

# Field Exploration of the Efficacy of Some Friendly Products in Combination with Some Pesticides against the Red Palm Weevil *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae) and Its Effect on Total Carbohydrates and Micronutrients in the Resulting Date Fruits

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## Abstract

Experiments were carried out against the red palm weevil, *Rhynchophorus ferrugineus* (Oliv.) (RPW in a private palm orchard containing varieties of Samani (domestic) and Ikhlas (imported) infested with the red palm weevil *Rhynchophorus ferrugineus* (Oliv.) (RPW) in El-Marg area, Cairo Governorate, Egypt, using Petroleum oil, Jojoba oil, and Inorganic salts, singly and mixed with each of insecticides (Acetamiprid, Profenofos, Dimethoate) by injection and spraying of infested palm trunks, as well as pouring these substances into pits around the roots of the affected palm trees. The data showed that Acetamiprid was the most effective against RPW. The effective mixtures against *R. ferrugineus* were Jujuba oil with Acetamiprid, also used car oil with inorganic salts, which resulted in 100% recovery of treated palm. Continuing treatment of infested palms for 6 consecutive months by injecting used car oil mixed with inorganic saline solution resulted in 100% recovery for both date palm cultivars. Spraying these substances on the affected trunks had no effect on RPW. Pouring the tested solutions around the roots of the affected palm had the least effect against RPW. Injection of the tested pesticides into the infested trunks increased the concentrations of carbohydrates and total micronutrients (Fe<sup>+</sup>, Mn<sup>+</sup>, Zn<sup>+</sup>, and Cu<sup>+</sup>) in the produced fruits more than those obtained by palms treated with mineral oils and inor-

ganic salt, compared to the control group. There is a significant difference between the treatments.

## Keywords

RPW, Pesticides, Natural Oils, Jujupa Oil, Inorganic Salts

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## 1. Introduction

Palm trees, like other fruit crops, are affected by many insect pests. The red palm weevil *Rhynchophorus ferrugineus* (RPW) is considered one of the most dangerous pests that attack palm trees not only in Egypt but also in Arab and Asian countries, where scientific references indicate the spread of the insect *R. ferrugineus* (Oliv.) in East Asian countries and moved to the Kingdom of Arabia Saudi Arabia, then the Gulf states. RPW entered Egypt at the end of 1992, where it appeared in the Sharkia Governorate and spread in various regions of the country, where it attacked all palm varieties, the most important of which were Zaghloul, Hayani, Samani, and ornamental palms. It has been reported that dates are low in fat and protein, but rich in sugars, especially fructose and glucose, which are a high source of energy in addition to dozens of minerals, the most important of which are selenium, copper, potassium, and magnesium [1]. The red palm weevil *R. ferrugineus* is active all year round, adults are most active during the summer months, when they have a greater ability to fly more than three kilometers per day also, Infestation by RPW can lead to severe damage to palm trees, followed by heavy losses in the quantity and quality of the resulting dates [2]. Furthermore, palm damage was found to occur mainly from the larvae of the two major palm species involved, *Phoenix dactylifera* and *P. canariensis*, but it can attack some other ornamental trees in the Mediterranean region [3]. It gained a foothold in the date palm *dactylifera* in several Middle Eastern countries as it moved to Africa and Europe, mainly due to the movement of infested planting material [4]. It has become a major source of economic loss in date production, especially in the Middle East region [5].

Several scientific researchers have evaluated the effectiveness of six synthetic insecticides using injection methods against the immature stages of the red palm weevil *R. ferrugineus* (Oliv.), and it turns out that the most effective against the insect were Pyriban<sup>®</sup> and Keiton<sup>®</sup> (62.5%), followed by Egycron<sup>®</sup> (58.3%), Fenthion<sup>®</sup> (37.5%), Fury<sup>®</sup> (29%) and Reagent<sup>®</sup> (25%). While the biocomplexes were less effective than synthetic insecticides, Biovar<sup>®</sup> (12.5%) and Avermectin<sup>®</sup> (4.1%) at a concentration of 0.3% [6]. Several researchers have contributed to suppressing the severity of the red palm weevil using biochemicals [7]. Others have evaluated the activity of three essential oils (EOs) E and aerobic fractions of A. as an alternative environmentally friendly method for the management of red palm weevil.

Some researchers have tested four vegetable oils from *M. officinalis*, *B. officinalis*, *L. nobilis*, and *C. ipecacuanha* to estimate their efficacy as insecticides, their effect on some biogeographical aspects, the morphological abnormalities at all stages, and it was found that the four oils tested disrupted some biological aspects of the tested insects [8].

In this direction, the sensitivity of the red palm weevil to Egyptian essential oils extracted from *S. aromaticum* and *C. eucalyptusa* was evaluated which has found that essential oils can be included as an integral part of an integrated pest control program against *R. ferrugineus* [9]. Through scientific experiments, it was concluded that early detection of RPW infestation in the Mediterranean region is important for the success of any integrated pest management program against red palm weevil, where the movement of agricultural materials from infected farms from one country to another must be stopped [4]. Through the results of the research published in the field of combating the red palm weevil, which has been conducted so far, it has been concluded that it is necessary to focus on natural alternatives as a tool in the integrated control program to overcome the damages of this dangerous insect strain that threatens palm productivity, not only in Egypt but also in other countries of the world.

Hence, this work aims to study the following points:

- 1) Evaluation of the role of some natural materials alone and complementary to some pesticides in controlling *R. ferrugineus* (Olivier) that invades palm trees in order to rationalize the use of chemical pesticides in order to protect the environment from pollution.
- 2) Estimation of the effect of natural substances and pesticides on total carbohydrate and micronutrient concentration in the resulting dates to provide a safe food product for the human consumer.

## 2. Materials and Methods

The average insect infestation was estimated using the following equation:

Enumeration of the infested holes (**Table 1**) in palm trees (Samani and Ekhlal), before starting the experiment using the following equation:

The average number of infested holes =  $(A/B) \pm SD$ .

A: total number of infested holes for the tested variety;

B: number of treatments.

The average % of recovery from injury after treatment was compared for the two varieties (Samani & Ikhlal) using the following equation:

Average % recovery =  $(a/b) \pm SD$ .

a: Total % recovery in the item regardless of treatment type;

b: number of treatments.

### 2.1. Quantities of Individually Tested Material

A—Natural oils: Jojoba oil (1 liter), B—Mineral oils: Used car oil (1 liter), C—Inorganic salts: zinc sulfate—calcium hydroxide—potassium iodide—calcium

**Table 1.** Effect of natural oil (Jujuba oil, petroleum oil), inorganic salts and pesticides in the control of the red palm weevil which attacks the Samani and Ekhlas varieties in orchard of date palms.

Materials	Methods	Samani						Ekhlas					
		No. of infested holes/tree (pre-treat.)	Accumulative no. of recovered holes (stop bleeding) post-treat. (month)			Total Recovered holes	% Recovered holes (6 months After treat.)	No. of infested holes/tree (pre-treat.)	Accumulative no. of recovered holes (stop bleeding) after treat. (month)			Total Recovered holes	% Recovered holes (6 months After treat.)
			2	4	6				2	4	6		
Jujupa oil	Injection	4	0.0	0.0	1	1	25	2	0.0	0.0	2	2	66.7
	Pouring	3	0.0	0.0	0.0	0.0	0.0	3	0.0	0.0	0.0	0.0	0.0
	Spray	2	0.0	0.0	0.0	0.0	0.0	2	0.0	0.0	0.0	0.0	0.0
Inorganic Salts	Injection	3	0.0	1	2	2	66.7	3	0.0	2	3	3	75
	Pouring	2	0.0	1	0.0	1	50	4	0.0	0.0	1	1	50
	Spray	2	0.0	0.0	0.0	0.0	0.0	2	0.0	0.0	0.0	0.0	0.0
Used Car oil	Injection	4	0.0	2	3	3	75	3	1	2	2	2	100
	Pouring	4	0.0	0.0	2	2	50	2	0.0	1	3	3	75
	Spray	2	0.0	0.0	0.0	0.0	0.0	4	0.0	0.0	0.0	0.0	0.0
Profenofos (Insecticide)	Injection	4	1	2	3	3	75	3	1	2	3	3	75
	Pouring	4	0.0	1	2	2	50	4	0.0	0.0	1	1	50
	Spray	1	0.0	0.0	0.0	0.0	0.0	2	0.0	0.0	0.0	0.0	0.0
Dimethoate (Insecticide)	Injection	4	0.0	1	1	1	25	2	0.0	0.0	1	1	33.3
	Pouring	4	0.0	0.0	1	1	25	3	0.0	0.0	1	1	33.3
	Spray	1	0.0	0.0	0.0	0.0	0.0	3	0.0	0.0	0.0	0.0	0.0
Acetamiprid (Insecticide)	Injection	4	2	3	3	3	75	4	1	2	3	3	100
	Pouring	2	0.0	1	1	1	50	3	0.0	1	2	2	66.7
	Spray	3	0.0	0.0	0.0	0.0	0.0	3	0.0	0.0	0.0	0.0	0.0
Total		53					566.7	52					725
Average ± SD		2.94 ± 1.11					51.5 ± 20.0	2.9 ± 0.75					65.9 ± 22.8

No significant difference between the infestation (%) with RPW in Samani and Ikhlas varieties ( $T = 0.09$  at  $0.05$ ). No significant difference between hospitalization % from infestation with RPW in the Samani and Ikhlas varieties ( $T = 0.80$  at  $0.05$ ).

phosphate and calcium nitrate (1 liter) were dissolved in 2 liter water and complete to 10 L (Stock solution), D—Concentrated chemical pesticides: Profenofos, Dimethoate, and Acetamiprid (1 liter) of each.

## 2.2. Amounts of Mixed Materials

### A) Jojoba mixtures:

Jojoba oil (1 liter) × Inorganic salt solution (1 liter), Jojoba oil (1 liter) × used

car oil (1 liter).

Jojoba oil (1 liter) × Profenofos (500 cm), Jojoba oil (1 liter) × Dimethoate (500 cm), Jojoba oil (1 liter) × Acetamiprid (500 cm).

**B) Used car oil mixtures:**

Used car oil (1 liter) × Inorganic salt solution (1 liter), Used car oil (1 liter) × Profenofos (500 cm), Used car oil (1 liter) × Dimethoate (500 cm), Used car oil (1 liter) × Acetamiprid (500 cm).

### 2.3. Field Treatment Methods

**1) Injection:** Ten infested palms were selected in each treatment of tested variety, Samani (domestic) and Ekhlal (imported). The counts of active (infested) holes were recorded for each palm (holes from which plant sap flowed due to injury). Four holes were drilled on 10 - 15 cm high from the active holes in a zigzag line for each palm in the infested trunk of palm trees. Aluminum tubes (35 cm long and 3 cm in diameter) were planted in each hole. Five cm of the tube is outside the trunk to supply the tested materials (natural or chemical). The tested substance were poured into aluminum tubes (30 cm per tube) separately.

The nozzle of filled tubes was closed with a cotton swab coated with Vaseline to reduce evaporation of the insecticide. The tubes are supplied with the tested materials when required. The treatment of affected palm trees was started from November to April of the following year (the period of inactivity and Agricultural services of palm trees). Treatment of infested palm trees stopped in the period from May to October (the period of flowering and ripening of dates. Paper stickers are placed on each treated palm tree. The label includes: type of palm—number of active holes and treating date.

**2) Pouring the pesticide into the soil:**

Four holes (diameter 30 cm - depth 30 cm/hole) were prepared in the soil around the roots of the affected palm. The tested materials were poured at a rate of 5 - 6 liters/pit. Then, each hole was filled with soil extracted from it and watered.

**3) Spray technique:** The infested palm trunk was sprayed with the tested substance at a rate of 6 liters/trunk using a back sprayer (20 liters capacity).

### 2.4. Examination of Treated Palm Trees

The number of active (infested) holes (still bleeding) and those recovered (stopped bleeding) for treated palms were recorded. An examination of the treated palm trees is carried out every month for a period of 6 months (the period of no flowers or fruits on the palm trees). The results were analyzed statistically using ANOVA and T test, as needed.

**Total carbohydrate content:** The total carbohydrate caloric content of dates was determined using a Spectoronic 21 optical spectrophotometer according to Naguib *et al.* (1962) [10].

**Micronutrients:** Mn, Fe, Cu and Zn in the date's fruits obtained from the treated palm trees using atomic absorption. Spectrophotometer Perkin El-mer 3300 according to Cottenie *et al.* (1982) [11].

### 3. Results

The data of **Table 1** showed that the average number of injured holes is close in the two cultivars (Samani & Ekhlas), where the average infestation of RPW was about  $2.94 \pm 1.11$  for the cultivar Samani and for the cultivar Ekhlas about  $2.9 \pm 0.75$ . Regarding average % recovery from injury recorded in **Table 1**, it was in Ekhlas variety about  $65.9 \pm 22.4$  is higher than the samani variety, where it reached  $51.5 \pm 20.0$ . Injection of Jojoba oil in the trunks of infested Ekhlas var. led to a recovery of about 66.7% of palm treated palms against RPW. Pour Acetamiprid in pits around the roots of the affected palm, it caused 50% the recovery of Samani var and 66.7% recovery of Ekhlas var. from the infestation with RPW. Spraying natural or chemical insecticide on the trunks of infested palm trees is ineffective against *R. ferrugineus* (Oliv.). There was no significant difference between the treatments for Samani and Al-Ikhlavars against RPW ( $T = 0.09$ ). There was no significant difference at 5% between hospitalization rates of the treated palm against the red palm weevil ( $T = 0.80$ ).

The results of the statistical analysis (**Table 2**) showed that the average number

**Table 2.** Efficient of Natural oil (Jujuba oil) in combination with petroleum oil, inorganic salts and insecticides in controlling red palm weevil, *Rhynchophorus ferrugineus* attacking Samani and Barhi varieties of date palm under field conditions.

Materials	Methods	Samani						Ekhlas					
		No. of active holes/tree	Accumulative no. of recovered holes after treat. (month)			Total	% Recovered holes	No. of Active holes/tree	Accumulative no. of recovered holes after treat. (month)			% Total Recovered holes	
			2	4	6				2	4	6		
Jujuba oil & Inorganic Salts	Injection	4	0.0	2	2	2	50	2	0.0	0.0	1	1	50
	Pouring	4	0.0	0.0	1	2	25	3	0.0	0.0	1	1	33.3
	Spray	2	0.0	0.0	0.0	0.0	0.0	3	0.0	0.0	0.0	0.0	0.0
Jujuba oil & Used Car oil (petroleum oil)	Injection	3	0.0	0.0	2	2	66.7	4	0.0	1	2	2	50
	Pouring	4	0.0	0.0	1	1	25	3	0.0	0.0	1	1	33.3
	Spray	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jujuba oil & Celikron (Insecticide)	Injection	3	0.0	1	2	2	66.7	4	1	2	3	3	75
	Pouring	2	0.0	0.0	0.0	0.0	0.0	2	0.0	0.0	1	1	50
	Spray	1	0.0	0.0	0.0	0.0	0.0	3	0.0	0.0	0.0	0.0	0.0
Jujuba oil & Sidon (Insecticide)	Injection	4	0.0	1	2	2	50	2	0.0	0.0	1	1	50
	Pouring	3	0.0	0.0	1	1	33.3	3	0.0	0.0	1	1	33.3
	Spray	3	0.0	0.0	0.0	0.0	0.0	4	0.0	0.0	0.0	0.0	0.0
Jujuba oil & Mossipilan (Insecticide)	Injection	4	1	2	3	3	75	4	1	2	4	4	100
	Pouring	4	0.0	1	2	2	50	3		1	2	2	66.7
	Spray	2	0.0	0.0	0.0	0.0	0.0	2	0.0	0.0	0.0	0.0	0.0

No significant difference at 5% between infestation (%) with RPW in Samani and Ikhlas varieties ( $T: 0.09$ ). No significant difference at 5% between hospitalization % from infestation with RPW in Samani and Ikhlas varieties ( $T: 0.61$ ).

of infested holes (active) in both tested cultivars is close, as it reached  $3.1 \pm 1.0$  for the Samani variety, and the average was about  $3.0 \pm 0.8$  for Ekhlas variety. The mean % recovered holes in both tested varieties was different where it reached  $49.1 \pm 18.4$  for the Samani variety, while the average % recovery from infection was about  $54.2 \pm 21.3$  for the Ikhlas variety, meaning that the Ikhlas variety is higher in recovery than the Samani variety after treatment against the red palm weevil.

**Injection** of the mixture of Jojoba with Acetamiprid into the affected palm stem is the most effective against RPW. The mixture of Jojoba oil with Profenofos (insecticide), coming next in terms of the severity of the effect against RPW, where led to recovery of the Ekhlas cultivar by 75% and the Samani var by 66.7%, of the treated palms. The injection of Jojoba oil mixed with car oil used in the infested trunk of palm trees cured Samani var. approximately 66.7% and Ekhlas of 50% from insect infestation.

Injection both mixture of Jojoba oil with a solution of inorganic salts, as well as the mixture of Jojoba with Dimethoate were the least effective against RPW, it leads to 50% recovery rate for Samani and Ekhlas vars of treated palm trees.

**Pouring** each of mixtures of Jojoba oil with a solution of inorganic salts, as well as the mixture of Jojoba with Dimethoate resulted in a recovery rate ranging from 25% for Samani var to 33.3% for Ekhlas from infestation with RPW.

**Spraying** of all tested mixtures on the trunk of the affected palm tree had no effect against *R. ferrugineus* (Oliv.). There was no significant difference at the 5% level between the average infestation rates with RPW in samani and the Ekhlas vars ( $T = 0.09$ ). Also, no significant difference at 5% level between recovery rates of Samani and Ikhlas cultivars from infestation ( $T = 0.61$ ). Statistical analysis of the data (**Table 3**) showed that the average number of infested holes before the start of the experiment was about  $3.1 \pm 0.9$  for the Samani variety, while it reached  $2.9 \pm 1.1$  for Ekhlas variety. This means that the two cultivars are similar in the rates of red palm weevil infestation.

As for the average % recovery from infestation after treatment against the red palm weevil, it was  $72.9 \pm 19.3$  for the Ekhlas variety, higher than for the Samani variety, where the average % recovery amounted to about  $66.7 \pm 25.6$

Injection the mixture of used car oil with a solution of inorganic salts, as well as the mixture of used car oil with Acetamiprid, led to 100% recovery of the treated varieties (Samani and Ikhlas) from insect infestation, whereas, injection of used car oil mixture of Profenofos into the infested trunk of palms (Samani and Ekhlas cultivars) resulted in 75% recovery of treated palm trees.

Pouring a mixture of used motor oil with Acetamiprid, into pits around the root of the affected palm trees resulted in the recovery of 66.7% of the treated palm. Using a mixture consisting of used car oil and Diamethoate resulted the recovery rates ranged from 50.0% for Samani var—66.7% for Ekhlas var from RPW infestation. However, pouring a mixture of used car oil with an inorganic salt solution led to the lowest recovery rates that were obtained from treating palm trees.

**Table 3.** Effect of Natural oil (petroleum oil) in combination with inorganic salts and insecticides in controlling red palm weevil, *Rhynchophorus ferrugineus* attacking samani and Barhi varieties of date palm under field conditions.

Materials	Methods	Samani						Ekhlas					
		No. of active holes/tree	Accumulative no. of recovered holes after treat. (month)			Total	% Recovered holes	No. of Active holes/tree	Accumulative no. of recovered holes after treat. (month)			Total	% Recovered holes
			2	4	6				2	4	6		
Car oil & Salts	Injection	4	1	2	4	4	100	4	1	2	4	4	100
	Pouring	2	0.0	1	1	1	50	2	0.0	0.0	1	1	50
	Spray	3	0.0	0.0	0.0	0.0	0.0	1	0.0	0.0	0.0	0.0	0.0
Car oil & Celikron (Profenofos)	Injection	4	2	3	3	3	75	4	1	2	3	3	75
	Pouring	4	0.0		1	1	25	2	0.0	1	1	1	50
	Spray	4	0.0	0.0	0.0	0.0	0.0	4	0.0	0.0	0.0	0.0	0.0
Car oil & (Saydon) (Dimethoate)	Injection	3	1	2	3	3	66.7	4	0.0	2	3	3	75
	Pouring	2	0.0	0.0	1	1	50	3	0.0	1	2	2	66.7
	Spray	2	0.0	0.0	0.0	0.0	0.0	4	0.0	0.0	0.0	0.0	0.0
Car oil & Mosspilan (Acetamiprid)	Injection	4	2	3	4	4	100	2	1	2	2	2	100
	Pouring	3	0.0	1	2	2	66.7	3	1	2	2	2	66.7
	Spray	2	0.0	0.0	0.0	0.0	0.0	2	0.0	0.0	0.0	0.0	0.0

NS difference at 5% between insect infestations (%) with RPW in the tested date palm varieties (Samani and Ikhlas) (T: Zero). There is a significant difference at 5% between the average % of hospitalization from infestation with RPW in the tested varieties of date palm (Samani and Ikhlas) (T: 2.51).

Spraying used car oil mixed with each of the tested natural or insecticides on the trunk of infested palm trees is ineffective in all treatments against RPW that infests the Samani and Ikhlas cultivars. There is no significant difference at 5% between the insect infestation (%) of (Samani and Ikhlas) (T: Zero). There is a significant difference at 5% between the average recovery rates of the tested date palm cultivars (Samani and Ikhlas) from RPW infestation. (T: 2.51).

The results recorded in **Table 4** showed that the injection of insecticides (Provinovus, Acetamiprid and Dimethoate) into palm trunks infested with RPW led to an increase in the concentrations of total carbohydrates in the resulting fruits (PPm), also causes an increase in the concentrations of micronutrients ( $Fe^+$ ,  $Mn^+$ ,  $Zn^+$ ,  $Cu^+$ ) at rates higher than those resulting from the injection of mineral oils, as well as the rates resulting from the injection of inorganic salts in the trunks of infested palm trees. There was a significant difference between the results of treatments of palm with insecticides and those containing mineral oils and inorganic salts LSD (0.05): 3.6.

#### 4. Discussion

The current results showed that Acetamiprid was the most effective insecticide



**Table 4.** Effect of different treatments of date palm trees with natural products and pesticides on total carbohydrates (mg/g) and micronutrients concentrations (ppm) of date fruits.

Treatments	Total carbohydrates	Fe <sup>+</sup>	Mn <sup>+</sup>	Zn <sup>+</sup>	Cu <sup>+</sup>
Control	98.0 <sup>a</sup>	1978.4 <sup>e</sup>	110.0 <sup>c</sup>	81.0 <sup>ef</sup>	28.6 <sup>de</sup>
Profenofos	112.0 <sup>b</sup>	2010.0 <sup>d</sup>	121.1 <sup>b</sup>	90.1 <sup>b</sup>	33.0 <sup>ab</sup>
Acetamiprid	110.4 <sup>b</sup>	2017.6 <sup>cd</sup>	119.3 <sup>b</sup>	87.8 <sup>c</sup>	31.8 <sup>bc</sup>
Dimethoate	109.2 <sup>b</sup>	2037.0 <sup>c</sup>	117.6 <sup>b</sup>	84.0 <sup>d</sup>	30.3 <sup>cd</sup>
Salts injection	104.2 <sup>c</sup>	2014.7 <sup>cd</sup>	103.7 <sup>d</sup>	80.7 <sup>ef</sup>	29.7 <sup>cde</sup>
Mineral oils	105.7 <sup>c</sup>	2001.7 <sup>de</sup>	112.3 <sup>c</sup>	83.3 <sup>de</sup>	27.4 <sup>e</sup>
LSD 5%	3.6	25.66	3.3	2.5	2.1

against the red palm weevil (RPW), followed by the pesticide (Profenofos), while the chemical pesticide (Dimethoate) was the least effective against *R. ferrugineus* that attacks the palm cultivars (Samani and Ekhlas). Our results are largely consistent with the previous study [12] which concluded that the injection of a concentrated insecticide: Marshall (Carbosulfan). It was found that the pesticide (pyrimifos-ethyl) and rogodial in young palm trees [Phoenix] caused a 98 percent mortality rate due to pests that attack modern palm trees, while the tested larvae were more exposed than adults to most of the tested insecticides (chlorpyrifos, imidacloprid) and nano-derivatives which revealed an increase in exposure time [13].

The results of the current study, which was conducted under orchard conditions, proved that the injection of a mixture of jujube oil with acetamiprid (insecticide) was the most effective against the red palm weevil that attacks date palm cultivars, as it resulted in 100% recovery of the treated palm trees (Ikhlas) and 75% of the treated Samani cultivar was infected with the insect *R. ferrugineus*.

Field trials were conducted in recent years [14] to evaluate the efficacy of Imidacloprid (Confidor<sup>®</sup> 240 OD) and *Steinernema carpocapsae* Weiser alone or in combination against the red palm weevil and concluded that both imidacloprid and *S. carpocapsae* in chitosan formulation demonstrated high efficacy against *R. ferrugineus*. When scientific researchers [15] injected some natural oils mixed with a pure pesticide into the stems infected with *R. ferrugineus*, it appeared that the protection ratio was high (100%) for all tested palm trees.

The present results showed that the use of the mixture consisting of used car oil (Mineral oil) with a solution of inorganic salts as well as the mixture of used car oil with Acetamiprid (Insecticide) led to 100% recovery of the treated palm varieties (Samani and Ekhlas) from infestation.

In current tests, it was found that injecting the mixture of used car oil with Profenofos (an insecticide) as well as used car oil mixed with dimethoate (a pesticide) into the trunks of infected palm trees resulted in recovery rates ranging from 66.7% to 75% of the infestation.

The current study showed that the injection of single pesticides (Provinovos, Acetamiprid, and Dimethoate) into affected palm trees resulted in higher concentrations of total carbohydrates and micronutrients ( $\text{Fe}^+$ ,  $\text{Mn}^+$ ,  $\text{Zn}^+$ , and  $\text{Cu}^+$ ) than those resulting from mineral oil. As well as the proportions resulting from the injection of inorganic salts into the trunks of affected palm trees. Pretorius analysis [16] revealed that the fruits of the date palm (*Phoenix dactylifera* L.) contain a high percentage of carbohydrates, fats, salts, minerals, protein, vitamins, and a high percentage of dietary fiber—minerals and other salts in different proportions including boron, calcium, cobalt, copper, fluorine, iron, magnesium, manganese, potassium, phosphorous, sodium and zinc. Previous studies [1] also showed that date meat is low in fat and protein, but rich in sugars, especially fructose and glucose. It is a high source of energy, and contains ten essential minerals, including selenium, copper, potassium, and magnesium.

## 5. Conclusions

The current results showed the following points:

1) Injecting the tested natural materials (singly or with pesticides) into the affected palm trunk is the best method that gave distinguished results for the recovery of the treated palm varieties (Samani and Ekhlas) from the infestation of the red palm weevil, *R ferrugineus*.

2) Pouring the tested materials into pits around the roots of the affected palm trees (Samani and Ekhlas vars.). It has low actions against RPW.

3) Continuing the injection of used car oil mixed with the inorganic salts solution, also the used car oil mixed with Acetamiprid for 6 consecutive months for palm trees infested with RPW, resulting in a 100% cure of the insect infestation in the treated cultivars (Samani and Ekhlas).

4) The injection of pesticides (Provinovos, Acetamiprid, and Dimethoate) into the affected palm trees resulted in higher concentrations of total carbohydrates and micronutrients ( $\text{Fe}^+$ ,  $\text{Mn}^+$ ,  $\text{Zn}^+$ , and  $\text{Cu}^+$ ) than those resulting from the injection of mineral oil and inorganic salts.

Therefore, it is necessary to focus on an integrated control program that includes legislation, mechanics, and agricultural, biological and chemical control to overcome the damages of this dangerous pest (RPW) that threatens the productivity of date palm not only in Egypt but also in various countries of the world.

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## Conflicts of Interest

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

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