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EFFICACY OF NEW CHEMISTRY INSECTICIDES AGAINST BRINJAL SHOOT AND FRUIT BORER (*LEUCINODES ORBONALIS*)

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ABSTRACT

Solanum melongena, or brinjal, a vital vegetable crop in Pakistan, faces significant damage from the primary pest, brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* , highlighting the urgent need for new chemistry insecticides. The present study investigated the impact of various insecticides on the infestation of BSFB). All insecticides demonstrated a significant reduction in infestation compared to the control, with varying levels of effectiveness. Emamectin benzoate and chlorantraniliprole emerged as the most effective, achieving a 13.33% infestation reduction at 15 days after spray (DAS). Lambda cyhalothrins exhibited similar infestation levels at 15 DAS but with a higher cumulative mean infestation of 13.33%. Imidacloprid and nitenpyram were the least effective, with infestation levels of 26.66% and 20.66% at 15 DAS, respectively. Intermediate efficacy was observed with other insecticides, with infestation levels ranging from 16.66% to 20.66% at 15 DAS. Following subsequent insecticide applications, a consistent reduction in infestation was observed for all treatments compared to the untreated control. Chlorantraniliprole demonstrated the highest efficacy, reducing infestation to 6.66% at 15 DAS, while imidacloprid exhibited the least effectiveness with infestation levels of 23.33% and 20% at 3 and 15 DAS, respectively. Emamectin benzoate remained the most efficacious insecticide in the third spray, achieving a notable reduction to 10% at 15 DAS. The study highlights the temporal decrease in infestation for most treatments over time, contrasting with the steady increase observed in the untreated control group. The findings emphasize the varying efficacy of insecticides in managing BSFB infestation and provide valuable insights for pest control strategies in brinjal cultivation.

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INTRODUCTION

Solanum melongena (Brinjal), a vital solanaceous vegetable crop, is also known as eggplant or aubergine. It is noteworthy that this vegetable originated in India and China but is now grown worldwide in all regions of the tropics and sub-tropics (Amiri et al., 2012; Kaushik et al., 2016). Brinjal is extensively cultivated in China, India, Pakistan, Bangladesh, the Middle East, Egypt, the Philippines, France, the U.S.A., Italy, and the Far East (GOP, 2010).

The global productivity of Brinjal is 51.23 million MT, with China being one of the largest producers at 32 million MT, followed by India at 12.55 million MT and Egypt at 1.19 million MT (Anonymous, 2020). According to Anonymous (2019), the total cultivated area for brinjal in the country is 8,427 hectares, yielding a total production of 84,255 tons annually. Javed et al. (2017) and Hassan et al. (2015) reported that the maximum productivity of the brinjal crop is recorded in the Punjab province, followed by Sindh and Balochistan provinces. In Pakistan, the brinjal output has been observed at approximately 97,466 kg per hectare (GOP, 2019).

Brinjal is generally considered a common vegetable for cooking in Pakistan due to its widespread availability at a low cost throughout the year. Brinjal serves as an excellent source of vitamins, minerals, proteins, nutrients, dietary fiber, antioxidants, and body-building factors (Obho et al., 2005). A 100 g brinjal fruit contains 0.7 mg iron, 12 mg calcium, 13 mg sodium, 5 mg ascorbic acid, 213 mg potassium (Nonnecke, 1989), 26 mg phosphorus, 0.5 vitamin A (International Units), and provides 25.0 calories (Tindall, 1978).

Approximately fifty-three species of insect pests, along with numerous other pathogens, have been identified as threats to brinjal crops on a global scale (Nayer et al., 1995; Aslam et al., 2019; Khan et al., 2019). Among them, twenty insect pests, including 1 mite pest and 19 insects, are presumed to cause significant damage (Hossain et al., 2016). The increase in temperature, both minimum and maximum, leads to a rise in the generation number, while a decrease in temperature extends the life cycle of insect pests. Consequently, the heightened variability in climatic conditions makes it challenging to effectively reduce the population of insect pests.

In Pakistan, some primary insect pests of brinjal include *Leucinodes orbonalis* (brinjal fruit borer, F: Pyralidae) (Javed et al., 2017a; Kassi et al., 2019; Muhammad et al., 2021a,b), *Euzophera perticella* (brinjal stem borer, F: Pyralidae) (Javed et al., 2017b), *Eublemma olivacea* (leaf roller, F: Noctuidae), *Epilachna vigintioctopunctata* (beetle, F: Coccinellidae), *Aphis gossypii* (aphid, F: Aphididae), *Bemisia tabaci* (Whitefly, F: Aleyrodidae), *Thrips palmi* (thrips, F: Thripidae) (Sirinavasan, 2009), and *Amrasca biguttula biguttula* (Cotton jassid, F: Cicadellidae) (Mahmood et al., 2002). Among them, the brinjal fruit borer and brinjal shoot borer are the most harmful pests, causing a reduction in the quality and quantity of brinjal fruits (Latif et al., 2010; Chakraborti and Sarkar, 2011).

The flowering, fruiting, inflorescencing, as well as vegetative stages of brinjal, are observed to be attacked by the brinjal borers (CABI, 2007). In germinating plants, larvae create holes in young soft shoots, leading to drooping, withering, and shoot drying. Subsequently, caterpillars bore into the buds of flowers and fruits, causing shedding, while the bored holes exhibit excreta (Patra et al., 2016). Consequently, damaged fruits become unsuitable for human use due to poor quality, resulting in a lower market value. The infestation of brinjal by the shoot and fruit borer may lead to productivity deficits of more than 90%, making BSFB the most harmful pest of the brinjal vegetable crop.

Farmers predominantly resort to chemical control for managing insect pests in brinjal cultivation (Aslam et al., 2004; Rahman et al., 2009; Saimandir and Gopal, 2012). To mitigate the impact of notorious pests, farmers often employ potent chemicals, increasing concentrations twice a week and consequently escalating cultivation expenses. This practice poses a significant risk to human health, as fresh brinjal reaching the market for consumption may contain residues of these potent chemicals. Beyond the health concerns, the regular use of the same insecticides leads to issues such as resistance development, outbreaks of secondary pests, pest resurgence challenges, and ecological disturbances, including the destruction of beneficial bio-agents. Some novel chemistry-based insecticide ingredients have shown greater efficacy at lower dosages and are considered safe for non-target organisms (Kameshwaran and Kumar, 2015; Pawar et al., 2016; Roy et al., 2016; Mukhtar et al., 2023; Shahbaz et al., 2023). Taking these considerations into account, the current project was initiated to assess the efficacy of selected insecticides against the brinjal borer (*L. orbonalis*) under field conditions.

MATERIALS AND METHODS

Experimental site

This trial was conducted at the agricultural field of Ghazi University, Dera Ghazi Khan, Air Port campus, with the primary objective of assessing the efficacy of new chemistry insecticidal treatments against brinjal shoot and fruit borer in Brinjal cultivation. Brinjal was sown during the kharif season of the year 2020-2021. Nursery beds were prepared for seedlings, and approximately 30-day-old seedlings were transplanted into the field plots. All recommended cultivation practices, including fertilizer application and irrigation, were followed for the cultivation of Brinjal.

Plot size

brinjal seedlings were planted in plots, each measuring 3.0 square meters. In all plots, the spacing between plants was 40 cm, and the spacing between rows was 60 cm.

Experimental design

The pattern of this trial was a Randomized Complete Block Design (RCBD). All treatments were replicated three times.

Insecticidal treatments

This field-based trial included nine treatments, excluding the control treatment (untreated). These nine treatments consisted of new insecticides belonging to various groups (Table 1).

Application of insecticides

Before applying the insecticides, the trial field was calibrated to measure the amount of water needed for each treatment. All plots, except the control plot, received three rounds of insecticide-based treatments sprayed on the brinjal crop during the growing season using a knapsack sprayer machine. The insecticides were applied at their recommended dosages. The first round of spraying was done one month after transplanting the brinjal seedlings into the plots, while the second and third rounds were done after 15 days intervals. The spraying was done in the evening to avoid insecticide drift.

Table 1: New chemistry insecticidal treatments tested for their effectiveness.

Treatments	Common Names	Trade Names	Dosage / Acre
T_1	Fipronil	Refree 5% SC	500 ml
T_2	Alphacypermathrin	Bestox 5 EC	250 ml
T_3	Emamectin benzoate	Proclaim 19 EC	200 ml
T_4	Chlorpyrifos	Lorsban 40 EC	1000 ml
T_5	Lambda Cyhalothrins	Karate 2.5 EC	330 ml
T_6	Lufenuron	Match 50 EC	200 ml
T_7	Imidacloprid	Confidor 200 SL	250 ml
T_8	Chlorantraniliprole	Coragen 20 SC	50 ml
T_9	Nitenpyram	Jasper 10 SL	200-250 ml
T_{10}	Control	-	-

Collection of data

In the case of scouting for brinjal borers, 10 plants were chosen irregularly (randomly) from each plot, and after observation, these plants were tagged. Pre-observation for brinjal fruit and shoot borer was conducted 24 hours before the application of insecticidal treatments. Post-observation for brinjal fruit and shoot borer was carried out on the 3rd, 6th, 9th, 12th, and 15th days after the spraying of all insecticidal treatments. Similarly, pre and post-observation for brinjal fruit borer were performed in the same manner as executed for the brinjal shoot borer. The obtained data were subjected to the given formula for calculating the shoot infestation percentage.

$$\text{Shoot Infestation \%} = \frac{Number\ of\ shoot\ infested}{Total\ number\ of\ observed\ shoot} \times 100$$

On the same way, fruit infestation percent was calculated by utilizing the under given formula.

$$\text{Fruit Infestation \%} = \frac{Number\ of\ fruit\ infested}{Total\ number\ of\ observed\ fruit} \times 100$$

Statistical analysis

The pre-observation (before spraying treatments) and post-observation (after spraying treatments) data were collected and subsequently subjected to one-way analysis of variance (ANOVA) using MSTAT software. The mean comparisons were then conducted using the LSD Test.

RESULTS

Shoot infestation (%) after first round of spray

All the insecticides reduced the infestation of brinjal shoot and fruit borer significantly compared to the control group, with varying degrees of effectiveness. The most effective insecticides were emamectin benzoate and chlorantranilliprole, which reduced the infestation to 13.33% at 15 DAS, followed by lambda cyhalothrins, which had the same infestation level at 15 DAS but a higher cumulative mean infestation of 13.33%. The least effective insecticides were imidacloprid and nitenpyram, which had infestation levels of 26.66% and 20.66% at 15 DAS, respectively. The other insecticides had intermediate levels of effectiveness, ranging from 16.66 to 20.66% infestation at 15 DAS (Table 1). The Table 1 also shows that the infestation decreased over time for most treatments, except for the control group, which increased steadily.

Shoot infestation (%) after second round of spray

After the second round of insecticide application, all insecticides significantly reduced the infestation of brinjal shoot and fruit borer compared to the untreated control, with varying degrees of efficacy. Chlorantranilliprole demonstrated the highest efficacy, reducing infestation to 6.66% at 15 DAS. Lambda cyhalothrins exhibited similar infestation levels at 15 DAS but had a higher cumulative mean infestation of 6%. Imidacloprid proved to be the least effective insecticide, with infestation levels of 23.33% and 20% at 3 and 15 DAS, respectively. The remaining insecticides exhibited intermediate levels of efficacy, with infestation levels ranging from 10% to 16.66% at 15 DAS. Notably, the infestation decreased over time for most treatments, except for the untreated control, where it increased steadily (Table 2).

Shoot infestation (%) after third application of spray

All tested insecticides caused a statistically significant reduction in infestation compared to the control group, exhibiting variable efficacy following the application of the third spray. Emamectin benzoate emerged as the most efficacious insecticide, achieving a notable reduction in infestation to 10% at 15 DAS. Chlorantranilliprole demonstrated comparable efficacy with an equivalent infestation level at 15 DAS, although with a slightly higher cumulative mean infestation of 9.33%. In contrast, imidacloprid displayed the least effectiveness, showing infestation levels of 23.33% and 20.66% at 3 and 15 DAS, respectively. Intermediary efficacy was observed with other insecticides, presenting infestation levels ranging from 10% to 16.66% at 15 DAS. Temporal analysis revealed a decreasing trend in infestation over time for the majority of treatments, except for the control group, which exhibited a steady increase in infestation (Table 3).

DISCUSSION

This trial-based investigation of novel chemistry insecticides against Leucinodes orbonalis revealed that new chemistry insecticidal treatments demonstrated highly significant results after 6, 9, 12, and 15 days of treatment spraying on the Brinjal crop. Among the new chemistry insecticidal treatments, chlorantranilliprole, emamectin benzoate, and lambda cyhalothrins exhibited superior outcomes in reducing shoot infestation by L. orbonalis after the first and second spray, and fruit infestation after the third spray. These findings align with those of Latif et al. (2010) who assessed the toxicity of nine insecticides (azadirachtin, chlorpyriphos, abamectin, cartap, thiodicarb, carbosulfan, flubendiamide, lambda-cyhalothrin, and cypermethrin) from various chemical groups against L. orbonalis in both laboratory and field conditions. The results revealed that chlorpyriphos and lambda-cyhalothrin reduced the incidence of brinjal shoot and fruit borers, leading to an increased yield rate compared to the untreated plot (control).

Our findings are supported by the study of Al-Mamun et al. (2014), who investigated the impact of various insecticidal treatments such as iImidacloprid (Impale 20SL), carbosulfan (Advantage 20 EC), and spinosad (Libsen 45 SC) on the infestation of eggplant borer (*L. orbonalis*). All the tested insecticidal treatments demonstrated potential to some extent in controlling borer infestation in the brinjal crop. However, spinosad exhibited superior efficacy with a decreased rate of infestation, followed by carbosulfan and imidacloprid. Similarly, in our present findings, imidacloprid showed lower potency against *L. orbonalis* infestation compared to the other applied treatments.

In the present study, fipronil treatment was observed to be the least effective after imidacloprid, with cumulative mean infestations of 20.66% and 15.33% after the first and second sprays for shoot infestation. In the case of fruit infestation during the third spray, the cumulative mean infestation was 15.33%. Sahu et al. (2018) evaluated the bio-efficacy of various insecticides, including thiodicarb at 0.75 kg a.i. per ha, cartap hydrochloride at 0.5 kg a.i. per ha, diflubenzuron at 0.1 kg a.i. per ha, carbofuran at 1.0 kg a.i. per ha, and triazophos at 0.5 kg a.i. per ha, as well as fipronil at 0.1 kg a.i. per ha, against *L. orbonalis*. The results indicated that thiodicarb performed well, reducing shoot (1.41%) and fruit (20.86%) infestations at 0.75 kg a.i. per ha. The application of new insecticides (fipronil + cartap hydrochloride + triazophos) resulted in the lowest shoot borer infestation (11.89%) and beetle damage. infestation to leaves (3.05%).

Table 1: Effectiveness insecticides against shoot infestation (%) by brinjal shoot and fruit borer after first round of spray.

Treatments	Before Spray	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS	Cumulative Mean Infestation
Fipronil	26.66 a	23.33 a	20.00 bc	16.66 bc	20 bc	23.33 bc	20.66 bc
Alphacypermethrin	30 a	26.66 a	20.00 bc	13.33 bcd	10 cd	16.66 cd	17.33 cd
Emamectin	23.33 a	20 a	13.33 c	6.66 d	10 cd	13.33 d	12.66 d
Chlorpyrifos	23.33 a	20 a	16.66 bc	10 cd	13.33 cd	20 bcd	16 cd
Lambda	30 a	23.33 a	16.66 bc	6.66 d	6.66 d	13.33 d	13.33 d
Lufenuron	26.66 a	23.33 a	20.00 bc	13.33 bcd	16.66 bcd	20 bcd	18.66 c
Imidacloprid	30 a	26.66 a	23.33 b	20 b	23.33 b	26.66 b	24 b
Chlorantranilliprole	26.66 a	20 a	13.33 c	6.66 d	10 cd	13.33 d	12.66 d
Nitenpyram	30 a	26.66 a	23.33 b	16.66 bc	16.66 bcd	20 bcd	20.66 bc
Control	26.66 a	30 a	36.66 a	40 a	46.66 a	50 a	40.66 a
LSD 0.05	10.79	10.38	7.88	7.95	8.98	7.60	4.78

Table 2: Effectiveness insecticides against shoot infestation (%) by brinjal shoot and fruit borer after second round of spray.

Treatments	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS	Cumulative Mean Infestation
Fipronil	20 bc	16.66 bc	10 bc	13.33 b	16.66 bc	15.33 bc
Alphacypermethrin	13.33 cde	10 cde	6.66 c	10 bc	13.33 bcd	10.66 de
Emamectin	10 de	6.66 de	6.66 c	3.33 c	10 cd	7.33 ef
Chlorpyrifos	16.66 bcd	10 cde	10 bc	13.33 b	16.66 bc	13.33 cd
Lambda	10 de	6.66 de	3.33 c	3.33 c	6.66 d	6 f
Lufenuron	13.33 cde	10 cde	6.66 c	10 bc	13.33 bcd	10.66 de
Imidacloprid	23.33 b	20 b	16.66 b	16.66 b	20 b	19.33 b
Chlorantranilliprole	6.66 e	3.33 e	3.33 c	3.33 c	6.66 d	4.66 f
Nitenpyram	16.66 bcd	13.33 bcd	10 bc	10 bc	13.33 bcd	12.66 cd
Control	53.33 a	56.66 a	60 a	66.66 a	70 a	61.33 a
LSD 0.05	8.67	8.01	7.81	8.15	7.45	4.19

The maximum reduction in shoot infestation percent was observed through the application of insecticidal-based treatments after the first and second sprays in the existing study. This finding aligns with that of Anwar et al. (2015) research on the effectiveness of various insecticides against brinjal fruit borer.

The tested insecticides included fenvalerate, profenofos, spinosad, chlorpyrifos, cypermethrin, and emamectin benzoate, which were compared with a control treatment. The results indicated that emamectin benzoate exhibited high potency against brinjal fruit borer, revealing a 40.1% infestation rate, followed by 40.4% for cypermethrin. Fenvalerate showed moderate management with a 41.31% infestation rate.

Table 3: Effectiveness insecticides against shoot infestation (%) by brinjal shoot and fruit borer after third round of spray.

Treatments	Before Spray	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS	Cumulative Mean Infestation
Fipronil	20 ab	16.66 ab	13.33 bc	13.33 bc	16.66 bc	16.66 bc	15.33 c
Alphacypermethrin	26.66 a	20 ab	16.66 bc	13.33 bc	10 cd	13.33 c	14.66 c
Emamectin Benzoate	16.66 b	13.33 b	10 c	6.66 bc	6.66 d	10 c	9.33 d
Chlorpyrifos	20 ab	16.66 ab	13.33 bc	13.33 bc	16.66 bc	16.66 bc	15.33 c
Lambda Cyhalothrins	20 ab	13.33 b	10 c	6.66 bc	10 cd	10 c	10 d
Lufenuron	23.33 ab	20 ab	16.66 bc	16.66 b	13.33 bcd	13.33 c	16 c
Imidacloprid	26.66 a	23.33 ab	20 b	16.66 b	20 b	23.33 b	20.66 b
Chlorantranilliprole	20 ab	16.66 ab	10 c	3.33 c	6.66 d	10 c	9.33 d
Nitenpyram	23.33 ab	16.66 ab	13.33 bc	10 bc	13.33 bcd	16.66 bc	14 cd
Control	20 ab	26.66 a	30 a	33.33 a	36.66 a	40 a	33.33 a
LSD 0.05	6.84	8.91	6.84	9.51	8.54	7.88	4.34

Yousafi et al. (2015) conducted a field trial testing various insecticidal treatments against brinjal fruit borer and suggested that, in the case of shoot attacks, flubendiamide and emamectin benzoate were effective in minimizing shoot damage. These findings supported the use of emamectin benzoate due to its potent influence against brinjal fruit borer.

The maximum reduction in shoot infestation percent was observed through the application of insecticidal-based treatments after the first and second sprays in the existing study. This finding aligns with that of Anwar et al. (2015) research on the effectiveness of various insecticides against brinjal fruit borer. The tested insecticides included fenvalerate, profenofos, spinosad, chlorpyrifos, cypermethrin, and emamectin benzoate, which were compared with a control treatment. The results indicated that emamectin benzoate exhibited high potency against brinjal fruit borer, revealing a 40.1% infestation rate, followed by 40.4% for cypermethrin. Fenvalerate showed moderate management with a 41.31% infestation rate. Yousafi et al. (2015) conducted a field trial testing various insecticidal treatments against brinjal fruit borer and suggested that, in the case of shoot attacks, flubendiamide and emamectin benzoate were effective in minimizing shoot damage. These findings supported the use of emamectin benzoate due to its potent influence against brinjal fruit borer.

In this investigation, emamectin benzoate significantly decreased brinjal borer attacks on shoots, with a cumulative mean infestation of 12.66% and 7.33% after the first and second sprays, respectively. In the case of fruit infestation, the cumulative mean infestation over five observations (3, 6, 9, 12, and 15 days after spray) was 9.33%. Islam et al. (2016) noted that the mixed formulation (buprofezin with emamectin benzoate) applied in fields exhibited better results, providing maximum protection to shoots (70.75%) and fruits (63.99%) with a maximum yield of sellable brinjal fruits at 9.94 tons per hectare.

The present findings are further supported by the investigation of Satyanarayana and Arunakumara (2017), wherein emamectin benzoate (5 WSG) demonstrated its potential by inducing minimal shoot infestation (0.31 ± 0.1%) after 7 days of application and (1.70 ± 0.2%) after 14 days of application. Regarding fruit damage, the first and second sprays of emamectin benzoate showed minimal damage (4.32 ± 0.21% and 11.09 ± 0.9%, 3.40 ± 1.1% and 10.96 ± 7.6%) after 7 and 14 days of application, respectively.

In terms of brinjal fruit productivity, emamectin benzoate exhibited a productivity rate of 38.50 tons per hectare, followed by flubendiamide with a productivity rate of 37.80 tons per hectare. Mane and Kumar (2019) reported that emamectin benzoate (25 WG) at the rate of 0.4 g per litre caused less fruit infestation (6.95%) with an increased productivity rate of 351.46 quintals per hectare, followed by spinosad (45 SC) at the rate of 0.5 ml per litre, which induced an 8.06% fruit infestation and 341.75 quintals per hectare in productivity.

Mainali et al. (2015) conducted an experiment to explore the potential of eight treatments (abamectin, spinosad, emamectin benzoate, tozen, karanjin, borer gourd (*Bacillus thuringiensis* var. *kurstaki* + *Metarhizium anisopliae* + *Verticillium lecanii* + *Beauveria bassiana*), chlorantraniliprole, and control) against *L. orbonalis*. The results revealed that both chlorantraniliprole and spinosad significantly reduced fruit damage percentages on both count and mass bases (6.57% and 6.31%) and (12.08% and 11.15%), respectively, in comparison to the remaining treatments. This finding aligns with existing research, wherein chlorantraniliprole significantly decreased brinjal borer infestation on both shoots and fruit, with a cumulative mean infestation of 12.66% after the first spray and 4.66% after the second spray. In the case of the third spray for fruit infestation percentage, the cumulative mean infestation was 9.33%. Similar outcomes were reported by Sen et al. (2017), who observed chlorantraniliprole (30 g a.i. per ha) as an effective treatment, resulting in 3.32% fruit and 3.76% shoot infestation. Lekha et al. (2018) observed chlorantraniliprole (40g a.i. per ha.) with the best results after tolfenpyrad application for shoot infestation reduction (17.9%, 15.8%, 18.2%, 19.5%) after the first and second applications, 7 days apart during 2016 (Rabi) and 2017 (Kharif), respectively.

Furthermore, our results are more or less consistent with those of Rahman et al. (2019), who stated that the minimum infestation rate was recorded by the application of emamectin benzoate + abamectin (shoot 6.71 percent and fruit 11.58 percent), followed by lufenuron (shoot 6.89 percent and fruit 14.51 percent), lambda-cyhalothrin (shoot 15.73 percent and fruit 16.45 percent), and flubendiamide (shoot 9.53 percent and fruit 25.47 percent). This statement was in accordance with the case of lufenuron but opposed to lambda-cyhalothrin because, in the present study, lufenuron demonstrated moderate effectiveness (cumulative mean infestation for shoot 18.66% after the first spray, 10.66% after the second spray, and 16% after the third spray for fruit infestation), while lambda-cyhalothrin induced significant results in both shoot and fruit infestations (13.33% cumulative mean infestation after the first spray, 6.00% after the second spray for shoot infestation, and 10.00% after the third spray for fruit infestation).

Singh and Sachan (2015) conducted a field trial-based investigation that encompassed both insecticidal and plant-based treatments. Their study concluded that the application of spinosad (45 SC) at a rate of 200 ml per ha was significantly effective in reducing borer population and infestation on brinjal shoots and fruits throughout all data collection periods. Following spinosad, the effectiveness of chlorpyrifos (at the rate of 1 L per ha) and neemarin (3 L per ha) was observed. This finding aligns with our own, as in our trial, chlorpyrifos exhibited a moderate impact against borer infestation, with a cumulative mean infestation of 16%, 13.33%, and 15.33% after the first spray for shoots, the second spray for shoots, and the third spray for fruit infestation. A study by Vinayaka et al. (2019) further supports our findings, indicating that chlorantraniliprole and emamectin benzoate treatments were significantly effective, while treatments involving *B. thuringiensis* and azadirachtin demonstrated the least efficacy against *L. orbonalis*. Additionally, treatments such as lambdacyhalothrin, pyriproxyfen + fenpropathrin, and spinosad were recorded as comparatively effective. Reddy and Kumar (2022) reported that for shoot attacks, chlorantraniliprole demonstrated potency with 7.87% infestation after the first spray, followed by 9.03% for flubendiamide and 11.84% for emamectin benzoate. Moderate effectiveness was observed with 12.83% for spinosad and 15% for cypermethrin, while 16.35% for lambda cyhalothrin and 20.69% for azadirachtin were recorded as least effective in managing the attack of *L. orbonalis*. Similarly, in our current findings, alphacypermethrin and nitenpyram treatments exhibited moderate effectiveness against both shoot and fruit infestations.

In the case of fruit attacks, chlorantraniliprole, flubendiamide, and emamectin benzoate were recorded as potent for pest control, with a percent attack of 8.30%, 9.69%, and 11.90%, respectively. Other treatments, such as spinosad and cypermethrin, demonstrated average effectiveness with a percent infestation of 13.91% and 16.55%, respectively.

CONCLUSION

It has been reported that the infestation of *Leucinodes orbonalis* (brinjal shoot and fruit borer) is significantly reduced by the application of newly developed insecticidal treatments. Among the tested insecticidal treatments, chlorantraniliprole and emamectin benzoate demonstrated a consistent decline in brinjal shoot and fruit infestation by *L. orbonalis* after 6 and 9 days of exposure. However, certain treatments including lufenuron, alphacypermethrin, chlorpyrifos, and nitenpyram, also yielded moderate results. On the other hand, fipronil and imidacloprid exhibited the least effectiveness against *L. orbonalis* infestation.

AUTHORS' CONTRIBUTION

MSN and MF conceptualized and designed the study; MF and SM conducted trials, collected and arranged data; AR and KS analyzed the data; MSN and MF wrote the manuscript; MSN supervised the work; AR proofread the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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