Improving an Integrated Pest Management Strategy for Brinjal Shoot and Fruit Borer (*Leucinodes Orbonalis*) Under Field Condition

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ABSTRACT: Eggplant (*Solanum melongena*) is a vital vegetable in South Asia and various other countries. The Brinjal Shoot and Fruit Borer is a significant pest that causes substantial losses to farmers, resulting in up to 80% damage to fruits. This study was conducted during the Rabi season of 2022 at a local farmer's field in Malam Jaba Swat. Five insecticides via Chlorpyrifos 20 EC (Dursban) at a rate of 1000 ml/ha, Chlorantraniliprole 20 SC (0.006%), Cypermethrin 25 EC at a rate of 250 ml/ha, Neem oil and Tobacco leaves extract were evaluated for their effectiveness against the shoot and fruit borer, *Leucinodes orbonalis*. The application of Chlorantraniliprole 20 SC resulted in the lowest percentages of shoot infestation (14.17%) and fruit infestation (10.42%), along with the highest yield (665.0 kg/ha^{-1}) and the maximum CBR (cost-benefit ratio) of 10.6. Cypermethrin 25 EC also showed promising results with shoot infestation at 14.76%, fruit infestation at 13.42%, yield at 611 kg/ha^{-1}, and CBR at 9.0. Chlorpyrifos 20 EC exhibited slightly less effectiveness with shoot infestation at 15.82%, fruit infestation at 14.74%, yield at 639.7 kg/ha^{-1}, and CBR at 9.3. Tobacco leaves extract at a concentration of 500g/l (15.78% shoot infestation, 15.36% fruit infestation, 628.7 kg/ha^{-1} yield, and CBR of 7.4) and Neem oil at a concentration of 100ml/l (17.03% shoot infestation, 15.70% fruit infestation, 591.7 kg/ha^{-1} yield, and CBR of 7.00) showed moderate effectiveness. The highest levels of shoot infestation (23.06%), fruit infestation (23.89%), and lowest yield (390 kg/ha^{-1}) were observed in the control group. In conclusion, the chemical insecticides Chlorantraniliprole 20 SC and Cypermethrin 25 EC demonstrated the best results in managing the pest, while the botanical extract tobacco leaves could serve as an alternative to chemical insecticides.

Keywords: Brinjal shoot borer, fruit borer, chemicals, botanicals, Malam Jaba.

INTRODUCTION

Brinjal (*Solanum melongena* L.) is an extensively cultivated and economically significant vegetable in many countries, particularly among low-income consumers and small-scale farmers (Bhushan *et al.*, 2011). However, the brinjal production of is often hampered by the infestation of various insect pests, with more than 36 pests reported to affect this crop from planting to harvest (Regupathy *et al.*, 1997). One of the most destructive pests is the brinjal shoot and fruit borer (BSFB), scientifically known as *Leucinodes orbonalis* Guenee (Crambidae: Lepidoptera) (Alam *et al.*, 2003). This monophagous pest exclusively targets brinjal plants and causes severe damage to the tender shoots and fruits (Alam *et al.*, 2006).

The brinjal shoot and fruit borer has become a major production constraint in brinjal-growing countries, particularly in Asia, where it inflicts significant damage, especially during the fruiting stage (Alam *et al.*, 2003). The feeding behavior of this pest involves the larvae boring into the growing tips of young shoots during the vegetative stage of the crop, resulting in wilting and yellowing of the shoots. The larvae also cause substantial damage to fruits, with an estimated 20-60% damage to fruits and 12-16% damage to shoots (Ahmed *et al.*, 2008). The pest's impact is particularly severe during the summer and rainy seasons, causing over 90% damage (Ara *et al.*, 2007).

To control insect pests like the brinjal shoot and fruit borer, various methods have been employed, including the use of chemical insecticides, biological control, synthetic insecticides, resistant varieties, and semio-chemicals that affect insect growth, development, and population dynamics (Ahmed *et al.*, 2013; Ahmed *et al.*, 2016; Fu *et al.*, 2017; Ahmed *et al.*, 2018; Ahmed *et al.*, 2019). However, the use of chemical insecticides raises concerns due to their high cost, potential toxicity, development of pest resistance, resurgence of certain pest populations, and adverse effects on beneficial organisms such as pollinators and natural enemies (Adedire *et al.*, 2011; Iqbal *et al.*, 2021; Qari *et al.*, 2020).

As a result, there is a growing need for alternative, environmentally sustainable, affordable, and user-friendly solutions to combat insect pests in brinjal cultivation. One approach is to explore the use of botanicals, which have shown potential as bioinsecticides. Botanical insecticides derived from plant parts and derivatives have been used traditionally and have advantages such as ready availability, cost-effectiveness, and reduced harm to natural enemies and pollinators (Adedire *et al.*, 2011; Iqbal *et al.*, 2021; Qari *et al.*, 2020). Additionally, natural plant products, including volatile organic compounds and other derivatives, have been employed for pest control in various regions worldwide, demonstrating their efficacy against a wide range of pests (Ahmed *et al.*, 2018; Ahmed *et al.*, 2019; Iqbal *et al.*, 2021; Tiroesele *et al.*, 2015; Darshanee *et al.*, 2017).

The renewed interest in natural products as alternatives for pest control is driven by the increasing awareness of environmental pollution caused by synthetic insecticides. Natural products have been found to have reduced environmental impacts compared to synthetic insecticides, leading to a resurgence in research in this field (Iqbal *et al.*, 2021; Ahmed *et al.*, 2021). Before the development and widespread use of synthetic insecticides in the 1940s, botanical insecticides were commonly employed by farmers as effective weapons against crop pests (Isman, 2008). While synthetic insecticides may act more quickly than botanicals in pest control, they can have negative effects on biocontrol agents (Oladimeji & Kannike, 2010; Khaliq *et al.*, 2014; Ursani *et al.*, 2014).

Many farmers heavily rely on synthetic chemical insecticides for pest management. However, the excess use of these pesticides is associated with drawbacks such as high costs, high toxicity, the potential for pest resistance development, resurgence of certain pest populations, and adverse effects on beneficial organisms and the environment. Therefore, it is crucial to adopt bio-rational approaches for managing brinjal insect pests that align with integrated pest management (IPM) strategies and are safe, economical, and selective.

The primary theme of this study was to assess the efficacy of both chemical and herbal insecticides against major pests of brinjal. By assessing the effectiveness of these control methods, we aimed to provide farmers with alternative and sustainable pest management approaches that reduce dependence on synthetic insecticides. This research was essential for promoting environmentally friendly practices, ensuring the long-term productivity and profitability of brinjal cultivation, and minimizing the potential risks associated with chemical pesticide use.

The brinjal shoot and fruit borer pose a significant threat to brinjal production, causing substantial damage to shoot and fruits. Traditional reliance on synthetic insecticides for managing pest population raises concerns due to their adverse effects on the non-target organisms and environment. Therefore, exploring alternative approaches such as botanical and herbal insecticides is crucial to develop sustainable and effective pest management strategies. By evaluating the efficacy of these methods, this study aims to contribute to developing IPM practices that are safe, economically viable, and environmentally friendly for brinjal cultivation.

MATERIAL AND METHODS

Experimental Site

The experiment was conducted during the Rabi season of 2022 at a local farmer's field in Malam Jaba, Swat. The field followed a randomized block design with a plot size of 25 m² and a spacing of 75 cm × 75 cm. The transplantation of Bemisal variety seedlings took place on April 10, following the recommended package of practices, except for insect-pest management practices.

Insecticides

The insecticides used in the experiment were obtained from the local market in Swat. The chemical formulations included Chlorpyrifos 20 EC (Dursban) at a rate of 1000 ml/ha, Chlorantraniliprole 20 SC (0.006%), Cypermethrin 25 EC at a rate of 250 ml/ha, and Neem oil.

Botanical Insecticides

Tobacco Leaves Extract: Fresh tobacco leaves weighing 500 g were crushed and mixed with 500 ml of water to create a field solution.

Efficacy of Treatments

The population of *Leucinodes orbonalis* (shoot and fruit borer) was assessed on the day before spraying and on the 5th, 10th, and 15th days after applying the insecticides. Five plants were randomly selected and tagged in each plot to record the population of the shoot and fruit borer.

Percent Shoot Infestation

The number of infested shoots in each plot was recorded one day before spraying, as well as on the 5th, 10th, and 15th days after spraying on the selected plants in each plot. The percentage of shoot damage was calculated using the following formula: (Number basis).

$$\text{Percent shoot damage (\%)} = \frac{\text{Number of infested shoots}}{\text{Total number of shoots}} \times 100$$

Percent Fruit Infestation

Observations were recorded on the number of infested fruits and total number of marketable fruits on selected plants in a plot picking wise. The per cent fruit damage was worked out by using the formula (Number basis).

$$\text{Percent fruit damage (\%)} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits}} \times 100$$

Yield kg ha^{-1}

Tomato yield kg/ha^{-1} were calculated after each picking by using the following formula:

$$\textbf{Yield kg per ha}^{-1} = \frac{\text{Yield weight}}{\text{Area harvested } (m^2)} \times 10000$$

Cost benefit ratio

The best effective treatment in terms of CBR was calculated by using the method [22].

$$\textbf{C.B.R} = \frac{\text{Grass returns}}{\text{Total cost of cultivation}}$$

Data Collection

Data on the average infestation of fruits and shoots was collected at intervals of five days. The data was obtained by randomly selecting five plants in each subplot and recording the average number of infested and non-infested fruits and shoots.

Data Analysis

The collected data was analyzed using Statistix 8.1 software through a one-way analysis of variance (ANOVA). To determine significant differences, the means were separated using the Least Significant Difference (LSD) test with a probability level of P = 0.05, following the method described by Steel and Torrie (1984).

RESULTS AND DISCUSSION

Results

Fig.1: Prior to the first application of spray, there was no significant infestation of brinjal shoot borer observed in any of the treatments. However, after 5 days, the control plot exhibited the highest percentage of shoot infestation (23%), followed by Tobacco leaves extract at a concentration of 500g/l (18.12%), Neem oil at a concentration of 100ml/l (17.80%), and Chlorpyrifos 20 EC (16.46%). The

treatments with the lowest mean shoot infestation were Cypermethrin 25 EC (15.11%) and Chlorantraniliprole 20 SC (14.45%), with no significant difference between them. After 10 days, the control plot still showed the highest mean shoot infestation (25.39%), followed by Neem oil at a concentration of 100ml/l (13.44%), Tobacco leaves extract at a concentration of 500g/l (10.50%), and Chlorpyrifos 20 EC (10.45%). The treatments with the lowest mean shoot infestation were Chlorantraniliprole 20 SC (8.78%) and Cypermethrin 25 EC (7.75%), and they were not significantly different from each other. After 15 days, the control plot had the highest mean shoot infestation (23.47%), followed by Neem oil at a concentration of 100ml/l (16.44%), Chlorpyrifos 20 EC (15.70%), and Cypermethrin 25 EC (16.40%). The treatments with the lowest mean shoot infestation were Tobacco leaves extract at a concentration of 500g/l (13.86%) and Chlorantraniliprole 20 SC (13.43%), with no significant difference between them.

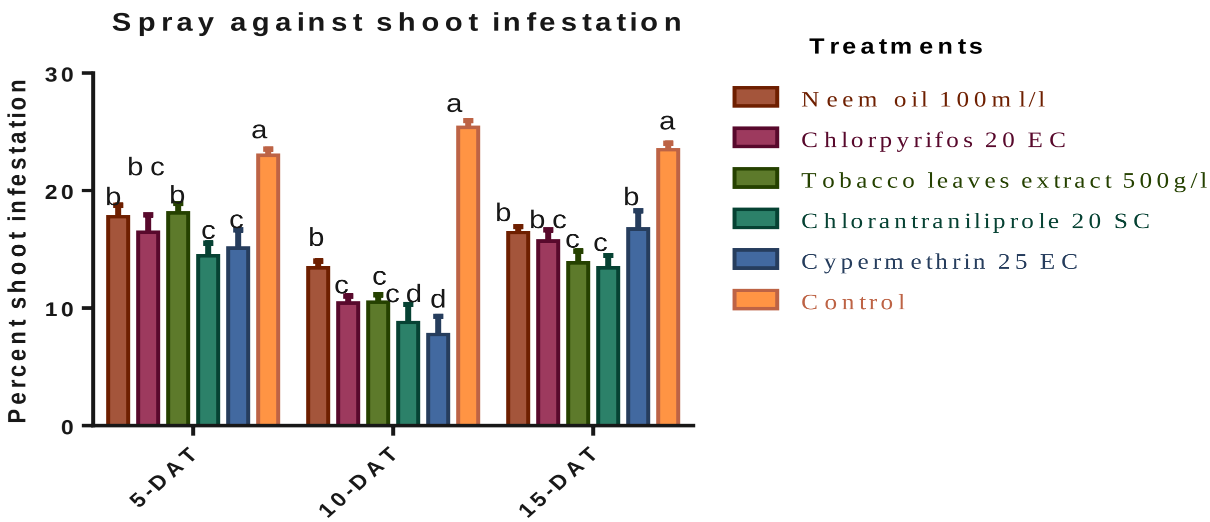

Fig.1. Means bar graph followed by the same lowercase letter do not differ statistically by LSD test at 5% probability.

Fig.2: The highest overall mean shoot infestation was observed in the control plot (23.06%), followed by Neem oil at a concentration of 100ml/l (17.03%), Chlorpyrifos 20 EC (15.82%), Tobacco leaves extract at a concentration of 500g/l (15.78%), and Cypermethrin 25 EC (14.76%). The lowest mean shoot infestation was recorded in Chlorantraniliprole 20 SC (14.17%).

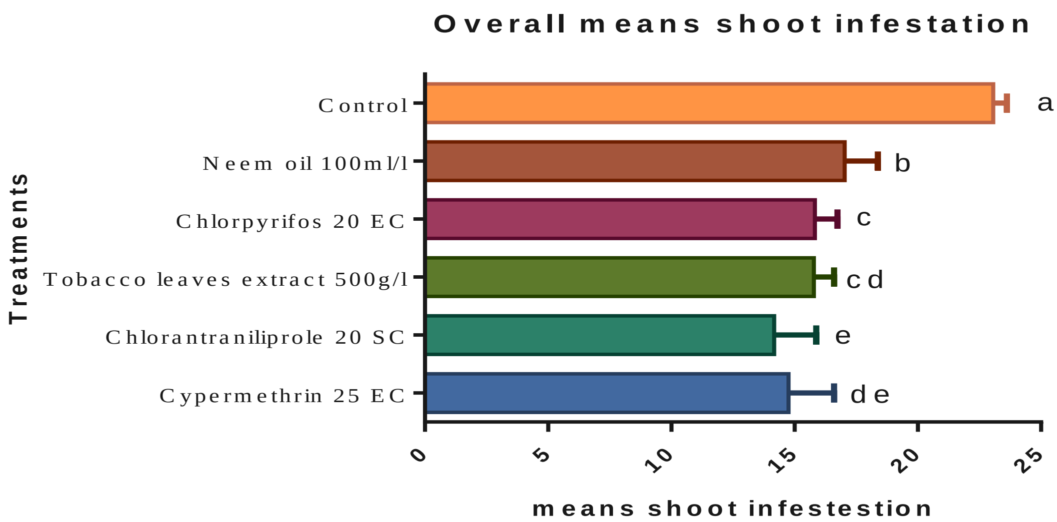

Fig.2. Means bar graph followed by the same lowercase letter do not differ statistically by LSD test at 5% probability.

Fig.3: Prior to the second application of spray for fruit infestation, there were no significant differences in infestation among the treatments. However, after 5 days, the control plot showed the highest percentage of fruit infestation (23.33%), followed by Neem oil at a concentration of 100ml/l (16.46%), Tobacco leaves extract at a concentration of 500g/l (16.12%), Chlorpyrifos 20 EC (15.13%), and Cypermethrin 25 EC (13.44%). The lowest fruit infestation was recorded in Chlorantraniliprole 20 SC (7.78%). After 10 days, the control plot had the highest mean fruit infestation (24.73%), followed by Neem oil at a concentration of 100ml/l (11.78%), Tobacco leaves extract at a concentration of 500g/l (10.84%), and Chlorpyrifos 20 EC (10.11%). The treatments with the lowest mean fruit infestation were Chlorantraniliprole 20 SC (6.44%) and Cypermethrin 25 EC (6.41%), and there was no significant difference between them. After 15 days, the control plot had the highest mean fruit infestation (27.47%), followed by Tobacco leaves extract at a concentration of 500g/l (15.19%), Cypermethrin 25 EC (15.07%), Neem oil at a concentration of 100ml/l (14.77%), and Chlorpyrifos 20 EC (14.38%). The lowest mean fruit infestation was recorded in Chlorantraniliprole 20 SC (8.43%).

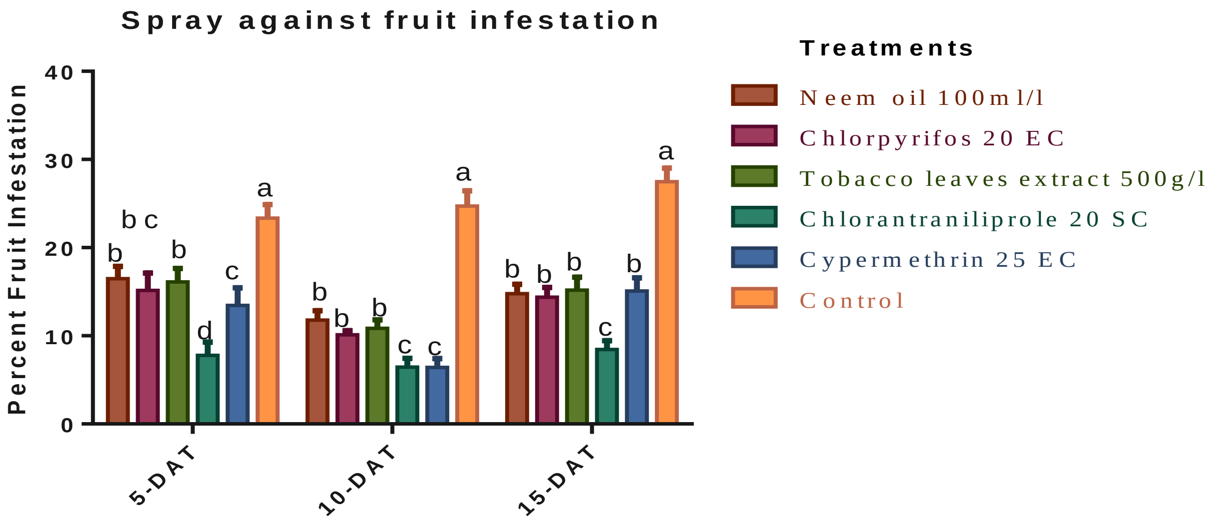

Fig.3. Means bar graph followed by the same lowercase letter do not differ statistically by LSD test at 5% probability.

Fig.4: The highest overall mean fruit infestation was observed in the control plot (23.89%), followed by Neem oil at a concentration of 100ml/l (15.70%), Tobacco leaves extract at a concentration of 500g/l (15.36%), Chlorpyrifos 20 EC (14.74%), and Cypermethrin 25 EC (13.42%). The lowest mean fruit infestation was recorded in Chlorantraniliprole 20 SC (10.42%).

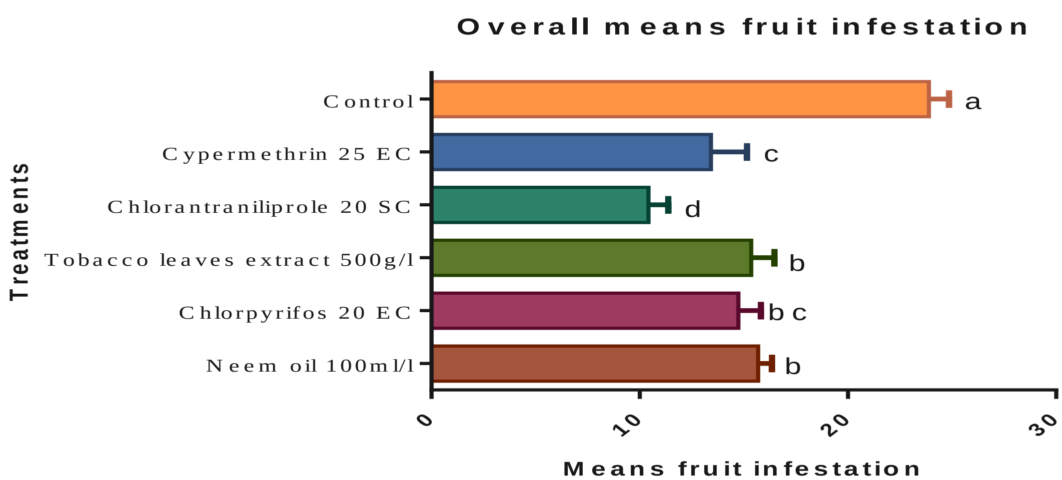

Fig.4. Means bar graph followed by the same lowercase letter do not differ statistically by LSD test at 5% probability.

Table 1. Cost benefit ratio of Different Synthetic and natural Insecticide against brinjal shoot and fruit borer.

Treatments	Market able Yield (kg ha^{-1})	Gross Income	Cost of Control	Return Over Control	Net Increase Over Control	CBR
	A	B	C	D=B-C	E=D-C	F=D/C
Neem oil 100ml/l	591.7^{d}	20708.5	2600.0	18108.5	15508.5	7.0
Chlorpyrifos 20 EC	639.7^{b}	22388.5	2165.9	20222.6	18056.7	9.3
Tobacco leaves extract 500g/l	628.7^{bc}	22003.5	2618.9	19384.6	16765.7	7.4
Chlorantraniliprole 20 SC	665.0^{a}	23275.0	2013.5	21261.5	19248.0	10.6
Cypermethrin 25 EC	611.7^{c}	21408.5	2140.5	19268.0	17127.5	9.0
Control	390.0^{e}	13650.0				
S±E	8.65					
CD(P=0.05**)**	19.28					

Price one Kg PKR=35/=

Yield kg/ha^{-1}and CBR

The plot treated with Chlorantraniliprole 20SC exhibited the highest yield, recording 665.0 kg/ha. It was closely followed by the plot treated with Chlorpyrifos 20 EC, which yielded 639.7 kg/ha. The Tobacco leaves extract 500g/l treatment resulted in a yield of 628.7 kg/ha, while the Cypermethrin 25 EC treatment yielded 611 kg/ha. The Neem oil 100ml/l treatment had the fifth highest yield, producing 591.7 kg/ha. In contrast, the control plot had the lowest yield, with only 390 kg/ha.

Regarding the Cost-Benefit Ratio (CBR), the plot treated with Chlorantraniliprole 20SC achieved the highest value, measuring 10.6. On the other hand, the plot treated with Neem oil 100ml/l had the lowest CBR, recording 7.

Discussion

The experiment took place at Malam Jaba Swat, a local farmer's field, in 2022. Its purpose was to examine the impact of various synthetic and botanical insecticides on shoot and fruit borer infestation. All treatments showed significant effectiveness in reducing the percentage of damage caused by the shoot and fruit borer compared to the control.

The synthetic insecticide Cypermethrin 25 EC, applied at a rate of 250 ml/ha, was found effective in reducing shoot damage caused by the shoot and fruit borer. These results are consistent with the findings of Shah *et al.* (2012), Bhagwan *et al.* (2017) and Pooja & Kumar (2022), who observed a similar reduction in shoot damage. Furthermore, all treatments were significantly better than the control in reducing shoot and fruit infestation. The treatment with chlorantraniliprole 20 EC exhibited the lowest shoot and fruit infestations, ranging from 2.77% to 4.97%. Similar results were reported by Mishra (2011) and Kushwaha *et al.* (2016). Chlorantraniliprole also yielded the lowest fruit infestation rate (10.42%) and the highest marketable fruit yield (665 kg/ha^{-1}), which aligns with the findings of Tripura *et al.* (2017). Chlorpyriphos was the next most effective treatment for reducing shoot and fruit infestation, consistent with the findings of Singh & Sachan (2015). Neem oil also demonstrated significant effectiveness in reducing shoot and fruit damage, in line with the findings of Yadav *et al.* (2015) and Naik & Kumar (2014), who reported that cypermethrin was effective against shoot and fruit borer populations. Similarly, Kumar *et al.* (2012) found that chlorpyriphos was highly effective in reducing shoot and fruit infestation.

Among the botanical treatments, neem oil exhibited the highest reduction in brinjal shoot and fruit borer infestation, supported by Rahman *et al.* (2009) and Shyamrao *et al.* (2018). The chemical insecticides cypermethrin (14.76% and 13.42%) and chlorpyriphos (15.82% and 14.74%) were found to be the most effective treatments for reducing shoot and fruit infestation, consistent with the findings of Singh & Sachan (2015) and Jagarlamudi *et al.* (2021). Singh and Sachan (2015) specifically reported that chlorpyriphos 20 EC at a rate of 1 lit/ha was the most effective treatment for reducing shoot and fruit damage. The maximum fruit yield of 591.7 kg/ha was achieved with this application, surpassing the control. Similar results were reported by Abirami *et al.* (2023).

Neem leaf extract, used as a treatment in the form of neem oil, resulted in a yield of 591.7 kg/ha, which was higher than the control. This finding is consistent with the results reported by Ashadul *et al.* (2014) and Khan *et al.* (2017), who also observed the positive impact of neem on yield. Consequently, neem oil is recommended as an environmentally friendly management technique for controlling brinjal shoot and borer, as reported by Saljoqi *et al.* (2023). Neem oil has also been employed to combat brinjal fruit and shoot borer infestations and reduce their levels, a finding that aligns with the research conducted by Sankar & Ashwani (2022).

CONCLUSION AND RECOMMENDATION

Based on the above findings, it was concluded that Chlorantraniliprole 20SC and Chlorpyrifos 20 EC have demonstrated the most effective management of brinjal shoot and fruit borers. These two sprays have proven to be highly efficient in reducing the population of these pests compared to other treatments. Furthermore, the utilization of botanical extracts has also shown promising results in mitigating the infestation of shoot and fruit borers. Therefore, it is highly recommended to consider these eco-friendly approaches for the effective and sustainable management of these pests.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to Syed Fahad Shah, Assistant Professor at Department of Entomology, The University of Agriculture Peshawar, for generously providing the necessary resources and facilities essential for the successful execution of this experiment.

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