of the pest. It is, therefore, essential to evaluate few insecticidal schedules involving some new insecticidal compounds for effective control of this pest.

2. MATERIALS AND METHODS

The field experiment to evaluate the effective insecticidal schedule for the management of brinjal shoot and fruit borer in brinjal was conducted during summer 2023 at Agricultural and Horticultural Research Station (AHRS), Bavikere, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga. The experiment followed a randomized complete block design (RCBD) consisting of seven treatments including an untreated check and was replicated three times. The "Harsha" hybrid seed developed by Kalash Seeds Pvt. Ltd were sown in nursery beds during March 2023. The transplantation was carried out with thirty days old uniform healthy seedlings at a spacing of 90 cm × 60 cm in plots measuring 3.6 m × 3 m. The crop was raised by following the recommended agronomic practices except protection schedule against brinjal shoot and fruit borer. However, the plant protection measures were taken as and when necessary to check the sucking insects as well as foliage feeders.

In the present investigation, nine insecticides *viz.,* spinosad 45 SC (Tracer) @ 0.4 ml/L, chlorantraniliprole 18.5 SC (Coragen) @ 0.3 ml/L, azadirachtin 10,000 ppm (Agroneem) @ 2.0 ml/L, lufenuron 5 EC (Subject) @ 1.0 ml/L, emamectin benzoate 1.9 EC (Emma) @ 0.3 ml/L, abamectin 1.9 EC (Abacin) @ 0.1 ml/L, malathion 50 EC (Killers) @ 2.0 ml/L, *Bacillus thurengiensis* var. kurstaki (BARC *Bt*) @ 2.0 g/L and spinetoram 11.7 SC (Summit) @ 1.0 ml/L having different mode of action were imposed in six schedules along with untreated check against brinjal shoot and fruit borer (Table 1). The insecticides emamectin benzoate 1.9 EC and abamectin 1.9 EC were used in combination @ 0.4 ml/L. The insecticide spray solution was freshly prepared at the site of the experiment just before spraying. The required quantity of insecticide per plot was thoroughly mixed in a small quantity of water and then poured into the bucket containing the remaining quantity of water. The spray solution was thoroughly mixed before spraying and frequently stirred during the spray. A high-volume knapsack sprayer was used for spraying insecticides with a spray volume of 500 L/ha. In all the treatments, sequence of insecticides was sprayed at 15 days interval till harvest (@ 40, 55, 70 and 85 DAT) to find out the best sequence for managing the shoot and fruit borer. The influence of different insecticidal schedules on per cent shoot damage, per cent fruit damage and marketable yield was recorded, along with the calculation of cost benefit ratio.

Observations on per cent shoot damage by brinjal shoot and fruit borer was recorded from five randomly selected plants one day before the first spray and five days and ten days after each spray/treatment application. The observations were converted into per cent infestation and the mean per cent shoot infestation was calculated using the formula as suggested by Thakare et al., [8].

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

The observations on per cent fruit damage was calculated at each picking by taking the data on number of fruits attacked by *L. orbonalis* and total number of fruits per plot. The observations were subsequently transformed into percentage to determine the level of infestation. The mean per cent fruit infestation was calculated using the formula as suggested by Iesa [9]

$$\text{Per cent fruit infestation} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

The marketable yield was determined by aggregating the yield of healthy fruits obtained from each individual picking. Later, marketable plot yield was converted into kilogram per hectare using the formula as suggested by Sheojat et al. [10]

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

Finally, the yield (kg/ha) was converted to MT/ha. The cost benefit ratio was calculated by

Table 1. Schedule of insecticides for *Leucinodes orbonalis* management

Treatment	Schedule of insecticides			
	40 DAT*	**55 DAT**	**70 DAT**	**85 DAT**
T_1	Spinosad 45 SC	*Bacillus thurengiensis* var. kurstaki	Emamectin benzoate + abamectin 1.9 EC	Azadirachtin 10,000 ppm
T_2	Chlorantraniliprole 18.5 SC	Spinosad 45 SC	Lufenuron 5 EC	*Bacillus thurengiensis* var. kurstaki
T_3	Azadirachtin 10,000 ppm	Lufenuron 5 EC	Chlorantraniliprole 18.5 SC	Spinetoram 11.7 SC
T_4	Lufenuron 5 EC	*Bacillus thurengiensis var*. kurstaki	Azadirachtin 10,000 ppm	Spinosad 45 SC
T_5	Emamectin benzoate + abamectin 1.9 EC	Spinetoram 11.7 SC	Chlorantraniliprole 18.5 SC	Lufenuron 5 EC
T_6 *(RPP)	Malathion 50 EC	Chlorantraniliprole 18.5 SC	Malathion 50 EC	Chlorantraniliprole 18.5 SC
T_7	Untreated Check			

**RPP- Recommended Package of Practise, DAT- Days After Transplanting*

considering the cost incurred in plant protection under various treatments, cost of production and the prevailing market price of brinjal. Cost effectiveness of each treatment was assessed based on net returns. The total cost of production includes both cultivation expenses and plant protection charges.

Gross return= Marketable yield × Market price

Net return= Gross return – Total cost of cultivation

$$\text{Cost benefit ratio} = \frac{\text{Gross return}}{\text{Cost of cultivation}}$$

The data pertaining to shoot and fruit infestation underwent an arc sine transformation before statistical analysis. The yield data was analysed directly. The collected field experiments data underwent analysis of variance (ANOVA) and F-test as per requirement of RCBD. The means have been separated and compared through CD and DMRT as per Gomez and Gomez [11].

The data recorded during the course of investigation, were also analysed with the help of computer software “OPSTAT” developed by Sheoran [12].

3. RESULTS AND DISCUSSION

The pooled analysis of data reveals that all insecticidal schedules were effective over the untreated check in reducing both shoot damage (Table 2) and fruit damage (Table 3), as well as in increasing marketable yield (Table 4) and providing a better return on investment (Table 5). The shoot infestation recorded on the day before spraying (DBS) did not differ significantly across treatments, indicating uniform pest incidence (13.16 to 14.73 %). The pooled analysis data of four sprays in six schedules during summer 2023 revealed that, the shoot damage remained persistent throughout the season, but there was a significant difference amongst sequences. The schedule (T1) having Spinosad 45 SC @ 0.4ml/L- *Bacillus thurengiensis* var. *kurstaki* @ 2.0 g/L- emamectin benzoate + abamectin 1.9 EC @ 0.4ml/L- azadirachtin 10,000ppm @ 2ml/L was found to be quite promising by limiting damage to 9.95 per cent only. The next best sequences were (T2) chlorantraniliprole 18.5 SC @ 0.3ml/L - spinosad 45 SC @ 0.4ml/L- lufenuron 5 EC @ 1.0ml/L- *Bacillus thurengiensis* var. *kurstaki* @ 2.0 g/L (10.96 %) and (T3) azadirachtin 10,000ppm @ 2ml/L- lufenuron 5 EC @ 1.0ml/L- chlorantraniliprole 18.5 SC @ 0.3ml/L- spinetoram 11.7 SC @ 1.0 ml/L (11.58 %) which were at par with each other, followed (T5) emamectin benzoate + abamectin 1.9 EC @ 0.4ml/L- spinetoram 11.7 SC @ 1.0 ml/L- chlorantraniliprole 18.5 SC @ 0.3ml/L- lufenuron 5 EC @ 1.0 ml/L (13.57 %), (T4) lufenuron 5 EC @ 1.0ml/L- *Bacillus thurengiensis* var. *kurstaki* @ 2.0 g/L- azadirachtin 10,000ppm @2ml/L- spinosad 45 SC @ 0.4ml/L (13.63%) and (T6) malathion 50 EC @ 2ml/L- chlorantraniliprole 18.5 SC @ 0.3ml/L-malathion 50 EC @ 2ml/L- chlorantraniliprole 18.5 @ 0.3ml/L (14.85%) which were at par with each other, whereas the highest shoot damage was recorded in the untreated check (19.98%).

Similarly, the fruit damage got to decline with the advancement of the season. Sequential application of (T2) chlorantraniliprole 18.5 SC @ 0.3ml/L - spinosad 45 SC @ 0.4ml/L- lufenuron 5 EC @ 1.0ml/L- *Bacillus thurengiensis* var. *kurstaki* @ 2.0 g/L was found to be quite promising by limiting the damage to 29.51 per cent damage and the treatment was at par with T1(30.86%) and T3 (36.08%). The highest fruit damage was recorded in the untreated check (56.36%).

Table 2. Mean per cent shoot damage by *Leucinodes orbonalis*as influenced by different protection regimes

Treatments (Schedules)	Mean shoot damage (%)									
		40 DAT*		55 DAT		70 DAT		85 DAT		Pooled mean (%)
	DBS*	5 DAS*	10 DAS	5 DAS	10 DAS	5 DAS	10 DAS	5 DAS	10 DAS	
T_1	13.16 (21.26)[a]	7.63 (16.00)[d]	11.22 (19.54)[e]	10.66 (19.04)[c]	11.36 (19.66)[d]	10.34 (18.75)[c]	8.78 (17.21)[b]	10.16 (18.56)[b]	9.45 (17.87)[bc]	9.95(18.38)[d]
T_2	13.18 (21.26)[a]	8.34 (16.76)[d]	13.91 (21.87)[de]	12.89 (21.02)[c]	14.52 (22.38)[c]	11.29 (19.63)[bc]	8.54 (16.96)[b]	9.95 (18.34)[b]	8.24 (16.67)[c]	10.96 (19.33)[cd]
T_3	13.41 (21.42)[a]	9.20 (17.61)[cd]	15.57 (23.22)[cd]	12.97 (21.08)[c]	14.57 (22.43)[c]	11.64 (19.93)[bc]	9.85 (18.29)[b]	8.75 (17.18)[b]	10.12(18.45)[bc]	11.58 (19.90)[c]
T_4	13.87 (21.84)[a]	11.45 (19.77)[bc]	19.00 (25.81)[bc]	16.73 (24.14)[b]	16.31 (23.81)[bc]	13.84 (21.84)[b]	10.88 (19.25)[b]	10.73 (19.08)[b]	10.16(18.57)[bc]	13.63 (21.67)[b]
T_5	13.18 (21.28)[a]	10.31 (19.15)[bc]	17.57 (24.77)[bcd]	16.92 (24.27)[b]	18.37 (25.37)[b]	14.46 (22.33)[b]	9.48 (17.9)[b]	9.50 (17.93)[b]	12.02 (20.25)[b]	13.57 (21.59)[b]
T_6	14.73 (22.57)[a]	13.46 (21.51)[b]	21.32 (27.49)[b]	17.34 (24.61)[b]	18.86 (25.74)[b]	14.77 (22.58)[b]	11.09 (19.43)[b]	11.56 (19.85)[b]	10.41(18.78)[bc]	14.85 (22.67)[b]
T_7	14.26 (22.18)[a]	17.33 (24.59)[a]	28.53 (32.27)[a]	21.82 (27.84)[a]	22.32 (28.19)[a]	21.35 (27.49)[a]	16.64 (24.04)[a]	15.42 (23.05)[a]	16.47 (22.57)[a]	19.98 (26.55)[a]
S.Em(±)	0.84	0.73	1.02	0.78	0.76	0.88	0.84	0.93	0.75	0.40
C.D. @ 5%	NS*	2.27	3.14	2.43	2.34	2.73	2.59	2.87	2.31	1.25
CV(%)	10.63	11.43	9.72	8.74	7.94	11.03	13.56	14.86	12.13	5.20

**DAT- Days After Transplanting, *DBS- Day Before Spraying, *DAS- Days After Spraying, *NS- Non-Significant, Figs. in parentheses are arc sine transformed values. Means followed by the same letter do not differ significantly by DMRT (P=0.05)*

Table 3. Influence of various protection regimes on mean percentage of fruit damage caused by *Leucinodes orbonalis*

Treatments (Schedules)	Mean fruit damage (%)				Pooled mean (%)
	First picking	Second picking	Third picking	Fourth picking	
T_1	38.40 (38.28)[cd]	34.47 (35.93)[d]	24.20 (29.44)[d]	26.37 (30.88)[de]	30.86 (33.74)[c]
T_2	33.29 (35.21)[d]	37.78 (37.91)[d]	31.22 (33.95)[d]	15.74 (23.24)[f]	29.51 (32.90)[c]
T_3	41.63 (40.18)[cd]	44.28 (41.71)[cd]	35.31 (36.44)[cd]	23.11 (28.69)[ef]	36.08 (36.91)[c]
T_4	55.75 (48.31)[b]	50.82 (45.47)[bc]	45.23 (42.26)[abc]	34.81 (36.15)[cd]	46.65 (43.08)[b]
T_5	47.64 (43.64)[bc]	57.74 (49.45)[ab]	42.93 (40.93)[bc]	40.66 (39.61)[bc]	47.24 (43.42)[b]
T_6	56.49 (48.73)[b]	59.10 (50.26)[ab]	47.88 (43.78)[ab]	48.11 (43.91)[b]	52.89 (46.66)[b]
T_7	61.83 (52.08)[a]	59.19 (51.3)[a]	51.14 (45.54)[a]	53.31 (47.37)[a]	56.36 (49.72)[a]
S.Em(±)	1.74	2.13	2.05	2.00	1.54
C.D. @ 5%	5.39	6.59	6.34	6.17	4.75
CV(%)	6.20	7.34	8.82	9.79	6.05

Figs. in parentheses are arc sine transformed values. Means followed by the same letter do not differ significantly by DMRT (P=0.05)

Table 4. Influence of different protection regimes on the marketable fruit yield of brinjal

Treatments (Schedules)	Marketable yield (MT/ha)				Pooled yield (MT/ha)
	First picking	Second picking	Third picking	Fourth picking	
T_1	22.92[a]	23.19[a]	24.65[a]	23.56[c]	23.55[ab]
T_2	24.30[a]	22.07[ab]	23.19[ab]	29.85[a]	24.85[a]
T_3	22.81[a]	18.02[c]	21.70[b]	27.63[b]	22.54[b]
T_4	16.88[c]	20.20[b]	17.02[cd]	20.21[d]	18.36[c]
T_5	20.96[b]	16.15[c]	18.74[c]	19.11[d]	18.74[c]
T_6	19.85[b]	17.26[c]	16.15[d]	14.30[e]	16.89[c]
T_7	4.37[d]	11.20[d]	7.44[e]	8.19[f]	7.30[d]
S.Em(±)	0.67	1.39	1.07	1.53	1.31
C.D. @ 5%	2.07	4.28	3.29	4.71	3.89
CV(%)	5.42	11.82	8.66	11.43	12.14

Means followed by the same letter do not differ significantly by DMRT (P= 0.05)

Table 5. Cost benefit ratio evaluation of different protection regimes tested against *Leucinodes orbonalis*

Treatments (Schedules)	Parameters						
	Marketable yield (MT/ha)	Gross returns *(₹/ha)	Inputs and other expenditure (₹/ha)	Plant protection cost (₹/ha)	Total cost of cultivation (₹/ha)	Net returns (₹/ha)	C:B ratio
T_1	23.55	588750	95252	24275	119527	469223	1: 4.93
T_2	24.85	621250	95252	27375	122627	498623	1: 5.07
T_3	22.54	563500	95252	27489	122741	440759	1: 4.59
T_4	18.36	459000	95252	25600	120852	338148	1: 3.80
T_5	18.74	468500	95252	26964	122216	346284	1: 3.83
T_6	16.89	422250	95252	26750	122002	300248	1: 3.46
T_7	7.3	182500	95252	-	95252	109917	1: 1.91

**Cost of marketable fruits - ₹ 25/kg, Cost of labour – ₹ 280/ person*

Cost of chemicals (₹): Lufenuron 5 EC (250 ml) – 900, Spinetoram 11.7 SC (20 ml) – 298, Malathion 50 EC (500 ml) – 300, Spinosad 45 SC (75 ml) – 2065,Emamectin benzoate 1.9 EC (100 ml) – 256, Abamectin 1.9 EC (50 ml) – 350, Btkurstaki(50 g) – 150, Azadirachtin 1000 ppm (100 ml) - 450, Chlorantraniliprole 18.5 SC (60

Ultimately, six different schedules of insecticides /biorationals could render better marketable yield with the advancement of the season. In fact, all insecticides in different logical sequences proved effective in minimising the fruit damage, resulting in increased marketable fruit yield. The sequence (T2) chlorantraniliprole 18.5 SC @0.3ml/L - spinosad 45 SC @ 0.4ml/L- lufenuron 5 EC @ 1.0ml/L- *Bacillus thurengiensis* var. *kurstaki* @2.0 g/L was found to be quite promising and recorded the highest marketable fruit yield of 24.85 MT/ha followed by T1 (23.55 MT/ha), T3 (18.74 MT/ha) and (T4) Lufenuron (16.89 MT/ha). On the contrary, the lowest marketable fruit yield was recorded in the untreated check (7.30 MT/ha). There was around 16.25 MT/ha (T1), 17.55 MT/ha (T2), 15.24 MT/ha (T3), 11.06 MT/ha (T4), 11.44 MT/ha (T5) and 9.59 MT/ha (T6) increase in yield as compared to control. The highest cost benefit ratio (5.07) was registered in sequence T2, followed by T1 (4.93), T3 (4.59), T5 (3.83), T4 (3.80), T6 (3.46), whereas the lowest cost benefit ratio was recorded in untreated check (1.93) (Table-5).This highlighted the significance of implementing the insecticidal schedules, particularly T2 and T1 to achieve greater economic return.

The present study demonstrated that the use of newer insecticides with novel mode of action along with biorationals proved highly effective against BSFB offering the potential for superior biological and economic yields. The effectiveness of chlorantraniliprole in minimizing borer damage aligned with the conclusions made by various researchers. Mishra [13] found that chlorantraniliprole @ 40 and 50 g/ha reduced approximately 95-97 per cent shoot damage, 87-90 per cent fruit damage. Similarly, Saha et al. [14] and Devi et al. [15] also observed the efficacy of Chlorantraniliprole against brinjal shoot and fruit borer. Studies made by by Sajjan and Rafee [16] also confirmed the synthetic chemical targeting the ryanodine receptor (chlorantraniliprole), as the most effective against the brinjal shoot and fruit borer.

Anoorag and Simon [17] observed the efficacy of spinosad against BSFB revealing mere 9.84 percent shoot infestation and 7.35 percent fruit infestation by weight. The treatment also resulted in a notable increase in yield of brinjal fruit, reaching 239.30 q/ha. Abdullah et al. [18] also noted that among the treatments, spinosad was the most effective in reducing shoot and fruit infestation. Furthermore, Tripura et al. [19] found that foliar application of *Bt* at 2 g/L of water resulted the lowest shoot and fruit infestation of brinjal along with the highest marketable yield. The results of efficacy of emamectin benzoate + abamectin and lufenuron align with Rahman et al. [20] who recorded the lowest shoot (6.71%) and fruit (11.58%) infestation from emamectin benzoate + abamectin 6WG treated plots @ 0.50 g/L that was followed by, lufenuron 5 EC @ 1.0 ml/L (6.89% shoot; 14.51% fruits). They observed a similar trend in case of marketable fruit yield as well. The effectiveness of azadirachtin is supported by the findings of Srinivasan and Sundarababu [21], who reported that neem-based insecticides were highly effective in reducing the incidence of brinjal shoot and fruit borer.

4. CONCLUSION

Based on the current findings, it was evident that the sequential application spinosad 45 SC @ 0.4ml/L - *Bacillus thuringiensis* var. *kurstaki* @ 2.0 g/L - emamectin benzoate + abamectin 1.9 EC @ 0.4ml/L - azadirachtin 10,000 ppm @ 2ml/L effectively reduce the shoot damage caused by BSFB and proving to be remunerative. Chlorantraniliprole 18.5 SC @ 0.3ml/L - spinosad

45 SC @ 0.4ml/L - lufenuron 5 EC @ 1.0 ml/L - *Bacillus thuringiensis* var.*kurstaki* @ 2.0 g/L also demonstrated promising result. This sequence also exhibited exceptional performance in minimizing fruit damage and maximizing marketable yield. This sequence not only proved effective in reducing the impact of *L. orbonalis* but also demonstrated a strong economic viability with a notably high Cost-Benefit ratio. This suggests that adopting sequence T2 can lead to significant improvements in both pest management and economic gain in brinjal cultivation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Omprakash S, Raju SVS. A brief review on abundance and management of major insect pests of brinjal (*Solanum melongena* L.). International journal of applied biology and pharmaceutical technology, 2014;5(1): 228-238.
2. Anonymous. Area, production and productivity of brinjal in Karnataka and India (2021-2022-1st advance estimates), Indiastat.com; 2022.
3. Anonymous. National Horticultural Mission; 2016.
4. Lalita S and Kashyap L. Biology and mechanisms of resistance to brinjal shoot and fruit borer: A review. Journal of Entomology and Zoology Studies, 2020;8(2):2111-2118.
5. Jat HK, Shrisvastva VK. Cost: Benefit analysis of newer insecticides used in control of brinjal shoot and fruit borer (*Leucinodes orbonalis*Guenee) at Gwalior region of Madhya Pradesh. Journal of pharmaceutical innovation. 2023;12(3): 3091-3093.
6. Patra S, Thakur NS and Firake DM. Evaluation of bio-pesticides and insecticides against brinjal shoot and fruit borer (*Leucinodes orbonalis*Guenee) in Meghalaya of North-Eastern India. International Journal of Bio-resource and Stress Management, 2016;7(5): 1032-1036.
7. Shigaonkar RS, Shinde BD, Shelke SB, Chopkar PS, Durge SM, Choudhari RJ. To screen some brinjal cultivars against shoot and fruit borer, *Leucinodes orbonalis*. Journal of Pharmaceutical Innovation, 2022;11(1):1337-1341.
8. Thakare VS, Undirwade DB, Kulkarni US, Ghawade SM. Screening of brinjal genotypes for resistant reaction against brinjal shoot and fruit borer (BSFB) *Leucinodes orbonalis*Guenee. Journal of Entomology and Zoology Studies. 2021;9(1):1653-1657.
9. Iesa MA, Biology of brinjal shoot and fruit borer (*Leucinodes orbonalis*Guenee) and screening of various genotypes for resistance. Turkish Online Journal of Qualitative Inquiry, 2021;12(6):6025- 6032.
10. Sheojat BNKS, Dwivedi S, Kumar N, Naveen CA. 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. 2022;14(2): 149-154.
11. Gomez KA and Gomez AA. Statistical Procedures for Agricultural Research. 2nd Edition, John Wiley and Sons Publishers, New York. 1984;680.
12. Sheoran OP, Tonk DS, Kaushik LS, Hasija RC, Pannu RS. Statistical Software Package for Agricultural Research Workers. Recent Advances in Information Theory, Statistics & Computer Applications by D.S. Hooda & R.C. Hasija Department of Mathematics Statistics, CCS HAU, Hisar, Haryana (India), 1998;8(12):39-143.
13. Mishra HP. Bio-efficacy of chlorantraniliprole against shoot and fruit borer of brinjal, *Leucinodes orbonalis*Guenee. Journal of Insect Science. 2011;24(1):60-64.
14. Saha T, Chandran N, Kumar R, Ray SN. Field efficacy of newer insecticides against brinjal shoot and fruit borer, *Leucinodes orbonalis*Guenee (Lepidoptera: Pyralidae) in Bihar. Pesticide Research Journal. 2014;26(1):63-67.
15. Devi LL, Ghule TM, Chatterje ML, Senapati AK. Effectiveness of biorational insecticides for the management of brinjal shoot and fruit borer, *Leucinodes orbonalis*Guenee and on yield. *Ecology,* Environment and Conservation. 2015; 21(2):783-788.
16. Sajjan AA, Rafee CM. Efficacy of insecticides against shoot and fruit borer, Leucinodes orbonalis (Guen.) in brinjal. Karnataka Journal of Agricultural Sciences. 2015;28(2):284-5.

17. Anoorag RT and Simon S. Efficacy of spinosad and neem products against shoot and fruit borer (*Leucinodes orbonalis* Guen.) of brinjal (*Solanum melongena* L.). Journal of biosciences, 2010;3:208-209.
18. Abdullah MD, Mamun AL, Islam KS, Jahan M, Das G. Effect of spinosad and sex pheromone alone and in combination against the infestation of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. International Journal of Biological Sciences. 2014;4(1):20-24.
19. Tripura A, Chatterjee, ML, Pande R, Patra S. Biorational management of brinjal shoot and fruit borer (*Leucinodes orbonalis*Guenee) in mid hills of Meghalaya. Journal of Entomology and Zoology Studies. 2017;5(4):41-45.
20. Rahman MW, Gopal D, Uddin MM. Field efficacy of some new insecticides against brinjal shoot and fruit borer, Leucinodes orbonalis (Guen.)(Lepidoptera: Pyralidae) and their toxic effects on natural enemies. Journal of the Bangladesh Agricultural University. 2019;17(3): 319-24.
21. Srinivasan G, Sundarababu PC. Management of brinjal shoot and fruit borer *Leucinodes orbonalis* Guencee (*Lepidoptera: Pyralidae*) using neem products and insecticides. In: Proceedings of First National Symposium on Pest Management in Horticultural Crop. IIHR, Bangalore. 1998;1997:87–93.

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