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The Role of Mineral and Natural Oils in Integration with Inorganic Salts and Some Insecticides in Suppressing the Invasion of the Red Palm Weevil *Rhynchophorus ferrugineus* (RPW) Affecting Date Palms with Estimation of Its Residues in the Resulting Date Fruits

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Abstract

Applied experiments were conducted in the palm orchard in the Nubaria region. The orchard includes the varieties of Al-Barhi (imported) and Zaghloul (local) to examine the efficacy of some natural materials alone and in combination with some pesticides against the Red Palm Weevil *Rhynchophorus ferrugineus* (RPW) that infects palm trees in Egypt. Most insects caught by light traps, which have a role in the spread of the red palm weevil in palm groves, appear in early February and March. Peak numbers for the month of May until September namely *Phyllgnathus excavatus*. *Pseudophilus testaceus*, *Phonapata frontalis*, and *Oryctes elegans*. The neglected gardens of date palms are more compensating for insect infestation than those maintained in terms of agricultural and pest control services. Individual injection of insecticide (Mosspilan) was the most potent against RPW-infested Barhi var. with a recovery rate of 91.7%, followed by Selikron at 80%, and finally Saydon at 37.5%. Injection of the car oil used with Mosspilan followed by Selikron was effective against RPW. No significant difference between treatments of injection (F-value: 1.2). Mixing injection of mineral oils with chemical pesticides is effective against red palm weevil after two successive seasons. As a result, the pesticide was poured around the affected palm root, with a low recovery rate. There is no effect of palm spray. The best way to control the red palm weevil is the method of injecting the tested material (single or mixed) with the pure

pesticide into the trunk of the infected palm tree. The tested pesticide residues gradually decrease as the period after application is prolonged with an average loss of 0.12, 0.02 and 0.07 ppm after 90 consecutive days.

Keywords

RPW, Palm Varieties, Light Traps, Mineral Oil, Pesticides

1. Introduction

Cultivation of date palm varieties is widespread in various governorates of Egypt such as Matrouh, New Valley, North and South Sinai and the newly reclaimed lands with the production of 760 thousand tons of date fruits, equivalent to about 16% of the total fruit production. Egyptian date palm trees were invaded by many insect pests and others. It helps to infest the palms with the most dangerous date palm pest, especially the red palm weevil, *Rhynchophorus ferrugineus* Oliv. (RPW). It was discovered in Egypt at the end of 1992 in the Sharkia governorate, and then spread to the country's governorates, where all varieties of palm trees were attacked, which led to a decrease in date production about 25% loss in productivity and limited the spread of palm plantations in many areas and threatens national wealth in Egypt. Immediately, specialists in pest control began spraying the infested palm trees with different insecticides at several times to reduce the activity of the insect, but to no avail, although there are deep concerns now about environmental pollution and the emergence of insect resistance to the act of pesticides used [1]. Increasing the population of RPW and multiplying its harm, as this leads to a decrease in the number of palm trees over time, despite the great efforts made by the state to control it. [2] mentioned that about 2.2% of the whole number of palm trees in Egypt were infested until the year 2000. So the red palm weevil, *R. ferrugineus* (Olivier) has become a major source of economic loss in date production, especially in the Middle East [3].

In view of the danger of RPW and its economic importance, [4] mentioned that it is necessary to implement an integrated pest control program with an emphasis on biological methods in order to achieve significant progress in pest control for protecting the environment from pollution caused by the excessive use of chemical pesticides in pest control. For several years, plant protection specialists have focused on the search for effective alternatives for insect control and safe for humans in order to achieve progress in pest control and reducing pollution to the environment [4].

Studies on the host preference and its biological effects on RPW were to search for bio-alternative materials in control *R. ferrugineus* (Olivier) infesting palm trees [5]. In the same trend, inorganic salts, mineral oils and pesticides (individually and mixture) were applied [6], which gave high protection against RPW (100%) recovery for all tested palms. For this purpose, a field study was conducted [7] to

explore the effect of friendly and pesticide products against RPW pest and its effect on total carbohydrates and micronutrients in resulting date fruits. The present study aims to the following points:

1) Using light traps to participate in the survey and reduce the number of insect pests that attack palm trees and help the spread of RPW.

2) Using some environmentally friendly materials such as used car oil (alone and mixed) with some chemical pesticides in order to rationalize the use of chemical pesticides.

3) Estimating the residues of tested pesticides in the produced fruits from the treated palms in order to produce safe dates for human consumption while maintaining a clean environment from chemical pollution.

2. Materials and Methods

2.1. Experimental Tools

1) Light traps.

2) Mineral oils: petroleum oil (used motor oil). Only one liter (single or mixed).

3) Chemical pesticides: Profenofos (Selikron at 72% EC), Dimethoate at 40% EC (Saydon) and Acetamiprid (Mosspilan at 20% EC). Only one liter in single use 500 Sm in mixed).

The light traps: An orchard includes Barhi var. (imported palm) and Zaghloul (local variety) which suffer from a wide spread of palm borers, especially the red palm weevil *Rhynchophorus ferrugineus* Oliv. (RPW). The light traps (five traps) were placed in five locations in the palm grove. The distance between traps is about 500 m. Each trap consists of an electrical lamp, funnel and glass jar (3 kg) to collect insects. The captured insects were counted weekly and classified in the laboratory then saved in refrigerator. Monthly trapped insects were collected and statistically analyzed.

2.2. Natural Oils and Chemical Pesticides

Mineral oils: Used car oil was tested alone and in combination with insecticides using different techniques (injection, pouring and spraying).

Chemical insecticides: Used pure without dilution (alone or mixed).

Sampling of fruit produced: 100 grams of date fruits were taken from each treated palm from May till September. Samples were collected three times per month and kept frozen for pesticide residue analysis.

2.3. Chemical Analysis for the Detection of Pesticide Residues

Fruit samples were collected at different periods (60, 70, 80, 90 days) after treatment. All samples were placed in sample bags and stored in a deep freezer until chemical analysis. Pesticide residues were estimated according to [8] with minor modifications. Five ml of n-hexane was added to the extracts, and then it was concentrated to 0.5 ml for GLC analysis. All solvents and chemicals used were Pesticide analytical grade reagents free of interfering residues. As tested by gas

chromatography.

3. Techniques of Treatment

3.1. Injection Method

3 - 4 aluminum tubes (30 cm in length and 2 cm in diameter/tube) were inserted 25 cm into the affected stem at an angle of 45˚ above the active cavity with a distance of 15 - 20 cm. Leave 5 cm/tube outside the treated stem to pour the tested material. The tubes are distributed around the treated trunk with zigzag positions. The tested material is poured into the aluminum tube at a rate of 25 cm tested material/tube. The tubes were supplied with the tested materials within 15 - 21 days as needed using small funnel.

3.2. Pouring Method

Four circular holes were dug in the soil around the base of the affected palm (diameter 30 cm - depth 30 cm), then the tested material was poured into each pit (2 L tested material/pit). Each hole was filled with soil extracted from it and immediately irrigated with water.

3.3. Spray Method

The trunk and stem of the affected palm were sprayed each month with a solution of the tested materials (6 L/tree) using a back sprayer (20 liters capacity).

3.4. Examination of the Treated Palm

The number of active holes which the plant sap fluid of the treated palm is still bleeding (recovered), while those stopped the sap bleeding were recorded.

3.5. Statistical Analysis

Data are recorded and subjected to one-way Analysis of Variance (ANOVA) and T test.

4. Results

The results shown in Table 1 indicated that the collected insect pests that aid the spread of RPW such as stem borer, *Oryctes elegans*, palm stem beetle, *P. excavatus* borer, and frond pit, *Phonapate frontalis*, start appearing in early February in gardens. Date palm in Egypt, while the appearance of the long-horned date palm borer, *Pseudophilus testaceus*, began in early March. The numerical peak of *O. elegans* was recorded in May, while the numerical peak of *P. frontalis* appeared in June. The peak *of P. testaceus* and *P. testaceus* was obtained in July.

The results in Table 2 showed that the insect infestation rate of palm trees in the neglected gardens was higher than the insect infestation in the palm gardens where the agricultural and pest control services were conducted in the respective park (T-value: 4.7).

Table 1. Numerical fluctuation of insect pests collected by light traps in the farm of date palm during seasons 2018-2019 Nubariya, Beheira Governorate, Egypt.

Insect	Collected number of insects caught by light traps during Months of experiments												Total	**Aver. ± SD**
	Feb. 2018	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. 2019		
The bunch stalk Borer *(O. elegans)*	4	12	41	63	35	25	15	5	2	0.0	0.0	0.0	202	**22.4 ± 20.6**
Palm stem borer Beetle (*P. excavatus*)	7	17	24	34	56	79	129	225	130	40	10	11	762	**63.5 ± 66.7**
The longhorn date Palm borer (*P. testaceus*)	0.0	5	23	45	60	72	0.0	0.0	0.0	0.0	0.0	0.0	205	**41.0 ± 27.2**
The frond borer (*P. frontalis*)	7	30	64	75	80	50	40	13	5	0.0	0.0	0.0	364	**40.4 ± 28.8**

Note: F-value: 1.17, no significant difference.

Table 2. Monitoring the activity of date palm insects in the concerned date palm gardens and those neglected in the agricultural service.

Item	Insect infestation during experiment months												Total	**Aver. ± SD**
	Feb. 2018	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. 2019		
Insect infest. % in a cared garden	0.0	0.0	3	4	4	5	6	7	3	3	0.0	0.0	35	**4.4 ± 1.5**
Insect infest. % in a neglected garden	0.0	0.0	5	20	25	30	35	40	55	60	70	70	410	**41.0 ± 22.0**

Note: T-value: 4.7, significantly difference between the two treatments at 0.05 and 15 df.

The data presented in Figure 1 showed that the injection of Mosspilan into the affected palm trunk (Barhi var.) resulted 100% recovery, followed by Selikron 80% and finally Saydon (insecticide) 41.7%.

The results showed that the infested cultivar (Zaghloul) was less responsive to recovery from RPW infestation when treated with Mosspilan and Selikron, the cure rates ranged from 62.5% - 63.4%. The results showed that the single injection of pesticides was less effective against the red palm weevil, *R. ferrugineus* as it caused about 37.5% of the treated palms to recover. The data showed that spraying the palm or pouring the pesticide in the holes around the roots of the affected date palm has no effect on the red palm weevil. On the other hand, the results showed that the response rate of Al-Barhi cultivar to recover from infection was higher in all treatments than the Zaghloul cultivar.

The results in Figure 2 showed that the recovery of date palms in the two treated cultivars (Zaghloul and Barhi) increased with continued treatment for two successive seasons of the affected palm trees when using a mixture of mineral oils (petroleum oil) with chemical pesticides (Mosspilan or Selikron). The data

recorded in (Table 3) showed that after 60 days of use, the measured pesticide residues such as Profenofos (Silikron), Acetamiprid (Mosspilan) and Dimethoate (Sidon) in the ripening stages of date fruits were 0.3, 0.18 and 0.21 ppm (60 days after application) in a row. These amounts decreased after 70 days to 0.21, 0.11 and 0.14 ppm. The rate of decrease for residues was 0.12, 0.02 and 0.07 ppm after 90 days, respectively.

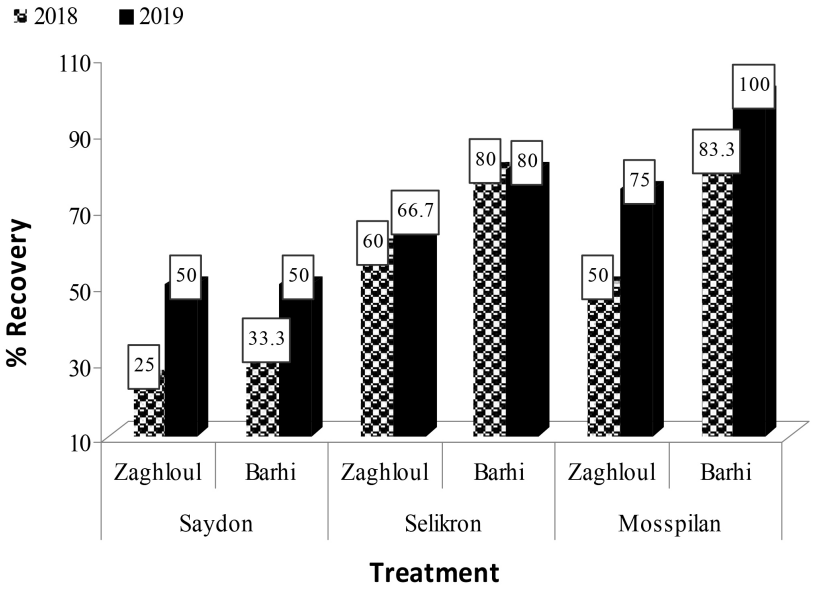

Figure 1. Effect of some chemical insecticides on the field activity of the red palm weevil, *Rhynchophorus ferugienus* infesting date palm trees. F-value (0.05): 13.13, no significant difference between the treatments.

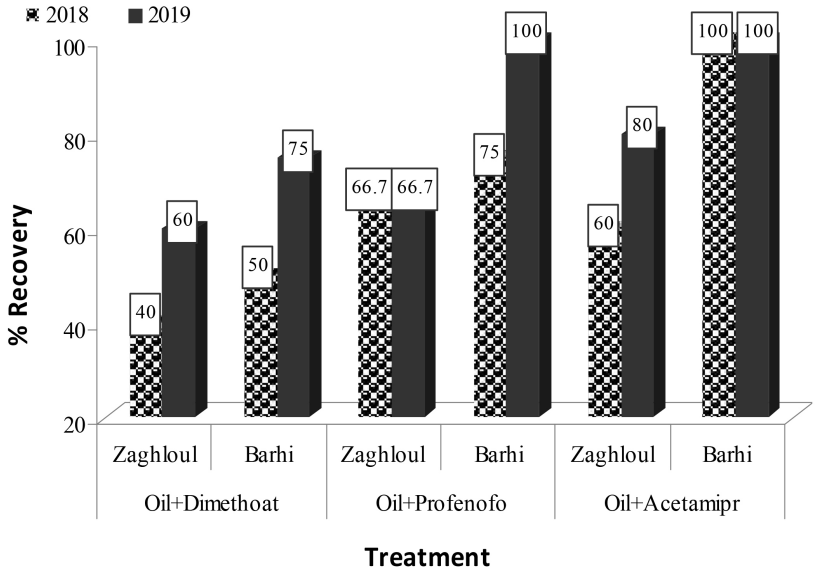

Figure 2. Effect of petroleum oil in combination with chemical insecticides on the red palm weevil *Rhynchophorus ferrugienus* under field conditions. F-value (0.05): 1.2, no significant difference between averages of recovered holes (post treatment) and injection treating the tested mixtures.

Table 3. Insecticide residues (ppm) in the date fruits at different intervals of application.

Periods after treatments	Residues of chemical insecticides		
	Profenofos (Selikron)	Acetamiprid (Mosspilan)	Dimethoate (Saydon)
60 days	0.3	0.18	0.21
70 days	0.21 (30.0)	0.11 (38.9)	0.14 (33.3)
80 days	0.16 (46.7)	0.08 (55.6)	0.1 (52.4)
90 days	0.12 (60.0)	0.02 (88.9)	0.07 (66.7)

Note: ND = None Detected.

5. Discussion

The present results indicated that the insects that help spread of the red palm, weevil, *R. ferrugineus* began to appear in early February and March, but the peak number of insects was recorded in the months from May to September based on the activity of each insect, which is more consistent with the results obtained [6], Where they found that the largest number of insects caught by the light trap in the palm grove was in the months from April to August, and the number decreased in December-January.

Recent studies have shown that the epidemiological spread of the red palm weevil *R. ferrugineus* may lead to the death of palms within a year or two, which limits the spread of palm plantations in many areas and threatens the national wealth in Egypt [1]. The light traps used in the current study showed that the most common insect pests found in the neglected palm gardens are *O. elegans*, which helped the spread of the red palm weevil among the palm trees, and the death of infested palms, which led to a decrease in the production of dates. So date palm trees have been suffering from the severe damage caused by the red palm weevil. [9] reported that insecticides (chlorpyrifos, endosulfan and methionone) were recommended by 0.1% to control *R. ferrugineus*. [10] mentioned that the major components of the IPM strategy are trapping the weevil using pheromone lure and monitoring reported detection of infestation by examining the palm, eliminating hidden breeding sites, clearing abandoned gardens and maintaining the sanitation of crops and fields, preventive chemical treatments, curative chemical control, implementation of quarantine procedures, training and education.

[6] found that the dispersal of Vuoradan granules (a soil pesticide) placed inside the dug holes surrounding the affected palm trees (100 g/hole) resulted in a recovery of 66.7% for the imported cultivars and about 33.3% for the local cultivars. The residues of the tested pesticides present in the decrease in the residues persisted by 60.0%, 88.9% and 66.7% as residues for the tested compound after 90 days, respectively. That is the tested pesticide residues decrease in different proportions with time after application.

The current study suggested that the difference in the sensitivity of palm cultivars to Red Palm Weevil (RPW) infection may be due to the difference in the components of palm cultivars, which makes it necessary to take all control measures in an integrated manner to reduce the damage caused by the red palm weevil, *R. ferrugineus*.

6. Conclusions

1) The data obtained from this applied study show that the most common insect pests in the date palm gardens are the palm stem borer *P. excavatus*, the longhorn palm borer *P. testaceus* and the frond borer *P. frontalis*, which have an influencing role in the spread of RPW on orchard of palm in Egypt. The assistant insect pests begin to appear in early February and March. The peak is from May till September. The lowest population was obtained in December and January.

2) The most powerful insecticides that have been injected individually against *R. ferrugineus* are Mosspilan followed by Selikron and finally Saydon.

3) Injection dates, the mixture of mineral oil (car oil used) with chemical pesticides (Mosspilan followed by Selikron) was the most effective against RPW.

4) Gradual reduction of chemical residues of the tested pesticides to different degrees over time after use.

The present study suggested that the integration of biological and chemical actions is absolutely necessary to reduce the damage of the red palm weevil *R. ferrugineus* Oliv. as well as insect pests that help spread. This saves the quantities of tested compounds, reduces costs, protects the environment from chemical pollution and reduces adverse effects on consumer health.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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