Plant Protection, 08 (02) 2024. 285-292 DOI:10.33804/pp.008.02.5142

Available Online at EScience Press
Plant Protection
ISSN: 2617-1287 (Online), 2617-1279 (Print)
http://esciencepress.net/journals/PP

Research Article

PERFORMANCE OF SOME BOTANICAL PESTICIDES AGAINST BRINJAL SHOOT AND FRUIT BORER (*LEUCINODES ORBONALIS* G.) ON BRINJAL

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ARTICLE INFO

Article history
Received: 28th March, 2024
Revised: 9th May, 2024
Accepted: 16th May, 2024

Keywords
Botanical pesticides
Brinjal shoot and fruit borer
Leucinodes orbonalis
Pest management
Crop protection

ABSTRACT

The shoot and fruit borer (*Leucinodes orbonalis* G.) is one of the major insect pests of the brinjal crop. Presently, farmers use synthetic insecticides to control this pest, which can cause health and environmental problems. Therefore, the goal of this study was to determine the performance of various botanical pesticides (neem, eucalyptus, karanj, and mahogany oils at 1%) against *L. orbonalis* under field conditions during 2023, after the 1st and 2nd sprays at 1, 3, and 7 days post-application. The results showed that all botanical pesticides were effective in reducing the shoot and fruit damage percentages after the 1st and 2nd sprays at all intervals compared to the control, with neem oil being the most effective in reducing the shoot and fruit damage percentages of *L. orbonalis*. The lowest shoot and fruit damage percentages were observed after the 1st and 2nd sprays at the 7-day interval with neem oil: shoot damage percentages were 12.5% and 9.8%, and fruit damage percentages were 22.2% and 12.4%, respectively. Similarly, the highest yield was obtained (13,013 kg/ha) when the crop was treated with neem oil, followed by eucalyptus, karanj, and mahogany oils at 1% with yields of 11,307, 10,499, and 9,947 kg/ha, respectively, whereas the minimum yield of 5,603 kg/ha of fruits was obtained in the control. Therefore, based on the present results, all botanical pesticides are highly recommended, with Neem oil being the most effective against the shoot and fruit borer.

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INTRODUCTION

Brinjal (*Solanum melongena* L.) is one of the most important vegetable crops in Southeast and South Asia, where it is commonly known as "Begoon". Originally termed eggplant in Europe, it belongs to the Solanaceae family. Major cultivation areas include Pakistan, China, India, Bangladesh, the Philippines, France, Italy, the USA, and Egypt (Anonymous, 2010). Brinjal is a rich source of minerals, nutrients, vitamins, antioxidants, proteins, dietary fiber, and essential building factors for the body (Matsubara et al., 2005; Oboh et al., 2005). In Pakistan, it is a staple vegetable in culinary practices due to its consistent availability and affordable prices throughout the year. The total cultivated area for brinjal in Pakistan was 8,427 hectares, yielding an annual production of 84,255 tons (Anonymous, 2019).

The Province of Punjab leads in both the area and production of this crop, followed by Sindh and Baluchistan (Javed et al., 2017a). The reported yield of brinjal in Pakistan is 97,466 kg/ha. Insect pests are one of the significant causes of yield decrease and are warning factors in brinjal crop production. Numerous insect pests attack brinjal crops from planting time until harvesting (Aslam et al., 2019; Khan et al., 2019). Some of the major insect pests of the brinjal crop in Pakistan include *Leucinodes orbonalis* G. (brinjal shoot and fruit borer), *Euzophera perticella* R. (brinjal stem borer), *Eublemma olivacea* W. (leaf roller), *Epilachna vigintioctopunctata* F. (beetle), *Aphis gossypii* (aphid), *Bemisia tabaci* G. (whitefly), and *Thrips palmi* K. (thrips) (Srinivasan, 2009; Javed et al., 2017b; Kassi et al., 2019).

L. orbonalis is the major insect pest of the brinjal crop (Latif et al., 2010; Jayakrishnan and Madhuban, 2012; Muhammad et al., 2021a,b) and is recorded in all brinjal-growing countries (Dutta et al., 2011). It is the most serious insect pest of the brinjal crop in Asia, particularly in Pakistan, Nepal, India, Sri Lanka, Bangladesh, the Philippines, Thailand, Cambodia, Vietnam, and Laos (AVRDC, 1994), as well as in the Sahara, Africa, and Southeast Asia (CABI, 2007). Areas with a humid and hot climate are favorable for its spread and occurrence (Srinivasan, 2009). It causes significant infestations in South Asia (Thapa, 2010), where yield losses can reach 85 to 90 percent (Misra, 2008; Jagginavar et al., 2009). The larvae at the vegetative stage bore into tender shoots, flowers, and fruits (CABI, 2007). Damage to flowers is rare, but damaged flowers cannot produce fruit (Alam et al., 2006). It is also reported to damage the midrib and petiole of leaves (Alpureto, 1994; AVRDC, 1998), causing drooping and withering of young shoots and leaves. Once fruit setting begins, shoot damage becomes negligible (Kumar and Singh, 2013) or completely disappears (Naqvi et al., 2009). After hatching, larvae bore inside the fruit, and the minute entrance hole is closed by the excreta of feeding larvae (Alam et al., 2006). The larvae feed on the fruit mesocarp, and their excretion and feeding result in the rotting of the fruit (Neupane, 2001), making it unfit for human consumption (Baral et al., 2006). Each larva can damage 4 to 7 fruits during its life span (Jayaraj and Manisegaran, 2010). Damage by this pest results in lowering the vitamin C content by up to 80 percent in damaged brinjal fruits (Sharma, 2002).

The local farmers mainly choose chemical applications as they produce fast results. However, these chemicals often cause secondary pest outbreaks, insecticide resistance, resurgence, environmental pollution, residual toxicity, and harmful impacts on animals, beneficial insects, and humans (Bhushan et al., 2011; Chakraborti and Sarkar, 2011).

Biological and botanical methods have been used in insect pest management since time immemorial because they are more eco-friendly and environmentally safe than chemical approaches. Botanicals and biological agents such as karanjin, azadirachtin, Bt, and *Beauveria* have been tested under field conditions and proven effective against both shoot and fruit infestations caused by insect pests (Tripura et al., 2017; Karmakar et al., 2018). Bio-rational methods, including indigenous products and bio-nutrients, along with reduced levels of fertilizers, significantly influence the occurrence of insect pests on brinjal crops. Combining 50% of the recommended doses of Bio-NPK and fertilizers with chemical insecticides like carbosulfan and spinosad can help reduce the population of brinjal shoot and fruit borer (Mallick et al., 2019). Additionally, improved pest control and high yields of up to 250.30 q/ha were achieved using chlorantraniliprole and azadirachtin (Tripura et al., 2017). Therefore, the goal of this study was to evaluate the performance of different botanical pesticides against the shoot and fruit borer, in brinjal under field conditions.

MATERIALS AND METHODS

Experimental site and design

The experiment was conducted at Agriculture Research Institute (ARI) Tandojam, Sindh, Pakistan, in 2023. The experimental design used was a Randomized Complete Block Design with five treatments, each replicated three times. The following treatments were used in this experiment:

T1 = Neem oil 1% (10 ml/L)
T2 = Karanj oil 1% (10 ml/L)
T3 = Eucalyptus oil 1% (10 ml/L)
T4 = Mahogoni oil 1% (10 ml/L)
T5 = Control

Experimental procedure and data observation

The brinjal crop variety Hybrid 303 was sown in the nursery, and the seedlings were then transplanted into an area of 12 m^2. The row-to-row spacing was 60 cm, and the plant-to-plant spacing was 45 cm. Recommended agronomic practices were followed to raise the crop. Thirty days after transplanting, two sprayings of botanicals were performed at 15-day intervals. The spraying was done uniformly over the entire canopy of the plants to ensure complete coverage. Irrigation was carried out after the applications, during the night. Adjacent unit blocks and plots were separated by 60 cm and 80 cm, respectively. Twelve seedlings were transplanted in each plot, spaced at 60 × 80 cm intervals. Each experimental plot covered an area of approximately 5.76 m^2.

Spraying was conducted at 8:00 am, after the dew had dried, and when there was a slow and stable wind velocity. Each treatment was applied at 15-day intervals, with two applications made during the study period. Treatments were applied to the whole plots. Observations on shoot and fruit damage were recorded on 10 randomly selected plants in the middle two rows of each plot. Data were recorded one day before, and 1, 3, and 7 days after each treatment application. Yield data of healthy fruits were taken at each picking.

The damage percentage of shoots was calculated using the following formula:

$$\text{Percentage shoot damage} = \frac{\text{Number of damaged shoots}}{\text{Total number of shoots}} \times 100$$

The damage percentages of fruits were calculated using the following formula.

$$\text{Percentage fruit damage} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits}} \times 100$$

Statically analysis

The data was subjected to analysis of variance (ANOVA). Significant differences among treatments were determined by Least Significant Difference (LSD) test at $P \leq 0.05$.

RESULTS

Effect of botanical pesticides on shoot damage by *L. orbonalis*

Table 1 presents the shoot damage percentages by *L. orbonalis* after the 1st and 2nd spray applications at 1-day, 3-day, and 7-day intervals using various botanical pesticides. Significant differences (P<0.05) were observed among treatments in shoot damage percentages.

After the 1st spray, neem oil 1% showed the lowest shoot damage percentages at 1-day, 3-day, and 7-day intervals (26.8%, 20.3%, and 12.5%, respectively), while the control showed the highest shoot damage percentages (47.3%, 46.5%, and 50.1%, respectively). This was followed by eucalyptus oil 1% (32.6%, 28.1%, and 21.5%), karanj oil 1% (38.1%, 34.9%, and 32.0%), and mahogoni oil 1% (43.3%, 38.9%, and 36.7%).

After the 2nd spray, neem oil 1% again showed the lowest shoot damage percentages at 1-day, 3-day, and 7-day intervals (20.2%, 16.1%, and 9.8%, respectively), while the control showed higher shoot damage percentages (31.4%, 34.6%, and 32.7%). This was followed by eucalyptus oil 1% (23.6%, 19.5%, and 14.4%), mahogoni oil 1% (28.5%, 26.2%, and 21.1%), and karanj oil 1% (29.1%, 27.9%, and 22.6%), which demonstrated intermediate levels.

Effect of botanical pesticides on fruit damage by *L. orbonalis*

The percentage of fruit damage by *L. orbonalis* after the 1st and 2nd sprays, observed at 1-day, 3-days, and 7-days post-treatment with different botanical pesticides, is presented in Table 2. The results showed that the fruit damage percentage varied significantly across different treatments (P<0.05).

After the 1st spray, the lowest fruit damage percentages were observed with neem oil 1% (41.5%, 33.3%, and 22.2% at 1-day, 3-days, and 7-days, respectively), while the highest damage percentages were seen in the control group (65.4%, 67.7%, and 68.4%). Intermediate levels of damage were noted with eucalyptus oil 1% (46.8%, 39.3%, and 25.0%), karanj oil 1% (51.8%, 46.3%, and 32.0%), and mahogany oil 1% (57.3%, 54.1%, and 38.4%).

Following the 2nd spray, the minimum fruit damage percentages were again found with neem oil 1% (23%, 17.8%, and 12.4% at 1-day, 3-days, and 7-days, respectively). The control group exhibited the highest damage percentages (44.2%, 44.2%, and 49.2%).

Eucalyptus oil 1% (25.1%, 22.3%, and 16.8%), mahogany oil 1% (30.5%, 27.3%, and 23.8%), and karanj oil 1% (32.8%, 28.7%, and 24.2%) also showed intermediate levels of damage.

Effect of different botanical pesticides on fruit yield in brinjal crop

Table 3 presents the fruit yield results for brinjal crops treated with different botanical pesticides. The results showed that there was a significant difference in fruit yield across the different treatments ($P<0.05$). At the first picking, the highest yield of fruits was obtained with neem oil treatment (6519.5 kg/ha), while the lowest yield was observed in the control (2991.8 kg/ha). The yields for the other treatments were as follows: eucalyptus oil 1% (5846.7 kg/ha), karanj oil 1% (5341.0 kg/ha), and mahogoni oil 1% (5133.2 kg/ha).

At the second picking, the highest fruit yield was again obtained with neem oil treatment (6493.1 kg/ha), and the lowest yield was in the control (2611.5 kg/ha). The yields for the other treatments were eucalyptus oil 1% (5460.6 kg/ha), karanj oil 1% (5158.3 kg/ha), and mahogoni oil 1% (4814.2 kg/ha).

Overall, the total maximum yield was achieved with neem oil treatment (13013 kg/ha), followed by eucalyptus oil 1% (11307 kg/ha), karanj oil 1% (10499 kg/ha), and mahogoni oil 1% (9947 kg/ha). The minimum yield was observed in the control (5603 kg/ha).

Table1. Effect of botanical pesticides on shoot damage by *L. orbonalis*.

% shoot damage after first spray				
Treatments	Pre-Treatment	1-Day	3-Days	7-Days
Neem oil 1%	41.4±5.3^{abc}	26.8±3.3^{de}	20.3±2.3^{de}	12.5±1.7^{d}
Karanj oil 1%	45.2±4.4^{ab}	38.1±4.1^{abc}	34.9±5.0^{bc}	32.0±5.7^{bc}
Eucalyptus oil 1%	41.3±2.9^{abc}	32.6±6.8^{bcd}	28.1±2.0^{bcd}	21.5±3.8^{cd}
Mahogoni oil 1%	46.2±7.3^{a}	43.3±0.7^{ab}	38.9±2.0^{ab}	36.7±10.2^{ab}
Control	45.2±1.6^{ab}	47.3±4.4^{a}	46.5±5.6^{a}	50.1±3.3^{a}
% shoot damage after second spray				
Neem oil 1%	28.9±5.1^{c}	20.2±4.0^{e}	16.1±1.8^{e}	9.8±2.8^{d}
Karanj oil 1%	34.7±4.3^{abc}	29.1±0.8^{cde}	27.9±5.9^{bcd}	22.6±4.5^{cd}
Eucalyptus oil 1%	30.5±2.8^{c}	23.6±3.7^{de}	19.5±2.4^{de}	14.4±0.5^{d}
Mahogoni oil 1%	32.6±4.3^{bc}	28.5±3.2^{cde}	26.2±5.9^{cde}	21.1±2.9^{cd}
Control	33.7±2.8^{abc}	31.4±1.6^{cd}	34.6±0.8^{bc}	32.7±2.8^{bc}

In each column, mean ± SE followed by the same letter do not differ significantly using LSD test ($p < 0.05$).

Table 2: Effect of botanical pesticides on fruit damage by *L. orbonalis*.

	% fruit damage after first spray			
Treatments	Pre-Treatment	1-Day	3-Days	7-Days
Neem oil 1%	57.6±9.5^{ab}	41.5±1.6^{cde}	33.3±2.6^{cde}	22.2±1.7^{de}
Karanj oil 1%	56.9±6.7^{ab}	51.8±3.8^{bc}	46.3±1^{bc}	32.±4.99^{cd}
Eucalyptus oil 1%	60.4±6.7^{ab}	46.8±5.9^{bc}	39.3±2.9^{bcd}	25.±1.74^{cde}
Mahogoni oil 1%	64.5±4.7^{ab}	57.3±7.5^{ab}	54.1±12.1^{ab}	38.4±10.3^{bc}
Control	66.9±1.1^{a}	65.4±5.8^{a}	67.7±14.7^{a}	68.4±3.6^{a}
% fruit damage after second spray				
Neem oil 1%	33.7±4.5^{c}	23±2.4^{f}	17.8±4.1^{e}	12.4±1.4^{f}
Karanj oil 1%	36.5±2.5^{c}	32.8±3.9^{def}	28.7±3.7^{cde}	24.2±2.1^{cde}
Eucalyptus oil 1%	34.7±5.2^{c}	25.1±2^{f}	22.3±4de	16.8±1.6^{e}
Mahogoni oil 1%	35.4±3.2^{c}	30.5±1.7^{ef}	27.3±5.3^{cde}	23.8±4de
Control	48.7±9.9^{bc}	44.2±6.1^{bcd}	44.2±1.5^{bc}	49.2±8.1^{b}

In each column, mean ± SE followed by the same letter do not differ significantly using LSD test ($p < 0.05$).

Table 3: Effect of different botanical pesticides on fruit yield in brinjal crop.

Treatments	1st Picking (kg/ha^{-1})	2nd Picking (kg/ha^{-1})	Total Yield (kg/ha^{-1})
Neem oil 1%	6519.5^{a}	6493.1^{a}	13013^{a}
Karanj oil 1%	5341.0^{c}	5158.3^{c}	10499^{c}
Eucalyptus oil 1%	5846.7^{b}	5460.6^{b}	11307^{b}
Mahogoni oil 1%	5133.2^{c}	4814.2^{d}	9947^{d}
Control	2991.8^{d}	2611.5^{e}	5603^{e}

In each column, mean ± SE followed by the same letter do not differ significantly using LSD test ($p < 0.05$).

DISCUSSION

The present study evaluated different botanical pesticides (neem, karanj, eucalyptus, and mahogany oils at 1%) against the shoot and fruit borer (*L. orbonalis*) in a brinjal field. Although the present work found that all botanical pesticides were effective in reducing the damage percentages of the shoot and fruit borer after the 1st and 2nd intervals compared to the control plot, neem oil at 1% was the most effective in reducing the damage percentage of *L. orbonalis*. The findings of several researchers regarding neem and other plant products against the brinjal shoot and fruit borer closely align with those of the present study. Dehariya et al. (2017) and Singh (2003) reported that neem oil, karanj oil, and eucalyptus oil were the most effective botanicals against the brinjal shoot and fruit borer.

These results are consistent with previous findings by Rahman et al. (2009), who also evaluated the field effectiveness of botanicals such as neem oil (4%), karanja oil (4%), mahogany oil (4%), neem cake (250 kg/ha), and a combination of neem oil + neem cake (4% + 250 kg/ha) against *L. orbonalis* at 15-day intervals. Similarly, Singh and Sachan (2015) reported that all treatments were effective in reducing the damage caused by the shoot and fruit borer compared to the control. Spinosad application was the most effective, followed by chlorpyrifos and neemarin, in reducing damage to the shoot and fruit at all intervals. Likewise, Sangma et al. (2019) observed the lowest infestation on shoots and fruit by *L. orbonalis* in neem oil 2% (13.44% and 15.88%), followed by jatropha leaf extract (14.19% and 16.28%) and papaya leaf extract (15.03% and 16.66%).

In the present results, the lowest shoot damage percentage was observed at all intervals after the 1st and 2nd spray with neem oil 1%, while the highest shoot damage percentage was observed in the control on the 1st day. These results are in line with the previous findings of Dehariya et al. (2017), who also observed the lowest shoot damage percentage after the 3rd and 4th spray of neem oil and the highest shoot damage percentage in the untreated control. Similarly, Rahman et al. (2009) reported the minimum reduction percentage of shoot damage by *L. orbonalis* in neem oil and neem cake-treated plots.

However, the fruit damage percentage by *L. orbonalis* was lowest after the 1st and 2nd spray at all intervals with neem oil 1%, and the maximum fruit damage percentage was recorded in the control, followed by eucalyptus oil 1%, karanj oil 1%, and mahogany oil. In the same way, Rahman et al. (2009) reported the minimum percentage of fruit damage by *L. orbonalis* with neem cake and neem oil treatments. Dehariya et al. (2017) also recorded the lowest fruit damage percentage after the 3rd and 4th spray of neem oil and the highest fruit damage percentage in the control plot with eucalyptus oil.

Similarly, our findings regarding the yields of healthy fruit across all treatments were significant. The maximum yield of healthy fruits (13013 kg/ha^{-1}) was obtained when the crop was treated with neem oil, followed by eucalyptus oil 1%, karanj oil 1%, and mahogany oil 1% (11307, 10499, and 9947 kg/ha^{-1}), whereas the minimum yield of healthy fruits (5603 kg/ha^{-1}) was obtained in the control. Dehariya et al. (2017) also observed the highest yield of healthy fruits (24.76 q/ha) in triazophos 40 EC (0.04%) treatment and the lowest yield in the untreated control plot (10.50 q/ha), followed by neem oil 1% treatment (20.54 q/ha of healthy fruits). Likewise, Sharma and Tayde (2017) noted significant differences in yields among treatments, with the highest yield of healthy fruits recorded in cypermethrin (204.16 q/ha), followed by spinosad (197.22 q/ha), emamectin benzoate (190.27 q/ha), and neem (163.83 q/ha).

CONCLUSIONS

It is concluded that all-botanical pesticides were found to be most effective against shoot and fruit borers compared to the control. The highest percentage of shoot and fruit damage was observed with neem oil at 1% after the 1st and 2nd sprays at all intervals. Neem oil showed promise as a potential botanical pesticide against *L. orbonalis*. The yields of healthy fruits among all treatments were significantly higher compared to the control. The maximum yield of healthy fruits was obtained when the crop was treated with neem oil, followed by eucalyptus oil at 1%, karanj oil at 1%, and mahogany oil at 1%.

RECOMMENDATIONS

Neeml, eucalyptus, karanj, and mahogany oils as insecticidal products should be used to combat and protect against *L. orbonalis*. Further studies are much needed to explore more botanical pesticides against *L. orbonalis* in both field and laboratory settings.

ACKNOWLEDGMENTS

We acknowledge this study to the Agriculture Research Institute (ARI) Tandojam for giving us all the necessary facilities for conducting this research work.

AUTHORS' CONTRIBUTIONS

HT performed the research during his master's degree; SSAB, DMS and HT planned, designed, and conducted all the experiments; SMASR, NKR, and AMP helped to collect and analyze the experimental data; AR and FA revised the whole manuscript with proofreading and scientific report writing.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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