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Evaluation of Various Pest Management Practices against Shoot and Fruit Borer *Leucinodes orbonalis* Guenee (Lepidoptera: Crambidae) in Brinjal *Solanum melongena* L.

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ABSTRACT

The experiments were conducted over two consecutive years: from October 30, 2020, to March 30, 2021 (Experiment I), and from December 27, 2021, to May 9, 2022 (Experiment II) at the Regional Research and Technology Transfer Station, Bhawanipatna, Odisha, India. This study aimed to evaluate eight different pest management strategies, comprising of insecticides, Carbofuran 3G, Flubendiamide 39.35SC, Chlorantraniliprole 18.5SC, Emamectin Benzoate 5%SG, *Bacillus thuringiensis,* Azadirachtin 0.15% EC, Spinosad 45% SG, and Neem cake, against *L. orbonalis* Among the tested strategies, spraying of Chlorantraniliprole 18.5 SC at 60 g a.i. ha^{-1} on the 30th, 45th, and 60th days after transplanting (DAT) (T_3) was the most effective. It resulted in the highest number of healthy fruits (57.6 fruits plot^{-1}), the lowest number of infested fruits (18.7 fruits plot^{-1}), and the lowest total weight of infested produce (7.6 kg plot^{-1}). The percentage of fruit infestation plot^{-1} on a weight basis (11.8%) was the lowest, and the percentage reduction of fruit infestation plot^{-1} on a weight basis (43.3%) was the highest in this practice. The yield (288.0 q ha^{-1}) and percentage of higher yield of *S. melongena* over the control (27.2%) were the highest in this practice. The benefit-cost ratio (1.7) was the highest in T_3. Thus, spraying of Chlorantraniliprole 18.5 SC at 60 g a.i. ha^{-1} on the 30th, 45th, and 60th DAT serves as the best practice and could be recommended for managing *L. orbonalis* in *S. melongena*.

KEYWORDS: Azadirachtin, *Bacillus thuringiensis* (*Bt*), chlorantraniliprole, economics, flubendiamide

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1. INTRODUCTION

Brinjal, *Solanum melongena* L., is a commercially cultivated vegetable of the family Solanaceae, commonly known as the poor man's vegetable (Tripathy et al., 2020). It is grown on an area of nearly 160,000 acres and produces approximately 50 mt of vegetables year^{-1}, globally (Islam et al., 2019). Among vegetables, *S. melongena* accounts for more than 8.14% of the cultivated area and 9% of the total output in India. Many *S. melongena* cultivars exhibit variations in their susceptibility to different pests and diseases (Singh et al., 2023b). The reduction in productivity of *S. melongena* is significantly affected by several insect pests and pathogens. Among various insect pests affecting the *S. melongena* crop, the shoot and fruit borer, *Leucinodes orbonalis* (Lepidoptera: Crambidae), is a major bottleneck in the production and productivity of this crop. The young larvae of *L. orbonalis* bore into the veins, midribs, and petioles of younger leaves and tender shoots, resulting in a typical drooping symptom. The larvae also attack the fruits, making their entry under the young calyx, leaving no visible signs of infestation. The larger holes seen on fruits are usually the exit holes of the larvae (Rajavel et al., 2011). The *L. orbonalis* is the most infectious and endemic pest of *S. melongena* found to infest the shoots and fruits throughout the year (Kar et al., 2020; Chen et al., 2021; Singh et al., 2023a). The loss due to *L. orbonalis* ranged from 20% to 90% in India (Shigaonkar et al., 2022). An effective management method against *L. orbonalis* in *S. melongena* is urgently needed to produce high-quality vegetables (Sahoo and Tripathy, 2020). Numerous new-generation pesticides have been evaluated for their effectiveness against *L. orbonalis* and have shown promising results. Nevertheless, to effectively address issues such as resistance development, residue accumulation, and pest resurgence, there is a pressing need to develop and utilize new chemicals with different mechanisms of action. For instance, Carbofuran functions as an irreversible inhibitor of the enzyme acetylcholinesterase (AChE), leading to pest mortality through endocrine disruption (Moreira et al., 2022). Additionally, insecticides such as Chlorantraniliprole, Spinosad, Emamectin benzoate, and Flubendiamide have proven effective against *L. orbonalis*, with residue levels falling below detectable limits (Rajavel et al., 2011; Mondal, 2024). Chlorantraniliprole specifically targets the ryanodine receptor, causing uncontrolled release of calcium from internal stores. This depletion of calcium causes paralysis and ultimately results in the insect's death. (Paramasivam, 2021). Spinosad exerts its insecticidal action by acting as an allosteric agonist of acetylcholine receptors, binding to nicotinic acetylcholine receptors (nAChRs) (Salgado and Sparks, 2005). Emamectin benzoate kills insects by blocking glutamate-gated chloride channels, disrupting nerve function (Pitterna, 2012). Flubendiamide binds to the insect's ryanodine receptors, the calcium channels mediating calcium release from intracellular stores in neuromuscular tissue, which results in death of insects by muscle contraction (Lummen, 2013). In addition to synthetic options, microbial pesticides and neem-based formulations are highly effective against a wide range of insect pests, offering the benefit of minimal residual effects on the environment (Jena et al., 2022a, b). Although some new generation insecticides have been found effective against *L. orbonalis* (Rajavel et al., 2011; Singh et al., 2023a), there is a lack of information on the effectiveness and economic feasibility of various formulations against *L. orbonalis* in the Western undulating zone of Odisha. To address this gap, this study was conducted to evaluate various combined management practices and identify a suitable management practice for *L. orbonalis* in the *S. melongena* crop in the western undulating zone of Odisha.

2. MATERIALS AND METHODS

2.1. Experimental site, details, materials, and procedure

The experiments were conducted sequentially over two consecutive years: from October 30, 2020, to March 30, 2021 (Experiment I), and from December 27, 2021, to May 9, 2022 (Experiment II), at the Regional Research and Technology Transfer Station, Bhawanipatna, Kalahandi, Odisha, India, under the western undulating zone of Odisha located at 19.92 °N lat and 83.15 °E long with an altitude of 237.12 m above mean sea level. An annual rainfall of 1330.5 mm was received in the area during both years of the experiments. The mean maximum and minimum temperatures were 39.9°C and 11.5°C, respectively.

Eight pest management practices against *L. orbonalis* were tested thrice in a randomized block design. In each experiment (Experiment I or II), a total of twenty-seven plots of 20 m^2 area, measuring 5 m length and 4 m width, were prepared, and plants were planted with a row-to-row spacing of 50 cm and plant-to-plant spacing of 50 cm in each plot. The total number of plants in each plot was 80. The total area of the experiment was 550 m^2. The pest management practices include,

T_1: Basal application of Carbofuran 3 G (Furadan) at 10 kg ha^{-1}+Need-based spraying of Cartap hydrochloride 50 SP at 1 g l^{-1} (Farmer's Practices); T_2: Spraying of Flubendiamide 39.35 SC (Fame) at 60 g a.i. ha^{-1} at 30, 45, and 60 Days After Transplanting (DAT); T_3: Spraying of Chlorantraniliprole 18.5 SC (Coragen) at 60 g a.i. ha^{-1} at 30, 45, and 60 DAT; T_4: Spraying of Emamectin Benzoate 5 SG (Track) at 10 g a.i. ha^{-1} at 30, 45, and 60 DAT; T_5: Spraying of *Bacillus thuringiensis* (*Bt*) (Dipel) 5% WP at 2 g l^{-1} at 30, 45, and 60 DAT; T_6: Spraying of Azadirachtin 0.15% EC (Totonem) at 3 ml l^{-1} at 30, 45, and 60 DAT; T_7: Spraying of Spinosad

45% SC (Tracer) at 75 g a.i. ha^{-1} at 30, 45, and 60 DAT; T_8: Basal application of Neem cake at 250 kg ha^{-1}+Spraying of Azadirachtin 0.15% EC (Totonem) at 3 ml l^{-1} at 30, 45, and 60 DAT, and K: Untreated (Control).

Solanum melongena seeds of the variety Utkal Keshari (BB-26) were treated with Carbendazim 50% WP (Bavistin) at 5 g kg^{-1} of seeds before sowing. The variety used for the study was released by the All India Coordinated Research Project (AICRP) on Vegetable Crops operating at the Odisha University of Agriculture and Technology in Bhubaneswar, Odisha, India, and was widely grown throughout the state. The treated seeds were sown on 30th October 2020 (Experiment I) and 27th December 2021 (Experiment II) on well-drained, pulverized, raised beds (1.5 m in length×0.5 m in width×0.15 m in height) under open-field nursery conditions for raising seedlings. Then, the seeds were covered with a finely sieved layer of farmyard manure (FYM) and mulched with paddy straw mulching to ensure optimum moisture content and soil temperature, protect seeds from ants and birds, and facilitate germination. To protect the seedbeds from termites, chlorpyrifos 20% EC (Dursban) at 2 ml l^{-1} was sprayed into the seedbeds and watered with rose cane. The emerging shoot tips became visible on the mulched materials after five to seven days after sowing. The paddy straw mulching, along with the unwanted plants, was then removed with extreme caution without causing any physical damage to seedlings. To protect the seedlings from the fungal infection, Carbendazim 12% WP+Mancozeb 63% WP (SAAF) at 2 g l^{-1} of water was applied. The seedlings were then allowed to grow in the nursery stage with essential plant protection measures implemented as and when needed. Simultaneously, the field was thoroughly prepared with the help of a cultivator, followed by a rotavator to achieve fine tillage. Farmyard manure (FYM) at 10 t ha^{-1} was used as an organic source of nutrients, whereas 125:75:125 kg of N, P_2O_5, and K_2O per hectare was used from urea, diammonium phosphate (DAP), and muriate of potash (MOP) as inorganic sources of nutrients. The full dose of FYM and half of these inorganic nutrients were applied at the time of planting as a basal dose. The rest of these nutrients were applied in two split doses at 30 and 45 DAT. Forty-five days old seedlings were lightly watered, carefully uprooted to protect their root systems and treated with Carbendazim 50% WP at 2 g l^{-1} (Bavistin) solution, and then transplanted to the main field on 17th December 2020 (Experiment I) and 3rd February 2022 (Experiment II) with a spacing of 50×50 cm^2 on a suitable bed of 20 m^2 area (5 m length×4 m width). The seedlings were watered using a rose cane immediately after transplanting. All other cultural operations were followed uniformly to acquire a healthy crop production. The last harvest of *S. melongena* crops was performed on 30th March 2021 (Experiment I) and 9th May 2022 (Experiment II), respectively. After harvesting, the *S. melongena* fruits were sold in the local market, and the price of *S. melongena* fruits sold in rupees (₹) was recorded.

The data on the number of healthy shoots plot^{-1}, number of infested shoots plot^{-1}, number of healthy fruits plot^{-1}, number of infested fruits plot^{-1}, weight of healthy fruits plot^{-1}, weight of infested fruits plot^{-1}, total *S. melongena* yield (q ha^{-1}), and the total cost of brinjal fruits sold were recorded.

2.2. Data analysis

The data recorded on the number of healthy shoots plot^{-1}, number of infested shoots plot^{-1}, infested shoot percentage, number of healthy fruits plot^{-1}, number of infested fruits plot^{-1}, weight of healthy fruits plot^{-1}, weight of infested fruits plot^{-1}, fruit infestation percentage, yield, gross monetary returns, and net monetary returns were subjected to analysis of variance (ANOVA) using Microsoft Excel. Treatment means were compared using the Least Significant Difference (LSD) test at p=0.05 probability level as derived by Gomez and Gomez (1989).

The expenses of the inputs in rupees prevailed during the experimentation period were considered the cost of cultivation (₹ ha^{-1}). Net returns per hectare (₹ ha^{-1}) were calculated to deduct the cost of cultivation from gross return (₹ ha^{-1}). The benefit-cost ratio was estimated using the formula below,

Benefit-cost ratio=Gross returns(₹ ha^{-1})/Cost of cultivation (₹ ha^{-1})

The percentage of higher monetary return than farmers' practices was estimated.

3. RESULTS AND DISCUSSION

The findings of the present study revealed that all evaluated insecticides resulted in significantly higher numbers of healthy shoots plot^{-1} compared to the control (p<0.05) (Table 1). The highest number of healthy shoots plot^{-1} was observed in the plot treated with Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT (77.5 shoots plot^{-1}). It was at par with plots treated with Flubendiamide 39.35 SC at 60 g a.i. ha^{-1} at 30, 45, and 60 DAT and Emamectin Benzoate 5% SG at 10 g a.i. ha^{-1} at 30, 45, and 60 DAT with 76.5 and 75.8 shoots plot^{-1}, respectively. All evaluated insecticides resulted in significantly lower numbers of infested shoots per plot compared to the control (p<0.05) (Table 1). The number of infested shoots plot^{-1} was significantly lower in plots treated with Emamectin Benzoate 5% SG at 10 g a.i. ha^{-1} at 30, 45, and 60 DAT, Flubendiamide 39.35 SC at 60 g a.i. ha^{-1} at 30, 45, and 60 DAT, and Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT with 4.2, 3.5, and 2.5 shoots plot^{-1}, respectively, compared to others. All

Table 1: Effect of *Leucinodes orbonalis* management practices on percentage plant infestation (%) in *Solanum melongena*

Treatment	Pooled data over the years 2020–21 and 2021–22			
	No. of healthy shoots plot^{-1}	No. of infested shoots plot^{-1}	Infested shoot (%)	Reduction of shoot infestation (%)
Carbofuran 3 G at 10 kg ha^{-1}+Cartap hydrochloride 50 SP at 1 g l^{-1} (Farmers practice)	72.7^{d}	7.3^{b}	9.2^{b}	38.3
Flubendiamide 39.35 SC at 60 g a.i. ha^{-1} at 30, 45, and 60 DAT	76.5^{a}	3.5^{e}	4.4^{e}	71.2
Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT	77.5^{a}	2.5^{e}	3.1^{e}	79.3
Emamectin Benzoate 5% SG at 10 g a.i. ha^{-1} at 30, 45, and 60 DAT	75.8^{ab}	4.2^{de}	5.2^{de}	65.5
Bacillus thuringensis (*Bt*) 5% WP at 2 g l^{-1} at 30, 45, and 60 DAT	74.2^{bcd}	5.8^{bcd}	7.3^{bcd}	51.4
Azadirachtin 0.15% EC at 3 ml l^{-1} at 30, 45, and 60 DAT	73.3^{cd}	6.7^{bc}	8.3^{bc}	44.2
Spinosad 45% SG at 75g a.i. ha^{-1} at 30, 45, and 60 DAT	74.7^{bc}	5.3^{cd}	6.7^{cd}	55.7
Neemcake at 250 kg ha^{-1}+Azadirachtin 0.15% EC at 3 ml l^{-1} at 30, 45, and 60 DAT	74.0^{cd}	6.0^{bc}	7.5^{bc}	50.0
Control	68.2^{e}	11.8^{a}	14.8^{a}	0.0
SEm±	0.6	0.6	0.8	--
CD (p=0.05)	1.7	1.7	2.2	--

The values followed by the same letter did not differ significantly (p>0.05) between treatments based on the LSD test

evaluated insecticides had a significantly lower percentage of shoot infestation and a higher percentage reduction of shoot infestation than the control (p<0.05) (Table 1). The percentage of infested shoots was significantly lower in plots treated with Emamectin Benzoate 5% SG at 10 g a.i. ha^{-1} at 30, 45, and 60 DAT, Flubendiamide 39.35 SC at 60 g a.i. ha^{-1} at 30, 45, and 60 DAT, and Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT with 5.2%, 4.4%, and 3.1%, respectively, compared to plots treated with other insecticides. The reduction in shoot infestation was the highest in the plot treated with Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT (79.3%) compared to others (Table 1).

The present findings were similar to those of Kameshwaran and Kumar (2015), who showed that the lowest mean per cent shoot damage was recorded in the treatment with Chlorantraniliprole 20 SC at 40 g a.i. ha^{-1}, followed by Emamectin benzoate 25 WG at 11 g a.i. ha^{-1}, and was superior to the untreated check. Similarly, Reddy and Kumar (2022) showed that Chlorantraniliprole 18.5 SC at 0.4 ml l^{-1} recorded the lowest shoot infestation, and it was followed by Flubendiamide 20 WG at 0.75 g l^{-1}, Emamectin benzoate 5 SG at 0.5 g l^{-1}, Spinosad 45% SC at 0.20 to 0.30 ml l^{-1}, and Azadirachtin 0.03% EC at 5 ml l^{-1}. The variations might be due to the different doses of insecticides and different ecological conditions in particular locations.

All evaluated insecticides have a significantly higher number and weight of healthy fruits than the control (K) (p<0.05) (Table 2). The highest number of healthy fruits plot^{-1} was observed in Emamectin Benzoate 5% SG at 10 g a.i. ha^{-1} at 30, 45, and 60 DAT treated plot (332.2 fruits plot^{-1}), closely followed by the plot treated with Flubendiamide 39.35 SC at 60 g a.i. ha^{-1} at 30, 45, and 60 DAT (324.0 fruits plot^{-1}), with no significant difference between them (Table 2). Conversely, the highest weight of healthy fruits (28.8 t ha^{-1}) was found in Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT treated plot. These findings align closely with Verma et al. (2021), who showed that the highest weight of healthy fruits plot^{-1} was observed in Emamectin benzoate 5 SG at 75 g a.i ha^{-1} treated plot, and it was followed by Spinosad 45 SL at 18 g a.i ha^{-1}, and NSKE (5%).

The plots treated with Flubendiamide 39.35 SC at 60 g a.i. ha^{-1} at 30, 45, and 60 DAT, Chlorantraniliprole 18.5

Table 2: Effect of *Leucinodes orbonalis* management practices on percentage fruit infestation (%) in *Solanum melongena*

Treatment	Pooled data over the years 2020–21 and 2021–22						
	Healthy fruits plot^{-1}		Infested fruits plot^{-1}		Infested fruits (%)		Reduction of fruit infestation (%)
	Number	Weight (t ha^{-1})	Number	Weight (t ha^{-1})	Number	Weight	
Carbofuran 3 G at 10 kg ha^{-1}+Cartap hydrochloride 50 SP at 1 g l^{-1} (Farmers practice)	315.2^{bc}	24.1^{e}	22.3^{ab}	4.4^{b}	6.6^{b}	15.6^{b}	24.6
Flubendiamide 39.35 SC at 60 g a.i. ha^{-1} at 30, 45, and 60 DAT	324.0^{ab}	27.2^{b}	19.8^{cd}	4.1^{bc}	5.8^{cde}	13.2^{cd}	36.3
Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT	310.8^{cd}	28.8^{a}	18.7^{d}	3.8^{c}	5.7^{de}	11.8^{d}	43.3
Emamectin Benzoate 5% SG at 10 g a.i. ha^{-1} at 30, 45, and 60 DAT	332.2^{a}	26.6^{bc}	19.8^{cd}	4.0^{bc}	5.6^{e}	13.2^{cd}	36.2
Bacillus thuringensis (*Bt*) 5% WP at 2 g l^{-1} at 30, 45, and 60 DAT	309.5^{cd}	25.5^{d}	21.7^{ab}	4.1^{bc}	6.5^{bc}	13.9^{c}	32.9
Azadirachtin 0.15% EC at 3 ml l^{-1} at 30, 45, and 60 DAT	295.2^{e}	25.2^{d}	22.0^{ab}	4.3^{b}	6.9^{b}	14.6^{bc}	29.2
Spinosad 45% SG at 75g a.i. ha^{-1} at 30, 45, and 60 DAT	301.0^{de}	25.9^{cd}	20.5^{bcd}	3.9^{bc}	6.4^{bcd}	13.4^{cd}	35.7
Neemcake at 250 kg ha^{-1}+Azadirachtin 0.15% EC at 3 ml l^{-1} at 30, 45, and 60 DAT	282.3^{f}	25.6^{d}	21.2^{abc}	4.0^{bc}	7.0^{b}	13.6^{c}	34.3
Control	263.7^{g}	22.7^{f}	23.0^{a}	5.9^{a}	8.0^{a}	20.7^{a}	0.0
SEm±	4.4	0.3	0.6	0.2	0.2	0.6	-
CD (p=0.05)	12.8	0.8	1.8	0.4	0.7	1.6	-

The values followed by the same letter did not differ significantly (p>0.05) between treatments based on the LSD test

SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT, Emamectin Benzoate 5% SG at 10 g a.i. ha^{-1} at 30, 45, and 60 DAT, and Spinosad 45% SG at 75g a.i. ha^{-1} at 30, 45, and 60 DAT had a significantly lower number of infested fruits per plot than the control (p<0.05), while plots treated with other insecticides did not differ significantly from the control (p>0.05). All tested insecticides had a significantly lower weight of infested fruits than the control (K) (p<0.05) (Table 2). The lowest number of infested fruits (18.7 fruits plot^{-1}) and the lowest weight of infested fruits (3.8 t ha^{-1}) were found in Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT treated plots. All tested insecticides have a significantly lower percentage of fruit infestation plot^{-1} than the control (p<0.05) (Table 2). The percentage of infested fruit plot^{-1} on a number basis was significantly lower in plots treated with Emamectin Benzoate 5% SG at 10 g a.i. ha^{-1} at 30, 45, and 60 DAT, Chlorantraniliprole 18.5 SC @ 30 g a.i. ha^{-1} at 30, 45, and 60 DAT, and Flubendiamide 39.35 SC at 60 g a.i. ha^{-1} at 30, 45, and 60 DAT with 5.6%, 5.7%, and 5.8%, respectively, compared to plots treated with other tested insecticides. On a weight basis, the lowest percentage of infested fruit per plot was found in Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT treated plot (11.8%), and it was at par with Flubendiamide 39.35 SC at 60 g a.i. ha^{-1} at 30, 45, and 60 DAT, Emamectin Benzoate 5% SG at 10 g a.i. ha^{-1} at 30, 45, and 60 DAT, and Spinosad 45% SG at 75 g a.i. ha^{-1} at 30, 45, and 60 DAT treated plots with 13.2%, 13.2%, and 13.4%, respectively (Table 2). The percentage reduction of fruit infestation plot^{-1} on a weight basis was the highest in Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT treated plot (43.3%) compared to plots treated with other insecticides (Table 2).

In the past, Verma et al. (2021) also revealed that the lowest infestation per plot was observed in Emamectin benzoate 5 SG at 75 g a.i. ha^{-1} treated plot, and it was followed by Spinosad 45 SL at 18 g a.i. ha^{-1}, and NSKE (5%). Moreover, Reddy and Kumar (2022) observed that Chlorantraniliprole 18.5 SC at 0.4 ml l^{-1} recorded the lowest fruit infestation, and it was followed by Flubendiamide 20 WG at 0.75 g l^{-1}, Emamectin benzoate 5 SG at 0.5 g l^{-1}, Spinosad 45% SC at 0.20 to 0.30 ml l^{-1}, and Azadirachtin 0.03% EC at 5 ml l^{-1}. The variations might be due to the different doses of insecticides, sources, and different ecological conditions in particular locations.

All tested insecticides resulted in significantly higher *S. melongena* yields and a higher percentage higher yield compared to the control ($p<0.05$) (Table 3). The *S. melongena* yield was significantly higher in Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT treated plot (288.0 q ha^{-1}) as compared to others. It was followed by plots treated with Flubendiamide 39.35 SC at 60 g a.i. ha^{-1} at 30, 45, and 60 DAT and Emamectin Benzoate 5% SG at 10 g a.i. ha^{-1} at 30, 45, and 60 DAT with 271.9 q ha^{-1} and 265.7 q ha^{-1} *S. melongena* yield. The highest percentage of higher yield of *S. melongena* over the control was found in Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT treated plot (27.2%) (Table 3). The present findings were supported by those of Kameshwaran and Kumar (2015), who showed that the highest yield was observed in the treatment with Chlorantraniliprole 20 SC at 40 g a.i. ha^{-1}, followed by Emamectin benzoate 25 WG at 11 g a.i. ha^{-1}, compared to the untreated check in the field experiments I and II, respectively. Similarly, Verma et al. (2021) showed that the highest marketable yield per plot was observed in Emamectin benzoate 5 SG at 75 g a.i. ha^{-1} treated plot, and it was followed by Spinosad 45 SL at 18 g a.i. ha^{-1}, and NSKE (5%).

The cost of cultivation was the highest in the plot treated with Neemcake at 250 kg ha^{-1}+Azadirachtin 0.15% EC at 3 ml l^{-1} at 30, 45, and 60 DAT (₹ 199,385 ha^{-1}). It was followed by plots treated with Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT, Flubendiamide 39.35 SC at 60 g a.i. ha^{-1} at 30, 45, and 60 DAT, and Carbofuran 3 G at 10 kg ha^{-1} mixed with Cartap hydrochloride 50 SP at 1 g l^{-1}, with ₹ 171,126 ha^{-1}, ₹ 170,213 ha^{-1}, and ₹ 169,240 ha^{-1}, respectively (Table 3). The gross monetary return and net monetary return were the highest (₹ 287,997 ha^{-1} and ₹ 116,871 ha^{-1}, respectively) in Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT treated plot compared to others. These findings were deviated from those of Kumari et al. (2023), who showed that the highest

Table 3: Effect of *Leucinodes orbonalis* management practices on fruit yield in *Solanum melongena* and their economics

Treatment	Pooled data over the years 2020–21 and 2021–22					
	Solanum melongena yield (t ha^{-1})	Percentage higher yield over control (%)	Cost of cultivation (₹ ha^{-1})	Gross monetary return (₹ ha^{-1})	Net monetary return (₹ ha^{-1})	B: C ratio
Carbofuran 3 G at 10 kg ha^{-1}+Cartap hydrochloride 50 SP at 1 g l^{-1} (Farmers practice)	24.110^{e}	6.3	169240	241097^{e}	71857^{d}	1.4
Flubendiamide 39.35 SC at 60 g a.i. ha^{-1} at 30, 45, and 60 DAT	27.190^{b}	19.7	170213	271862^{b}	101649^{b}	1.6
Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT	28.800^{a}	27.2	171126	287997^{a}	116871^{a}	1.7
Emamectin Benzoate 5% SG at 10 g a.i. ha^{-1} at 30, 45, and 60 DAT	26.570^{bc}	16.8	167335	265652^{bc}	98317^{b}	1.6
Bacillus thuringensis (*Bt*) 5% WP at 2 g l^{-1} at 30, 45, and 60 DAT	25.530^{d}	12.6	167725	255335^{d}	87610^{c}	1.5
Azadirachtin 0.15% EC at 3 ml l^{-1} at 30, 45, and 60 DAT	25.210^{d}	11.1	166885	252061^{d}	85176^{c}	1.5
Spinosad 45% SG at 75g a.i. ha^{-1} at 30, 45, and 60 DAT	25.910^{cd}	14.2	172246	259100^{cd}	86854^{c}	1.5
Neemcake at 250 kg ha^{-1}+Azadirachtin 0.15% EC at 3 ml l^{-1} at 30, 45, and 60 DAT	25.610^{d}	12.9	199385	256147^{d}	56762^{e}	1.3
Control	22.680^{f}	0.0	166075	226834^{f}	60759^{e}	1.4
SEm±	0.290	-	-	2854	2854	0.0
CD (p=0.05)	0.820	-	-	8222	8222	0.0

The values followed by the same letter did not differ significantly ($p>0.05$) based on the LSD test. B: C represents the Benefit: Cost ratio net profit was observed in the Flubendiamide 48 SC treated plot, and it was followed by Chlorantraniliprole 18.5 SC, Emamectin benzoate 5 SG, Azadirachtin 0.15% EC, and NSKE 5%. The variations might be due to the different doses of insecticides and different locations.

The benefit-cost ratio was the highest in Chlorantraniliprole 18.5 SC at 30 g a.i. ha^{-1} at 30, 45, and 60 DAT treated plot (1.7) (Table 3). However, this ratio in the plot treated with Neemcake at 250 kg ha^{-1} mixed with Azadirachtin 0.15% EC at 3 ml l^{-1} at 30, 45, and 60 DAT (1.3) was lower than the control (1.4). Kameshwaran and Kumar (2015) showed that the maximum benefit-cost ratio was observed in the treatment with Chlorantraniliprole 20 SC at 40 g a.i. ha^{-1}, followed by Emamectin benzoate 25 WG at 11 g a.i. ha^{-1}, compared to the untreated check in the field experiments I and II, respectively, which supports the present findings. Similarly, Verma et al. (2021) showed that the highest benefit-cost ratio was observed in Emamectin benzoate 5 SG at 75 g a.i. ha^{-1} treated plot, and it was followed by Spinosad 45 SL at 18 g a.i ha^{-1}, and NSKE (5%).

4. CONCLUSION

Among the tested insecticides, spraying of Chlorantraniliprole 18.5 SC at 60 g a.i. ha^{-1} at 30, 45, and 60 DAT resulted in the lowest weight of infested fruits, and the highest percentage reduction of fruit infestation $plot^{-1}$. The percentage of higher yield of *S. melongena* over the control and the benefit-cost ratio were the highest in this plot. Thus, it served as the best practice and could be recommended for the management of *L. orbonalis*.

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