Research Article

Efficacy of Botanical Insecticides Against, *Batrachedra amydraula* on *Phoenix dactylifera* at Field Conditions

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Abstract | Lesser date moth, a potential key insect pest species, extremely harming fruit of *Phoenix dactylifera* L, inducing tremendous date fruit yield and economic lossess. The research study was carried out to evaluate the efficacy of bio-rational insecticides against *Batrachedra amydraula* (Meyrick) at Taluka Kingri, District Khairpur under field conditions during, 2020-21. The four different bio-rational insecticides viz., (T_1) = *Azadirachta indica* oil, (T_2) = *Azadirachta indica* leaves extract, (T_3)= *Calotropis gigantea* leaves, (T_4) = *Citrullus colocynthis* fruit were applied against *B. amydraula* population and (T_5)= as control. The result revealed that neem oil caused maximum larvae reduction % in all three replications at (50.25%), (43.30%), (34.04%) overall (42.53%) in both years. Neem leaves extract (40.95%), (35.83), (34.08) overall (36.95%). *C. gigantea* (30.43%), (23.60%), (22.60%) overall (25.54%), and *C. colocynthis* (25.19%), (23.43%), (26.25%), overall (24.96%). There was significant effect of all the botanical insecticides but neem oil proved with best efficacy against this potential pest, hence recommended. Given district is regarded as the date palm biodiversity centre, here more than three hundred date palm varieties are being grown. It is strongly needed to develop new strategies with combination of commercial botanical pesticides. As an alternative and minimize the toxic chemical pesticides, because botanical insecticides are sustainable control mechanisms that show the potential to earn profitable yield.

Received | January 31, 2024; **Accepted** | March 09, 2024; **Published** | March 25, 2024
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Citation | Mangrio, W.M., F.A. Jatoi, H.A. Sahito, F.I. Sahito, B. Mal and N. Qureshi. 2024. Efficacy of botanical insecticides against, *Batrachedra amydraula* on *Phoenix dactylifera* at field conditions. *Pakistan Journal of Agricultural Research,* 37(1): 79-87.
DOI | https://dx.doi.org/10.17582/journal.pjar/2024/37.1.79.87
Keywords | *Azadirachta indica*, *Batrachedra amydraula*, *Calotropis gigantea*, *Citrullus colocynthis*, Neem oil, *Phoenix dactylifera*

Introduction

Date palm, the most valuable tree plants, grown abundantly in the Iran, Algeria, Iraq, Saudi Arabia, Egypt, Middle East, North Africa, UAE, and Pakistan (Alotaibi *et al.*, 2023). *Phoenix dactylifera*, regarded as the oldest tree and ancient crop have been cultivated since thousand years (Muralidhara *et al.*, 2017). Date palm fruit is enlightened in different religious books and recognized as the “paradise fruit”

(Akhtar *et al.*, 2014). Date fruit is a rapid source of energy, rich in nutrients containing carbohydrate, proteins, vitamins, fats, and minerals with prodigious economic value (Walsh *et al.*, 2020).

Date palm, the fruit bearing trees used in the manufacturing of fibrous materials, natural fiber composites, even nano-featured sheets also food for poultry, camel, sheep, cattle (Nadia *et al.*, 2018). Aseel, Fasli, Mozawati, Karbalian, Dhaki, Kohra, Jan Swore, and Begum Jhangi are economically profitable date cultivars in Pakistan, their moisture content of soft, semi-dry, and dry having positive effects on human physiology and health (Mallah *et al.*, 2017). Aseel variety of Khairpur-Sindh is the commercial, predominant and most exportable date palm variety (Soomro *et al.*, 2022).

Batrachedra amydraula species is a destructive insect pest, vigorously damaging date palms and causing more than 75% fruit losses (Babar *et al.*, 2023). *Rhynchophorous ferrugineus,* a widespread insect pest, mostly hits date fruit of the Aseel variety compared to Fasli and Karbalian, especially in Khairpur-Sindh, which is the main dates producer zone in Pakistan (Kubar *et al.*, 2017; Sahito *et al.*, 2017). In the same area, the *Oryzaephilus surinamensis* have been seemed a wide spread potential pest, relaying negative effect on dry and semi dry date fruits (Kousar *et al.*, 2020). The application of fumigant methyl bromide gas is the best remedy against this wide destructive pest (Kousar *et al.*, 2022). The other species of the date palm insect pests such as; *Oligonychus afrasiaticus*, *Ommatissus binotatus*, *Palmapsis phoenicis*, *Ectomyelois ceratoniae*,*Jebusaea hammerschmidit*, *Oryctes gamemnon*, *Oryctes elegnas,* and *Cadra cautella* are the common and most frequently occurring insect pests (Khan *et al.*, 2018). The larvae of many insect pests act as major constraints in increasing fruit productivity, retarding the growth of the host plants, and later the fruit my fall on the surface of earth (Mangrio *et al.*, 2023).

The bio-rational insecticides are gaining much importance due to safety profile on crop application with noticeable effects against insect pest management (Oliveira *et al.*, 2017). Parasitoids and predators have long been considered as an environmentally sound and bio-rational derivative is an easily sustainable and effective invasive pest management approach as an alternative to harmful synthetic chemical pesticides (Stevenson *et al.*, 2017). Nano-technology is also another promising tool of contemporary agriculture, and recently it has been received enormous interest (Awad *et al.*, 2022). In combat against insect pests, the wide use of chemicals has caused a loss of biodiversity, raised environmental and health issues (Mangrio and Sahito, 2022). Bio-rational insecticides reduce fruit productivity losses and enable us towards the pathway to eco-friendly insect pest management. In this context, proper surveillance could be analysed adequately (Abada *et al.*, 2023).

Materials and Methods

Location of experiment

The bio-rational insecticides viz., (T_1)= Neem oil (T_2)= Neem extract (T_3)= *C. gigantea* (T_4)= *C. colocynthis* (T_5)= Control were applied against the population reduction % of the lesser date moth at field during, 2020-21. The five acres containing five to ten years old Aseel, a prominent and highly recognized date palm variety of Khairpur, Sindh, has been selected and sprayed to evaluate the efficacy of given bio-rational insecticides against *B. amydraula,* at Prof. Dr. Abdul Khalique Jatoi farm, Taluka Kingri, District Khairpur Mirs, located at 27.85186 °N, 68.61301 °E.

Formulation of botanical insecticides protocol

For the preparation of the bio-insecticides, 5kg of neem leaves, *C. gigantea* leaves, and *C. colocynthis* fruit were collected individually from the local market and were kept for seven days under shade for drying purpose in the corridor of the Entomological Research Laboratory. Then dried *C. colocynthis* fruit, neem and *C. gigantea* leaves were boiled in 5 liters of water, when water was reached near to 3kg kept separated, minced, filtered and poured into bottles for further use. While as; 100% pure neem oil was purchased from the Pansarri store, the local market of Pir Jo Goth was utilized for population control of lesser date moth and the methodology followed as described (Oleiwi *et al.*, 2020).

Application of bio-rational pesticides

The formulated bio-rational insecticides were applied at the initial appearance of the lesser date moth frequently at inflorescence stage. Each treatment was replicated three time interval basis, the extract was formulated from draying leaves and fruits. The spray was done through sixteen liters of water containing the capacity of a shoulder knapsack sprayer machine by adding 100ml of each extract solution per tank individually. The prescribed and recommended five tanks per acre were sprayed with each botanical insecticide in each replication. The agronomic practices such as; watering, ploughing, weeding, fertilizers, watering, tree canopy management etc., agronomic practices were maintained on each acre according to need basis.

Pest data collection

The date palm orchard leaves, trunk, and fruit were sprayed with recommended doses of bio-rational insecticides. In each replication, the east, west, north, and south sides of the host plants were observed and the infestation % was evaluated. After the application of bio-rational insecticides, data of the insect pest population were taken (RCBD) from each acre including control. The pest data was taken after the 3rd days, 7th days, and 10th post-spray days. Through the application of (Handerson and Tilton, 1955) formula bio-rational pesticides efficacy and reduction % of the pest population were calculated. ANOVA of the pest population was statistically analysed by the application of statistics software, SXW, 8.1 USA version. The least significant differences were calculated at (P<0.05) among the mean values and figures were made with the help of Origin 2017, 64 Bit software, respectively.

Results and Discussion

Lesser date moth population reduction % after 1st spray, 2020

After 1st spray, the bio-rational insecticides neem oil proved most effective against LDM 7th day at (62.33±11.61%), 3rd day (49.95±6.72%) and 10th day (43.46±7.48%) followed by neem leaves extract after 3rd day at (53.81±8.92%), 7th day (44.10±6.47%), 10th day (28.58±5.25%). The *C. gigantea*, 7th day at (44.77±6.72%), 3rd day (19.53±3.35%), 10th day (18.19±3.84%), and *C. colocynthis*, 7th day at (32.35±6.47%), 3rd day (28.05±5.10%), 10th day (15.28±3.32%). The neem oil and neem leaves extract were found to be more effective compared to *C. colocynthis* and *C. gigantea*. Whereas, time intervals found at (DF= 3; F= 275; P= 0.01) with significant difference in pest population after the application of neem oil, neem leaves extract at (DF= 3; F= 514; P= 0.02), *C. gigantea* at (DF= 3; F= 847; P= 0.05) and *C. colocynthis* at (DF= 3; F= 214; P= 0.04). The significant difference among the population reduction and days consumption was found at (P< 0.05), Tukeys test after doing one-way ANOVA. The maximum reduction % of the insect pest counted after the 7th day compared to the 3rd and 10th day of post-spray in all treatments. The values are shown as mean and standard error in three replications. The small and capital letters indicate the time interval difference in each treatment as depicted in (Figure 1).

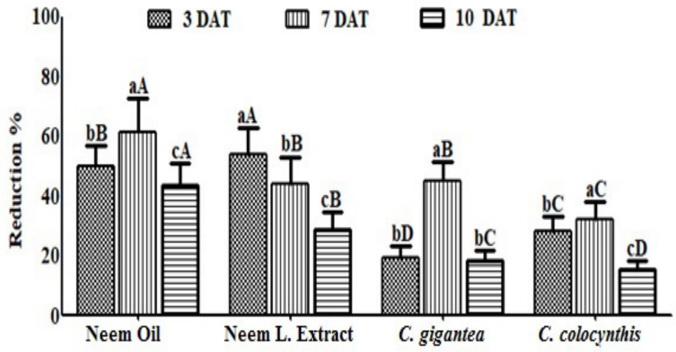

Figure 1: *LDM population reduction % after 1st spray at field conditions, 2020.*

Lesser date moth population reduction % after 2nd spray, 2020

The 2nd spray was performed to manage the population of lesser date moth and to determine the impact of the bio-rational insecticides. After 2nd spray, the neem oil was found with maximum effect after 7th day at (54.25±10.48%), 3rd day (45.46±6.31%), and 10th day (38.47±8.71%) followed by neem leaves extract at 3rd day (51.67±7.46), 7th day (38.10±7.52%) and 10th day (22.72±3.38%). *C. gigantea* after 7th day at (34.35±7.52%), 3rd day (21.42±4.55%), 10th day (15.46±2.81%) and *C. colocynthis*, after 7th day at (31.55±7.11%), 3rd day (27.08±5.31%) and 10th day (10.18±2.91%). The population reduction % of the insect pest after 2nd spray of the neem oil and neem leaves extract proved more efficacy power followed by *C. colocynthis* and *C. gigantea*. Whereas significant difference was found at (DF= 3; F= 3.15; P= 0.04) in pest population after the application of neem oil, neem leaves extract at (DF= 3; F= 735; P= 0.01), *C. gigantea* at (DF= 3; F= 264; P= 0.05), and *C. colocynthis* at (DF= 3; F= 265; P= 0.03). The analysis of variance and significant difference in the pest population and consumption of days was found at (P< 0.05), in one way. The data revealed that all treatments found maximum efficacy power after the 7th day of post-spray followed by the 3rd and 10th day. The values in (Figure 2) indicate the mean and standard errors in replications. While as; small and capital letters indicate the time interval difference in each treatment.

Lesser date moth population reduction % after 3rd spray, 2020

The 3rd spray was applied to overcome the infestation of lesser date moth. After spraying of bio-rational insecticides neem leaves extract found with maximum effect 3rd day at (52.81±6.75%), 7th day (35.10±6.81%) and 10th day (12.55±3.18%) followed by the neem oil at 3rd day (46.58±5.55%), 7th day (34.22±5.52%) and 10th day (30.44±8.28%). The bio-pesticide of *C. gigantea* after 3rd day at (27.51±5.15%), 7th day (24.55±5.12%), 10th day (23.16±3.59%), and *C. colocynthis*, after 3rd day at (37.07±6.11%), 7th day (31.33±6.11%), and 10th day (10.28±1.97%). A significant difference in pest population was found after the application of neem oil at (DF= 3; F= 188; P= 0.03), neem oil extract at (DF= 3; F= 107; P= 0.01). After the application of *C. gigantea* bio-rational insecticide, the significant difference was recorded at (DF= 3; F= 197; P= 0.05) and *C. colocynthis* at (DF= 3; F= 132; P= 0.03). The one-way ANOVA of the pest population and significant difference was found at (P<0.05). All applied bio-rational insecticides were found more effective on the 3rd day followed by the 7th and 10th day of post-treatment on 3rd spray against the population reduction of the LDM. The values in (Figure 3) show the standard error and mean population of the pest in replications, while as; capital and small letters represent the in time interval difference in applied bio-rational insecticides.

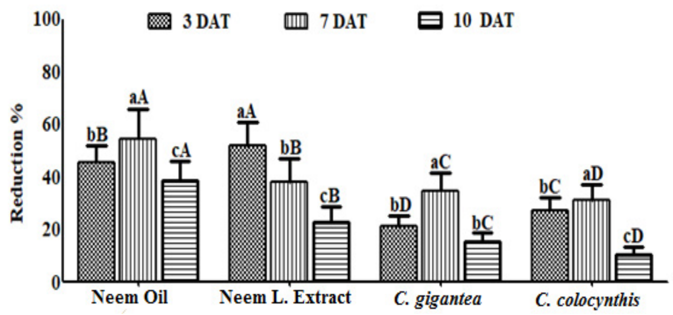

Figure 2: *LDM population reduction % after 2nd spray at field conditions, 2020.*

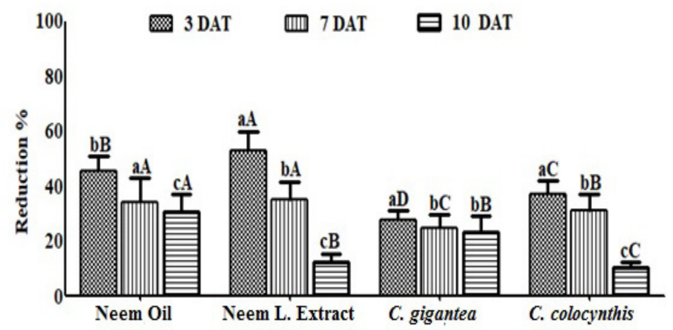

Figure 3: *LDM population reduction % after 3rd spray at field conditions, 2020.*

Lesser date moth population reduction % after 1st spray, 2021

In the 2nd year of study, same bio-rational insecticides were applied to overcome LDM population and for the authentic efficacy of the same bio-insecticides. After 1st spray, the neem oil proved with maximum effect after 7th day at (55.31±6.67), 3rd day (54.93±6.75%), and 10th day (35.51±6.46%) followed by neem leaves extract after 3rd day at (53.56±8.63%), 7th day (44.10±5.55%), 10th day (21.56±4.93%). The bio-insecticides *C. gigantea* after 7th day caused reduction at (43.33± 5.12%), 3rd day (29.31±6.25%), and 10th day (27.42±5.38%), *C. colocynthis* after 7th day at (32.11±6.18%), 3rd day (31.03±6.44%) and 10th day (12.28±2.87%) against the population reduction of LDM. After the spray of neem oil against the pest population were found with significant differences at (DF= 3; F= 443; P= 0.01), neem oil extract at (DF= 3; F= 898; P= 0.04), *C. gigantea* at (DF= 3; F= 606; P= 0.02), and *C. colocynthis* at (DF= 3; F= 361; P= 0.03). The significant difference was found at (P< 0.05). The maximum efficacy of all bio-insecticides was recorded on the 7th day, followed by the 3rd and 10th post-treatment days. The values are shown as mean ± SE in three replications, while as; small and capital letters indicate the difference in spray time intervals against the population reduction of the pest as shown in (Figure 4).

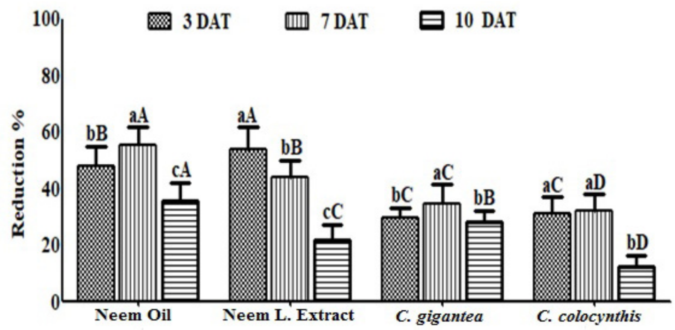

Figure 4: *LDM population reduction % after 1st spray at field conditions, 2021.*

Lesser date moth population reduction % after 2nd spray, 2021

To overcome the infestation of lesser date moth at field conditions, 2nd spray was done and the same bio-rational insecticides were applied against the pest species. After 2nd spray, the neem oil was found most effective, caused with maximum population reduction after 7th day at (49.22±6.41%), 3rd day (46.93±6.75%), and 10th day (25.45±7.91%) followed by neem leaves extract after 3rd day at (45.82±7.81%), 7th day (40.05±6.27%), and 10th day (16.62±4.12%). The botanical insecticide *C. gigantea* after 3rd day at (27.41±6.61%), 7th day (24.77±4.81%), 10th day (18.21±4.11%), the *C. colocynthis* extract after 3rd day at (33.06±5.66%), 7th day (26.31±5.14%), 10th day (12.38±2.17%) against the population reduction of LDM. After the application of neem oil, the significant difference was observed in the pest population at (DF= 3; F=242; P= 0.03), neem oil extract at (DF= 3; F= 648; P= 0.02), *C. gigantea* at (DF= 3; F= 362; P= 0.01) and *C. colocynthis* at (DF= 3; F= 335; P= 0.03), with significant differences at (P< 0.05) in the pest population at post-spray. The maximum control of all botanical insecticides against the pest population reduction % was recorded after 3rd day, followed by 7th day and 10th day of post-sprays. In all replication, the values are depicted in (Figure 5) as mean and standard errors in the population % of the pest. The capital and small letters show difference in the post-spray time intervals within each treatment.

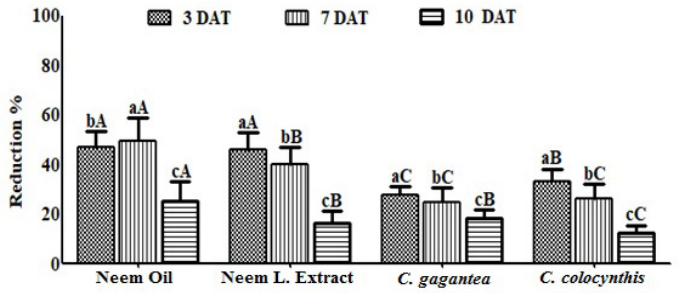

Figure 5: *LDM population reduction % after 2nd spray at field conditions, 2021.*

Lesser date moth population reduction % after 3rd spray, 2021

The 3rd spray was done at date palm field conditions for pest population reduction and determination of botanical insecticides effect against lesser date moth. After 3rd spray neem oil was found with maximum efficacy after 3rd days at (40.47±5.37%), 7th days (34.12±7.13%), 10th days (29.44±6.18%) followed by neem leaves extract after 3rd days at (41.81±8.11%), 7th days (38.10±6.12%), 10th days (13.32±2.72%). *C. gigantea*, after 3rd days at (25.13±5.11%), 7th days (19.12±3.24%), 10th days (16.15±2.82%), the *C. colocynthis*, after 3rd days at (39.08±6.72%), 7th days (25.51±4.92%), 10th days (14.22±2.11%) against reduction % of the lesser date moth at field conditions. A significant difference was found after the application of neem oil in 3rd spray at (DF= 3; F= 83.21; P= 0.03), neem oil extract at (DF=3; F= 637; P= 0.01), *C. gigantea* at (DF= 3; F= 58.21; P= 0.04) and *C. colocynthis* at (DF= 3; F= 58.21; P= 0.04). ANOVA found at (P< 0.05) in post-sprays. The maximum control of bio-rational insecticides against pest population was recorded after 3rd days, followed by 7th and 10th post-treatment days. The values are shown (Figure 6) as mean ± SE reduction % of the insect pest population. However, capital and small letters indicated the statistically significant difference within treatments in post-spray day's consumption.

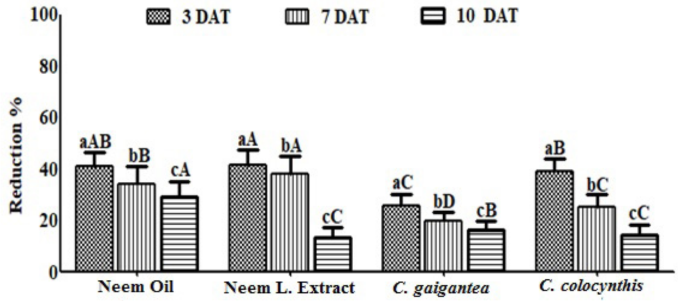

Figure 6: *LDM population reduction % after 3rd spray at field conditions, 2021.*

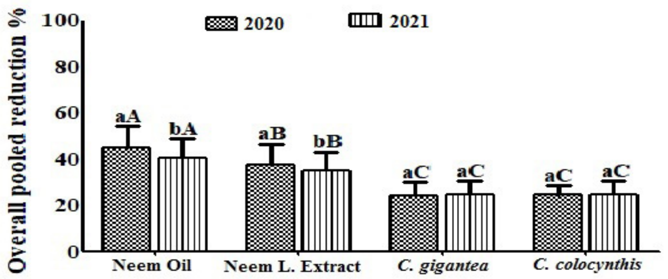

Figure 7: *The overall pooled reduction % of the lesser date moth in 2020-21.*

Overall pooled efficacy of bio-rational insecticides against LDM, 2020-21

The overall reduction % of the pest population, the neem oil found with maximum efficacy power at (50.25±9.72%), (43.30±8.14%) and (34.04±7.12%) in both years of the study, the significant difference found at (DF=1; F= 33.61; P= 0.04). The neem leaves extract caused (40.95±8.22%), (35.83±6.45%) and (34.08±6.28%) population reduction of the pest, at DF= 1; F= 9.13; P= 0.02) with significant difference. The botanical insecticide *C. gigantea* caused (30.43±6.46%), (23.60±5.81%) and (22.60±5.35%) control against the population reduction of the lesser date moth found at (DF= 1; F= 21.25; P= 0.04) significant difference. The bio-rational insecticide *C. colocynthis* efficacy was recorded at (25.19±5.11%), (23.43±5.73%) and (26.25±6.45%) in both years of the study with significant differences at (DF= 1; F= 15.18; P= 0.05), respectively. When data was subjected to analysis, the ANOVA found at (P< 0.05) among the pest population after all replications and treatments. The neem oil was found to be the maximum control, followed by neem leaves extract, *C.*

colocynthis, and *C. gigantea* in both years against lesser date moth species. The values are shown (Figure 7) as mean ± SE reduction population of the insect pest in both years in the date palm field. However, capital and small letters indicate the statistical difference in the pest population after post-spray in days consumption.

Pakistan is the 6th largest date fruit producer country throughout the world and Khairpur, Sindh is the central hub for growing novel date palm varieties, dates fruit are mainly infest by LDM larvae at ripening stages (Jatoi *et al*., 2021). Before this study, the biology of the same invasive insect pest species was studied under two different temperatures at the same locality (Jatoi *et al*., 2020). Generally, the larval stages of the insect pest feed an entire content of fruits and new emerging leaves (Mangrio *et al*., 2020). The findings of this study showed that after 1st spray against, lesser date moth, the neem oil caused maximum reduction 62%, neem leaves extract 53%, *C. gigantea* 44%, and *C. colocynthis* 32% population reduction of the pest in 2020. This is the work similarity of (Oleiwi *et al*., 2020) used mixture of eucalyptus + common myrtle, common myrtle, and eucalyptus found with positive effect against the population reduction of lesser date moth, these bio- insecticides caused 49.50, 50.30, and 37.20 %.

After 2nd spray the maximum pest population of the insect pest was reduced at 54% after the application of neem oil, 51% neem leaves extract, 34% *C. gigantea* and 31% *C. colocynthis*. This is more or less similar to work (Duso *et al*., 2022), find out the efficacy of *B. thuringiensis, spinosad, pyrethrins, azadirachtin,* and *Beauveria bassiana* natural insecticides against the population reduction of *Eupoecilia ambiguella*, a major key insect pest in vineyards and reported that the *B. thuringiensis* and spinosad were more effective than other bio- insecticides. After 3rd spray, the maximum control caused neem leaves extract at 52%, neem oil at 46%, *C. colocynthis* at 37%, and *C. gigantea* at 27% against LDM as documented (Ramzi and Biondi, 2021) released parasitoid, bio-pesticides, and parasitoid + bio- insecticide against the population reduction of *Tuta absoluta* and detected with positive prevalence. Sapkota *et al.* (2022), laid experiment against the population reduction of the *Plutella xylostella*, they sprayed *Beauveria bassiana, Metarhizium anisopliae,* and Azadirachtin found at 65%, 76%, and 95% effective against population reduction of the pest species.

In 2nd year of the study 2021, the neem oil caused maximum population reduction at 55%, neem leaves extract at 53%, *C. gigantea* at 43%, and *C. colocynthis* at 32% after 1st spray as reported (Iamba and Sandrina, 2020), they applied garlic extract, chili extract, and seasonal seaweed against the population reduction of *Plutella xylostella* L. and all the conventional insecticides proved effective against the pest population. After the 2nd spray the maximum population reduction caused by neem oil at 49%, neem leaves extract at 45%, *C. colocynthis* at 33%, and *C. gigantea* at 27%, this is more or less published work of (Oleiwi *et al*., 2020) applied *Bacillus thuringiensis* commercial formulation against the *B. amydraula* and counted 7.67% population reduction of the pest species. After the application of neem leaves extract botanical insecticides were found with maximum control at 41%, neem oil 40%, *C. colocynthis* at 39%, and *C. gigantea* 25%, as documented (Ngegba *et al*., 2022), discussed that the phytochemical in diverse plant species are most effective against myriads, and botanical insecticides are inexpensive, rapidly biodegradable, accessible, and widely available with little toxicity.

The neem oil proved with maximum control at 42.53, neem leaves extract 36.95%, *C. colocynthis* 24.96%, and *C. gigantea* 25.54% in both years of the study. This is work similarity of (Soares *et al*., 2019) documented that, like as lesser date moth, the *Tuta absoluta* is the wide destructive pest species of the Solanaceous, for their management they released *Nesidiocoris tenuis* predator along with botanical insecticides found significant control. Adouane *et al.* (2022), documented that, synthetic insecticide, the rosemary essential oil as an alternative against population reduction of *Ectomyelois ceratoniae*. For any insect pest management, the application of botanical insecticides or plant extracts is a broad ecological approach and key solution method and eco-friendly integrated pest management techniques are the best curative tools for future endeavours (Mangrio *et al*., 2020).

Conclusions and Recommendations

The district Khairpur is the biodiversity centre for date palms. Here more than three hundred date palm varieties are being grown of which the Aseel variety is the most commercial and considered as the "Queen" variety of this region. There are many insect pest species vigorously damaging to date palm orchards, of which *B. amydraula* is a destructive species causes more than 75% productivity losses. In this scenario, the eco-friendly botanical insecticides were applied and all were found effective against lesser date moth population reduction. Again, the wide use of insecticides should be limited because these toxic pesticides develop resistance power in insect pest species and relying adverse effects on human health. It is recommended that bio-rational insecticides are useful tools for preventing losses caused by insect pest species, recently botanical insecticides have exhibited potential alternatives against pest population control. It is strongly needed and an immediate call to implement advanced bio-rational insecticides to combat the LDM.

Acknowledgments

All authors extend gratitude to thank date palm growers of Prof. Dr. Abdul Khalique Jatoi's farm, where botanical insecticides were applied on date orchards against the population reduction % of lesser date moth, and pest data was gathered.

Novelty Statement

Khairpur is the main hub for date fruit production in Sindh-Pakistan. Aseel variety is the Queen and prominent variety of this region, but unfortunately this commercial variety is frequently harmed by lesser date moth pest species, in this context, there is dire need to introduce eco-friendly botanical extracts for the conservation and susceptibility against lesser date moth species.

Author's Contribution

Wali Muhammad Mangrio is the principal author of this research manuscript, who applied botanical insecticide at the date palm field, observed insect pest data as post-treatment, and wrote the paper.
Faheem Ahmed Jatoi statistically analysed pest data.
Hakim Ali Sahito supervised the research work in both years of the study.
Fahmeeda Imdad Sahito conceived designated and arranged tools.
Bhugro Mal participated in data collection.
Naseem Qureshi helped in proof reading and final editing.

Data availability statement

Due to ethical privacy, the finding of this research paper is available at the request of corresponding author.

Consent for publication

The corresponding author accepts all responsibility for publishing this scientific work.

Conflict of interest

The authors have declared no conflict of interest.

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