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Abstract

The lesser date moth, *Batrachedra amydraula* Merck is one of the most important pests affect date palm fruits, which cause great losses to the yield, whether in quantity or quality. This study was conducted in Basra province / Al-Qurna district to study the effect of harmal plant seeds on the numerical density, percentage and severity of infection caused by lesser date moth on the date palm trees. The results showed that the highest number of lesser date moths' population density was appeared in the fogging treatment (111.3 / trap), while the lowest was in the fumigation treatment (64.3 / trap). The lowest percentage of infection by lesser date moth was in the aqueous extract treatment of (29.7%), while the highest was in the fumigation treatment (31.4%). In the first period, the treatment of aqueous extract gave the best results, as the percentage of infection was (17.8%). The lowest rate of infection severity was also in the treatment of aqueous extract (2.2 / 5 fruit), while the highest was in the fogging treatment (6.5 / 5 fruit). In the third period, both treatments of fumigation and fogging gave the best results, as the infection severity was (0/5 fruit) compared to the control for the same period of (8.9 / 5 fruit). The treatment of aqueous extract gave the best results in reducing the severity of infection by lesser date moth, while the treatment of fogging gave the best results in reducing the number density of lesser date moth.

Keywords: Date palm, fogging, fumigation, infection, population, severity.

1. Introduction

The date palm (*phoenix dactylifera* L) belongs to the Arecaceae family and Arecales order, which is one of the monocotyledons trees. The date palm needs many service operations, the most important of which is the pollination of flowers (known as inflorescences) carried on female palm trees by means of flowers carried on male palm trees. Accordingly, they are called cross-pollinated dioecious palms [1]. The date palm, like other fruit trees, is affected by many pests that cause great losses, especially if they are left uncontrolled. The lesser date moth, *Batrachedra amydraula* Merck, and dust mites (dust spider), *Oligonychous afrasiaticus* Mcg, are the most important pests that affect the date palm fruits, which cause great losses to the yield, whether in quantity or quality [2]. The lesser date moth's adults lay eggs on the outside of fruits and hatch larvae that enter the date leading to its spoilage and fall, as the fruits turn into dry, small and hung on raceme by means of silk threads. Then, the color of fruits turns to red as a result of the larvae absorbing juice of these dates before they ripen. Also, perforated fruits can be seen near the neck, where the larvae move from one date to another by silk threads that weaved via the larvae. The first generation of larvae attack the flowers, which leads to their damage, while the second and third generation of larvae attack the fruits causing their fall in a large number [3, 4].
Worldwide, medicinal and aromatic plants have been used in several studies as a source of providing better health, bio-insecticidal, antibacterial, and antifungal activities [5-8]. Harmal plant, *Peganum harmala*, belongs to the family Zygophylaceae, and it is one of the wild and aromatic plants that are widely spread in central and northern Iraq. The seeds of harmal contain a high percentage of active compounds, especially the alkaline substances (Harmalin, peganine, hermalol and harmine) [9, 10]. There is a lot of research proving the vital efficacy of seed oil as an antibacterial and antifungal in treating

skin infections [11], cancer treatment [12] and toxic anthelmintic [13]. A relationship was found between the expulsion and attraction ratios of different concentrations of ethyl alcohol extract and aqueous extract for harmal seed oil, as the highest expulsion rates were recorded in adult insects on plants after 48 hours when exposed to the boiled and cold aqueous extract [14]. The extract of Harmal plant is found to be the most effective on both insects (rusty flour beetle and sawn grain beetle) in their larval and adult stages on the store grains with four concentrations 200, 400, 600 and 800 ppm [15]. The *P. harmala* seed oil is used in spices for its strong aroma [16], and it contains polyunsaturated fatty acids such as oleic, linoleic and palmitic [17]. *P. harmala* seeds are characterized by strong toxicity, as the study of [18] indicated that the aqueous extract of the seeds was fatal to rats as the lethal dose of 50% (LD_{50}) reached 420 mg / kg. [19] also showed that *P. harmala* oil had an effect on killing Khabrah larvae by 66% after a three-day period of treatment at a rate of 32.5 mg / ml. The percentage of killing in diamond-back moth larvae after treatment with ethanol extract of harmal seed at concentrations of 30 and 40 mg / ml was 66-100%, respectively [20].
Traps of all kinds (adhesive, light and pheromone) are one of the methods used to control certain pests or to identify the time and place of their appearance and determine the time of their peak. Yellow traps have been widely and effectively used in Iraq in controlling the white tobacco fly *Bemisia tabica* (Genn) in tomato fields [21]. Since the lesser date moth causes huge losses annually in the quantity and quality of Iraqi dates, in contrast the chemical pesticides that are used in controlling this pest are very expensive in addition to their harmful effect on the environment and public health. Therefore, it is very necessary to think about a safe and cheap way to control this pest and thus obtain high production and good quality. This study aimed to use the aqueous extract, fumigation and fogging of the seeds of Harmal plant to find out to what extent they can effect on the percentage and severity of infection by lesser date moth on dates of Al-Sayer variety, which is widely spread in Basra province.

2. Materials and Methods

This experiment was carried out in Basra / Qurna district, after selecting 12 palm trees of Al-Sayer variety. These trees were divided into four groups, at a rate of three replicates, in addition to the control treatment for each group. Different treatments were used for *P. harmala* seeds (Harmal seed fumigation, Harmal seed powder and aqueous extract of Harmal seeds). The numerical density, percentage and severity of lesser date moth infection were calculated before and under treatment as follows:

2.1. Spraying with aqueous extract of P. harmala seeds

Seeds of *P. harmala* plant were obtained from the local market, and the aqueous extracts were prepared with a weight of 100 gm from *P. harmala* seeds and placed in 500 ml of water and boiled for an hour after which the aqueous extract of *P. harmala* seeds was taken and placed in a glass container. Then, the aqueous extract was diluted to 10%, and 900 ml of water was added onto each 100 ml of extract [22]. The aqueous extract of *P. harmala* seeds was applied by a sprinkler.The treatment was applied to three replicates randomly and the numerical density, percentage and severity of infection with lesser date moth were calculated for ten days. After that, the spraying process was repeated after every four weeks, and the count was done on the basis of taking three racemes from each panicle of the three replicates, five fruits from each raceme (taken randomly from the middle of the panicle) was examined under an anatomic microscope. The fruit was divided by a blade or knife and placed under a microscope where it is examined and verified whether the fruit contains eggs or larvae of the lesser date moth. To calculate the numerical density of lesser date moths' adults, pheromone traps were used as in Figure 1.

Figure 1. A pheromone trap that used for calculating the numerical density of lesser date moth's adults.

The pheromone was provided by Agriculture Department in Al-Qurna with cartons divided into squares with an area of each square (1 cm^2), these cartons contain adhesive material as shown in Figure 2.

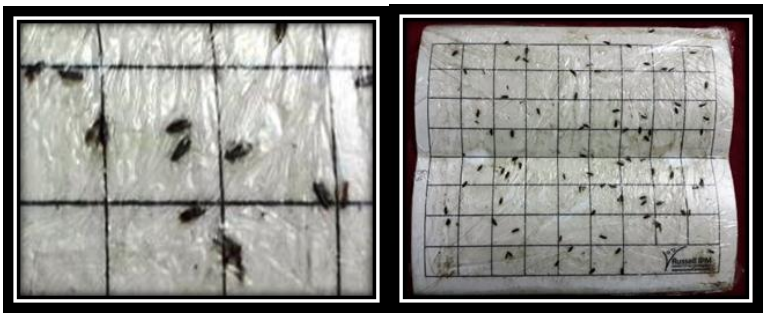

Figure 2. A picture of the adhesive carton that included within the pheromone tarps.

Traps were set up at a rate of 12 traps for an area (0.625 hectare) of the date palm. The numerical density of the lesser date moth was counted by calculating the number of moth attached to these adhesive cartons and the results were recorded in special tables prepared for this purpose [21].

2.2. Fumigation with harmal seed fume

The *P. harmala* seeds were fumed on burning coals and the fruits were fumigated with an evaporation device Figure 3.

Figure 3. An evaporation device that used to fume the harmal seeds on burning coals.

Each treatment was applied with three replicates randomly and the numerical density, percentage, and severity of lesser date moths' infection were calculated for a period of ten days, and the spraying process was repeated after every four weeks, and the counting was done on the basis of taking three dates from each raceme with three replicates. Then, five fruits from each raceme (taken randomly from the middle of panicle) were checked under an anatomical microscope. The fruits were divided by a blade or knife and placed under a microscope, where they were examined and verified whether the fruit contains eggs or larvae of lesser date moth. The numerical density of lesser date moth's adults is calculated using the pheromone traps described above.

2.3. Dusting with powdered harmal seeds

The *P. harmala* seeds were completely crushed and placed in a fogger as shown Figure 4.

Figure 4. A fogger device that used to dust the *P. harmala* seed powder.

Each treatment was applied with three replicates randomly and the numerical density, percentage, and severity of lesser date moth's infection were calculated for a period of ten days, and the dusting process was repeated after every four weeks. The counting was carried out on the basis of taking three dates from each raceme with three replicates. Then, five fruits from each raceme (taken randomly from the middle of the panicle) were examined under an anatomical microscope. The fruit was divided by a blade or knife and placed under a microscope, where it was examined and verified whether the fruit contains eggs or larvae of lesser date moth. The numerical density of lesser date moth's adults was calculated using the pheromone traps described above.

3. Results and discussion

3.1. Calculating the numerical density of lesser date moth's adults

3.1.1. Calculating the population density of lesser date moth's adults during the period of control treatment:

The result in Figure (5) showed that the highest numerical density of lesser date moth was at the first reading of the second treatment, which was (93 insects / trap). While, the lowest was at the first and second readings of the first treatment (zero insect / trap), as well as at the second and third reading of the third treatment and all the readings of the fourth treatment, which was (zero insect / trap). Since the traps were set at a rate of one trap for each replicate, this indicates that the attraction of lesser date moth's adults to the trap with no other factor being against the insect in the larval or egg stage and may lead to an increase in the numerical density in the traps due to the increase of lesser date moth's adults in the second and third generation. Al-Azzawi [23] reported that the numbers of lesser date moth's adults increases in April and early June.

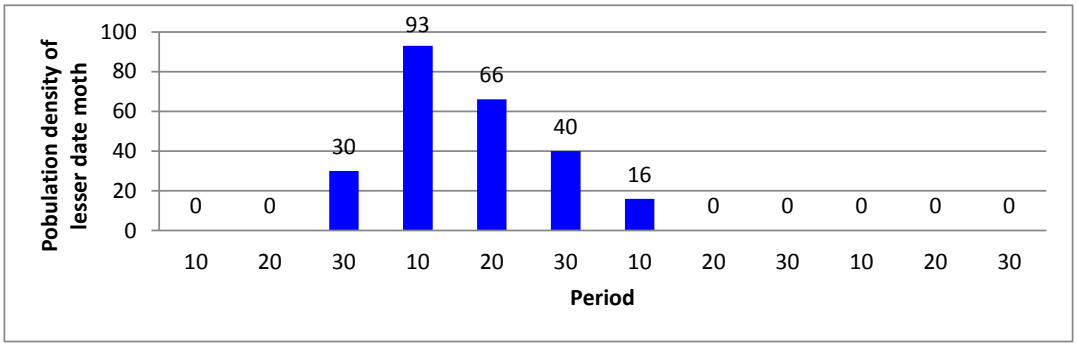

Figure 5. Population density of lesser date moth during the period of control treatment.

As for the first and second readings of the first treatment, as well as in the second and third reading of the third treatment, and all the readings in the fourth treatment, which recorded zero / trap, may be due to the fact that the appearance of adults in March as winter dormant period is less as a source of initial infection and also after May with the increase of temperature.

3.1.2. Calculating the numerical density of lesser date moth's adults during the period of fogging treatment.

The results in Figure (6) illustrate that the highest numerical density of lesser date moth was recorded at the second reading of the second treatment, which was (111.3 insects / trap). While, the lowest was at the first and second readings of the first treatment (zero / trap), as well as at the second reading of the third treatment and at all readings of the fourth treatment (zero / trap).

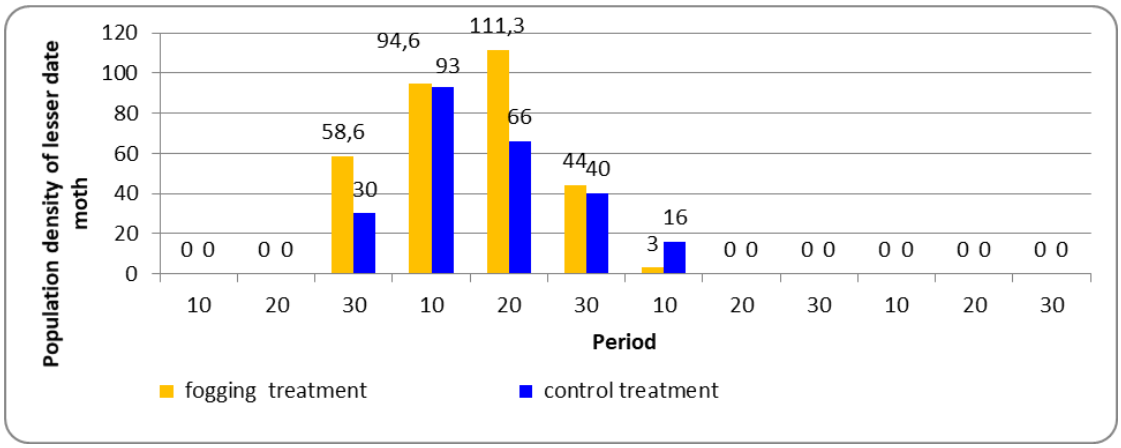

Figure 6. the calculation of the numerical density of lesser date moth's adults for the treatment of fogging of *P. harmala* seeds.

Since the traps were set at a rate of one trap for each replicate, this indicates that the attraction of lesser date moth's adults to the trap and also because the fogging does not penetrate into the fiber to reach the eggs or larval stage, as the lesser date moth's female lay its eggs inside the fiber or between palm trunks within white silk cocoons [23]. This leads to increase in the population on the traps due to the increase of lesser date moth's adults in the second and third generation because the fogging does not affect the eggs or larval stage. Whereas, the aqueous extract of the *P. harmala* plant was the most effective for the adults of red flour beetle and Saw grain beetle [15], and also was the most efficient in repelling the adults of house flies [14].

3.1.3. Calculation of population density of lesser date moth's adults during the period of evaporation treatment

The results in Figure (7) illustrate that the highest number of lesser date moth's adults under evaporation treatment was at the first reading of the second treatment, which was (64.3 / trap). While, the lowest was at the first and second readings of the first treatment, as well as at the second and third reading of the third treatment and at all readings of the fourth treatment, which were (zero / trap).

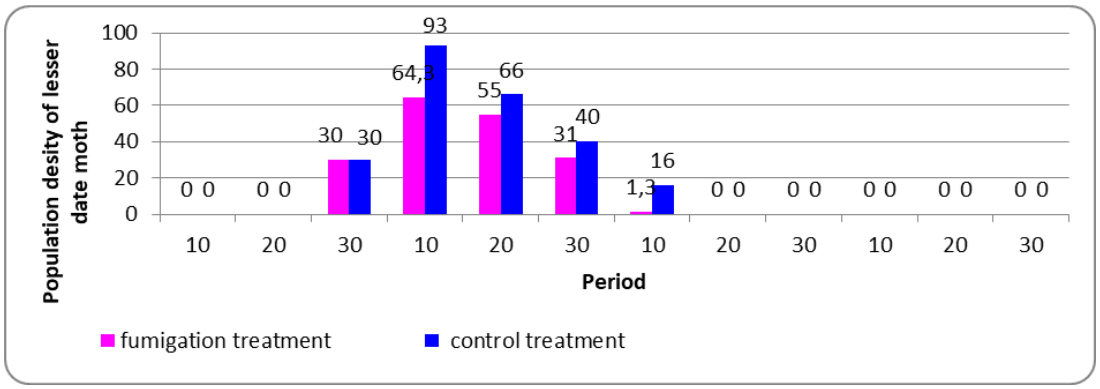

Figure 7. the calculation of numerical density of lesser date moth's adults for the fumigation treatment of *P. harmala* seeds.

Accordingly, it can be concluded that the average numerical density of lesser date moth's adults under evaporation treatment had decreased compared to the control and fogging treatments, and this may be attributed to the penetration of fumigation into the fiber and between the palm trunks, which affected the eggs and larvae of lesser date moth's adults. It may be attributed to the repellant effect resulting from the evaporation of *P. harmala* plant seeds that distance the adults from their biosphere, as they are weak-flying insects. Importantly, the Harmal plant seeds are considered toxic because they contain many compounds, such as flavonoids, tannins, reflux compounds, anthocyanins, and others [24].

3.1.4. Calculation of population density of lesser date moth's adults during the period of aqueous extract treatment

From the results in Figure (8), it was found that the highest numerical density of lesser date moth's adults under the aqueous extract treatment was at the first reading of the second treatment, which was (99.3/trap), while the lowest was at the first and second readings of the first treatment, as well as at the second and third reading of the third treatment and at all readings of the fourth treatment, which were (zero/trap).

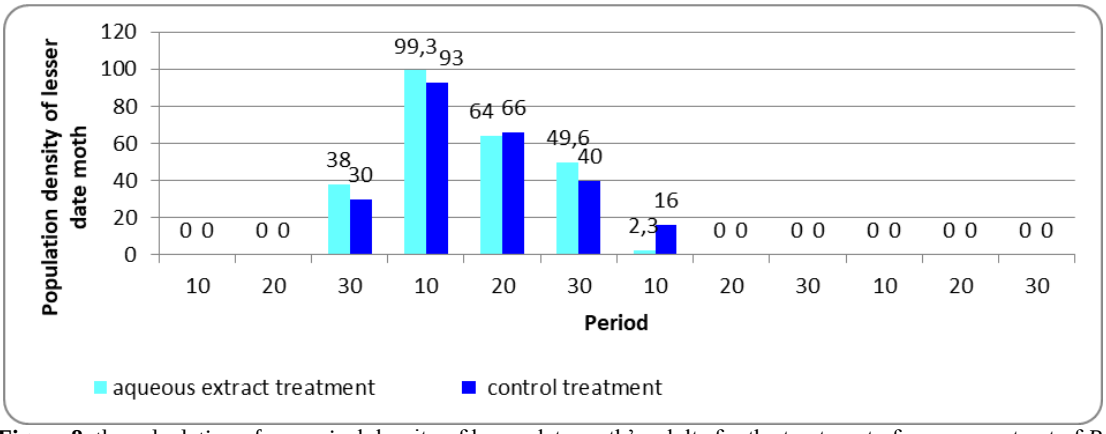

Figure 8. the calculation of numerical density of lesser date moth's adults for the treatment of aqueous extract of *P. harmala* seed.

Similarly, the traps were set at a rate of one trap for each replicate, this indicates that the attraction of lesser date moth's adults to the trap because the aqueous extract does not affect the moth's adults and does not have a repellant effect and does not affect the eggs or larval stage because it does not reach them, and this may lead to an increase in the numerical density in the traps due to the increase of lesser date moth's adults in the second and third generation. As the effect of *P. harmala* plant was on the survival of lesser date moth's larvae of the third generation at a rate of 66-100% after exposure to the treatment of ethyl extract at a concentration of 30- 40 mg / ml [20].

3.2. The effect of harmal seeds on the percentage of lesser date moth's infection on Al-Sayer date palm variety

The lowest percentage rate of infection caused by lesser date moth was observed in the treatment of aqueous extract of *P. harmala* seeds (29.7%), while the highest rate was at the treatment of evaporation (31.4%) compared with the control treatment (38.9%) as shown in Table 1. It was also found that the lowest rate of infection percentage by lesser date moth was in the fourth period, which was (0%), and the highest was in the second period, which was (75.3%), as shown in Table 1.

Table 1. shows the effect of harmal plant seeds on the percentage of lesser date moth's infection on Al-Sayer date palm variety.

Average of treatment effect	Infection % by period			Treatments
	3	2	1	
38.9	33.3	94.4	27.8	Control
31.1	33.3	67.8	23.3	Fogging
31.4	33.3	71.1	21.1	Evaporation
29.7	33.3	67.8	17.8	Aqueous extract
	3.3	75.3	22.5	Period average
	9	36	15.16	L.S.D

3.3. The effect of P. harmala plant seeds on the severity of lesser date moth's infection on Al-Sayer date palm variety

Interestingly, from the interaction among the treatments, it was noticed that the lowest percentage of infection was recorded in the fourth period that was similar to the control treatment (0%) due to indolence of moths in high temperatures that cause inactivity and limit spread of insects. While, the highest percentage of infection was recorded in the second period, which reached to 71.1 % compared with the control treatment (94.4%) in the same period. As for the percentage of infection that reached 17.8% when using the aqueous extract treatment compared to the control treatment 27.8% in the same period can be explained by the ability of aqueous extract of *P. harmala* seeds to kill the lesser date moth in panicles and racemes, which led to a decrease in the percentage of infection. Another explanation is may be due to the effect of aqueous extract of the *P. harmala* seeds in expelling the adults from fruits, and thus their inability to lay eggs. Al-Khafaji [14] indicated that the highest rate of expulsion of house fly's adults reached 66.2% with cold aqueous extract of the seeds of *P. harmala* plant after 24 hours of treatment as they contain a high percentage of alkaloids, or may be fatal if the larvae are exposed to it. This result is in agreement with Muhi-eldeen *et al.* [18] who reported the fatal effect of the aqueous extract of *P. harmala* seeds on rats when using the lethal dose (LD_{50}) of 420 mg /kg.

From the results shown in Table (2), it was found that the lowest percentage rate of infection by lesser date moth in the treatment of aqueous extract of *P. harmala* seeds (2.2 / 5 fruit). While, the highest rate was recorded in the treatment of fogging (6.5 / 5 fruit) compared to the control treatment (20.6 / 5 fruit). In terms of infection severity by lesser date moth, it was found that the lowest rate noticed in the fourth period (0/5 fruit), while the highest rate was recorded in the second period (26.2 / 5 fruit).

Table 2. shows the effect of harmal seeds on the severity of lesser date moth's infection on Al-Sayer date palm variety.

Average of treatment effect	Infection % by period			Treatment
	3	2	1	
20.6	8.9	60	13.3	Control
6.5	0	21.4	4.4	Fogging
6.4	0	18.9	6.7	Evaporation
2.2	2.2	4.4	4.4	Aqueous extract
	2.2	26.2	7.2	Period average
	12.39	6.2	6.2	L.S.D

Remarkably, from the interaction among the treatments, it was found that the lowest severity of infection recorded at the treatments of fogging, evaporation and aqueous extract of *P. harmala* seeds in the fourth period, and at the treatments of evaporation and fumigation in the third period, which were similar to the control treatment (zero / 5 fruit) during the fourth period. While, the highest severity of infection was recorded at the fogging treatment with *P. harmala* seeds (21.4 / 5 fruits) in the second period compared to the control treatment (5/60 fruits) in the same period.

From the results above, it can be clearly stated that using the seeds of *P. harmala* plant whether as fogging, evaporation and aqueous extract treatments can lead to the least severity of infection by lesser date moth in the fourth period. This statement may be attributed to the absence of lesser date moth during that period due to the unfavorable environmental conditions for its spread. While, when using the treatments of fumigation and evaporation in the third period, the severity of infection was (zero / 5 fruit) compared to the control treatment (8.9 / 5 fruit) in the same period. This may be attributed to the toxicity of harmal seeds and their killing action to lesser date moth. Al-Faidi [15] stated that the use of aqueous extract of *P. harmala* plant increased the death rate to kill the larvae of stored grain insects, reaching 93.3-100%. This result is in agreement with the findings of Tahrouch et al. [25] who indicated that *P. harmala* seeds contain turbine compounds at high rates (25) %, especially the active compound dihydrobenzofurane 2.3.

Conclusions

The effect of harmal plant seeds on lesser date moth was evident through the results. Where the percentage of infection was reduced in the aqueous extract treatment (29.7%) and the fumigation treatment (31.4%) compared with the control treatment (38.9%). The lowest rate of infection severity was in the treatment of aqueous extract (2.2 / 5 fruit). In the third period, the two treatments of fumigation and fumigation gave the best results, as the infection severity was (0/5 fruit) compared to the control treatment for the same period (8.9 / 5 fruit). The study showed that the treatment of aqueous extract gave the best results in reducing the percentage of infection and the severity of infection caused by lesser date moth.

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