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Environmentally Safe Non- Traditional Control Measures of *Rhynchophorus ferrugineus*. Oliv. (Coleoptera: Dryophthoridae) in Palm Orchards in Egypt

Hashim, S. M. and Huda R. K. Ali
Plant Protection Research Institute, Agric. Res. Center, Dokki, Giza, Egypt

ABSTRACT

A relatively safe control measures conducted to control *Rhynchophorus ferrugineus*, Oliver (Coleoptera: Curculionidae) in palm orchard at El-Kattatba district, (Menofia governorate). The percentages reduction of infestation for the used 7 applications for one year treatment (2016), two successive years (2016 and 2017), and three successive years (2016, 2017 and 2018) were, ranked, as follow; A: Horticultural treatments: 1) offshoots removal (27.73 increased to 34.87 then 38.88%), 2) pruning with dusting agricultural sulfur (15.06 increased to 17.65 then 19.24%), 3) offshoots removal and pruning with dusting agricultural sulfur (34.06 increased to 39.50 then 45.69%). B: Chemical treatment: 4) local painting with hydrated lime and spraying orange oil (80.57 increased to 85.08 then 89.58%), 5) local injection with recommended insecticide (61.35 increased to 71.01 then 79.16%). B: Chemical treatment: 6) offshoots removal and pruning with dusting agricultural sulfur together with local painting with hydrated lime and spraying orange oil and using pheromone traps treatment resulted in 86.03% increased to 88.24% then 96.39%, and 7) offshoots removal and pruning with dusting agricultural sulfur together with local injection with recommended insecticide treatment resulted in 68.78% increased to 78.15% then 91.78%. This study aimed to eliminate the pesticide use, decrease the environmental pollution and encouraged the role of the biological control agents.

INTRODUCTION

The date palm, *Phoenix dactylifera* L., is the most important fruit crop in the Middle East, cultivated since prehistoric times. The unique agro-climatic conditions prevailing in the Middle East and the nature of the crop, coupled with transportation of planting material have helped in the rapid development and spread of the pest in a short period of about a decade. Feeding of the soft tissues by this concealed borer often leads to the death of the palm, Abraham *et al.* (1998). Heavy infestations of red palm weevil are mainly responsible for palm trees destruction and finally their death. Synthetic insecticides have been tried to manage the population of this invasive borer *Rhynchophorus ferrugineus*, Oliver. Although several insecticides from different groups are found to be potent, however, environmental pollution and development of insecticide resistance limit their efficacy against red palm weevil. Abdel Kareim *et al.* (2017). So, the aim of the present work is to use environmentally safe preventive and curative measures for controlling *R. ferrugineus* including non-traditional control measures involving agricultural practices, behavior manipulation including insect aggregation pheromones and ovipositional deterrents sprays, local and injection trunk treatments as well , the combined effect of these treatments on the course of three successive years.

MATERIALS AND METHODS

Date palm trees (*Phoenix dactylifera*) orchards (more than 15 years), about 10 feddans area with trees 8x8 meters apart located at El-Kattatba district, (Menofia governorate), were subjected to control trials. Date palm trees were infested with the most economically important borer insect borers *R. ferrugineus* Experiments were extended during three successive seasons from January 2016 to December 2018.

The following 7 treatments were evaluated in the orchard using completely randomized design (20 infested trees each treatment and each tree was considered a replicate).

Horticultural treatments:

Offshoots removal:

Regular removal of offshoots is to be properly implemented, weevil infestation occurs at the base near the offshoots or where offshoots have been removed, so, the mother palm treated with PVC (Polyvinyl chloride) paint or a copper sulphate product, also, soil have to be put around the base of the palm to protect the cut.

Pruning with dusting agricultural sulfur treatment:

In winter (January 2016, 2017 and 2018), the regular horticultural pruning with dusting agricultural sulfur was conducted including the infested fronds using a sharp pruning saw. When the fronds are pruned, larvae may tunnel their way into the frond bases through the cut end where eggs will be laid. Treatment of cut surfaces with dusting agricultural sulfur will ensure the control of infestation.

Offshoots removal and pruning with dusting agricultural sulfur treatments:

Treatments numbers 1 and 2 were applied together.

Chemical treatments:

Local painting with hydrated lime, spraying orange oil and pheromone traps:

Hydrated lime (Calcium hydroxide) was used to paint the stem (2meters from the ground), and infested sites four times each season at monthly intervals (May, June, July, and August). Painting was practical using a brush.

Orange oil (Brief EM 6%SL), at the rate of 300 cc per 100 liters of water was sprayed locally four times each season at monthly intervals (May, June, July, and August).

Spraying was practiced by a knapsack sprayer and mainly directed towards the trunks as well as the other infested sites. Pheromone traps were made as described by Abraham *et al*. (1998) and Muthiah *et al*. (2002), using 10-L plastic bucket with lids. Four windows (1.5 x 5 cm) were made equidistantly at the top of the bucket just below the upper rim, the pheromone lure was hung on the inner side of the lid using a metal wire (2 traps per feddan i,.e, per 0.42 ha.). The aggregation pheromone lure used was Ferrolure+ 700 mg (4-methyl-5-nonanol "9 parts" 4methyl-5-nonanone "1part", greater than 95% chemical purity, releasing rate 3-10 mg/day) produced by ChemTica International.

Local injection with recommended insecticide:

Aquaprimo 35% SC (Imidacloprid) at the rate of 75 cc per 100 liters of water was injected using knapsack pivot in the site of infestation and around the infestation spot at equal distance after making holes using drill with drill bit 1.5cm. diameter and 30 cm length.

Combined treatments:

Offshoots removal, pruning with dusting agricultural sulfur, Local painting with hydrated lime, spraying orange oil and pheromone traps treatments:

Treatment numbers 3 and 4 were conducted together.

Offshoots removal, pruning with dusting agricultural sulfur and Local injection with recommended insecticide treatments:

Treatment numbers 3 and 5 were conducted together.

Untreated:

Check treatment:

Check trees were left untreated as control treatment.

Procedures of treatments:

The previously mentioned 7 treatments were carried out for the first season from January 2016 to December 2016. During the second season (January 2017 to December 2017), the same previous treatments were conducted on other infested trees in nearby area of the same orchard with the same technique for confirmation.

In the meantime, the same previous 7 treatments were conducted on the same first year trees to evaluate the effect of the same 7 treatments when applied for two successive years (from January 2016 to December 2017) and for three successive years from (from January 2016 to December 2018).

Evaluation of treatments:

The efficiency of treatments was based on the percentage reduction of the weevils' infestation, as follow:

% reduction of infestation = [(C – T) / C] x100

Where,

C: the mean number of treated trees.

T: the mean number of infested trees.

Grouping of treatments was based on ANOVA test and "Least Significant Difference" (Snedecor and Cochran, 1990).

RESULTS AND DISCUSSION

Effect of one single year, two and three successive treatments.

a. Effect of horticultural treatments alone:

1. Effect of offshoots removal treatment:

Offshoots removal treatment alone was of considerable value since weevils were severely attacked the fronds as well as the stem of trees. The percentage reduction in *R. ferrugineus* infestation due to this treatment reached 27.73, 34.87 and 38.88 % during the three successive years, respectively, (Table1). These findings are in agreement with AL-Dosary *et al.* (2016), they stated that the date palm without offshoot removal recorded the highest infestation (79%).

2. Effect of pruning with dusting agricultural sulfur treatments:

Because infestation with *R. ferrugineus* expanded all the year round, pruning with dusting agricultural sulfur of newly infested fronds was of some value as the percentage reduction in weevils infestation was 15.06, 17.65 and 19.24 % during the corresponding years of study, (Table1). Results are somewhat in agreement with El-Lakwah *et al.* (2011), they proved that pruning of date palm and adding agricultural sulfur was resulted in lowering the infestation rate with *R. ferrugineus* by 5.3% and 4% during two successive years of their study.

3. Effect of offshoots removal and pruning with dusting agricultural sulfur together:

Remarkable degree of *R. ferrugineus* infestation reduction was achieved when offshoots removal and pruning with dusting agricultural sulfur treatments were applied together. The increased percentages reduction of the weevil infestation reached 34.06, 39.50 and 45.69%, during the three successive years of study, respectively, (Table1). Similarly, Al-Dosary *et al*. (2016) listed offshoot removal of date palm among cultural practices to manage *R. ferrugineus* infestations. Also, Abraham *et al*. (1998), indicated the importance of offshoots removal on the course of periodic removal of old leaves and offshoots as it helps to maintain a clean palm without hiding sites for the weevil.

b. Effect of chemical treatments:

4. Local painting with hydrated lime, spraying orange oil and using pheromone traps:

Application of local chemical treatments with hydrated lime, local spraying of orange oil and using pheromones traps gave good results during the three successive years of study, it was 80.57, 85.08 and 89.58%, respectively, (Table1). Using of orange oil against adult weevils was used in the present work for the first time in Egypt based on our field observations that date palm plantations having scattered citrus plants or neighboring citrus plantations showed lower infestation percent with red palm weevil compared to other plantations away from citrus plants, mostly all over the country, Similarly, Abdel Kareim *et al.*(2017) concluded that essential oils extracted from clove, eucalyptus and lemon grass served as repellency oils for *R. ferrugineus* oviposition and the mixed oils of both (eucalyptus and lemon grass) exhibited high oviposition deterrent effect against *R. ferrugineus* female*s* .Also, Dawit and Bekelle (2010) evaluated the repellency of orange oil against the Mexican bean weevil *Zabrotes subfasciatus* (Coleoptera: bruchidae), they indicated that *Citrus sinensis* L., peels oil possess feeding and ovipositional deterrent effect on *Z. subfasciatus*.

Moreover, Hoddle *et al*. (2013), assessed a pheromone trapping system during the period from (2007-2012) seasons in the Al Ahsaa Directorate in Saudi Arabia and they proved that mean monthly trap captures of *R. ferrugineus* and the percentage of traps capturing weevils declined significantly from 2009 to 2012 by an average of 65% and 90%, respectively, indicating that trapping and dispersal pressure was significantly reduced.

5. Local injection with recommended insecticide:

Injection of Imidacloprid in the rate of 57cm/100 liter water in the site of infestation and around it at equal distances (adequate amount of solution should be consumed until leaking out) gave a promising infestation reduction reached 61.35%, 71.01% and 79.16% during the three years of study, respectively, (Table1). Very little is known about the effect of the systemic insecticides belonging to imidacloprid against *R. ferrugineus* except Shawir *et al*. (2006), they evaluated the effectiveness of imidacloprid against young larval stages of red palm weevil, while, eggs and adults showed more tolerance to imidacloprid. Moreover, they proved that imidacloprid was found to be potent in suppressing emergence of the adults from pupae, their findings encouraged the present work to make trials using imidaclorid for trunk injection.

e. Effect of combined treatments:

6. Effect of Offshoots removal pruning with dusting agricultural sulfur, local painting with hydrated lime, spraying orange oil and using pheromone traps:

Application of these treatments together achieved an excellent infestation reduction results on the course of

the three successive years of study, 86.03% 88.24% and 96.39%, respectively, (Table1). Similarly, Al-Dosary *et al*. (2016), showed that *R. ferrugineus* can be managed by deploying an Integrated Pest management (IPM) strategy comprising of several tactics including regulatory methods, behavior manipulation involving insect aggregation, mass trapping adult weevils and cultural practices including offshoot removal.

7. Effect of Offshoots removal pruning with dusting agricultural sulfur, local injection with recommended insecticide:

Very good results were obtained when application of these combined treatments together, the infestation reduction reached 68.78%, 78.15% and 91.78%, respectively, during the corresponding three years of study, (Table1).

Table 1. Effect of one single year, two and three successive treatments on the percentage reduction of *R. ferrugineus* infestation in palm tree orchards at Menofia governorate during 2016, 2017 and 2018 seasons.

Treatments	% Reduction of infestation					
	1 year treatment (2016)		2 years treatments (2016& 2017)		3 years treatments (2016 - 2018)	
	Mean No. of infested spots/ trees	%	Mean No. of infested spots/ trees	%	Mean No. of infested spots/ trees	%
Horticultural Treatments:						
1- Offshoots removal	16.6	27.73	15.5	34.87	15.3	38.88
2- Pruning with dusting agricultural sulfur	19.5	15.06	19.6	17.65	15.2	19.24
3- Offshoots removal and pruning with dusting agricultural sulfur	15.1	34.06	14.4	39.50	13.6	45.69
Chemical Treatments:						
4- Local painting with hydrated lime , spraying orange oil and pheromone traps	4.5	80.57	3.6	85.08	2.6	89.58
5- Local injection with recommended insecticide	8.9	61.35	6.9	71.01	5.2	79.16
Combined Treatments:						
6- Treatments, 3 + 4	3.2	86.03	2.8	88.24	0.9	96.39
7- Treatments, 3 + 5	7.2	68.78	5.2	78.15	2.1	91.78
Untreated Treatments:						
8- Check	20.8	--	23.8	--	25	--

Statistical analysis:

Statistical analysis and grouping of the 21 treatments applied for one, two and three years tabulated in Table (2) results concluded that there were significant differences between treatments and classified as:

a. Superior group (more than 85 %):

1- Offshoots removal, pruning with dusting agricultural sulfur, local painting with hydrated lime, spraying orange oil and pheromone traps for three years, 96.39%.

2. Offshoots removal, pruning with dusting agricultural sulfur and local injection with recommended insecticide for three years, 91.78%
3. Local painting with hydrated lime, spraying orange oil and pheromone traps for three years, 89.58%.
4. Offshoots removal, pruning with dusting agricultural sulfur, local painting with hydrated lime, spraying orange oil and pheromone traps for two years, 88.24 %.
5. Offshoots removal, pruning with dusting agricultural sulfur, local painting with hydrated lime, spraying orange oil and pheromone traps for one year, 86.03 %.
6. Local painting with hydrated lime, spraying orange oil and pheromone traps for two years, 85.08 %.

b. Sufficient group (60 – 85%):

1. Local painting with hydrated lime, spraying orange oil and pheromone traps for one year, 80.57 %.
2. Local injection with recommended insecticide for three years, 79.16%.
3. Offshoots removal, pruning with dusting agricultural sulfur and local injection with recommended insecticide for two years, 78.15 %.
4. Local injection with recommended insecticide for two years, 71.01 %.
5. Offshoots removal, pruning with dusting agricultural sulfur and local injection with recommended insecticide for one year, 68.78 %.
6. Local injection with recommended insecticide for one year, 61.35 %.

c. Moderate group (30 – less than 50%):

1. Offshoots removal and pruning with dusting agricultural sulfur for three years, 45.69%.
2. Offshoots removal and pruning with dusting agricultural sulfur for two years, 39.50%.
3. Offshoots removal for three years, 38.88%.
4. Offshoots removal for two years, 34.87%.
5. Offshoots removal and pruning with dusting agricultural sulfur for one year, 34.06%.

d. Least group (Less than 30 %):

1. Offshoots removal for one year, 27.73%.
2. Pruning with dusting agricultural sulfur for three years, 19.24%.
3. Pruning with dusting agricultural sulfur for two years, 17.65%.
4. Pruning with dusting agricultural sulfur for one year, 15.06%.

It could be concluded that repetition of some treatments increased the reduction of infestation and was of great value and should be applied to the promising ones only. Other treatments should be repeated each two or more years according to their response to application.

Generally speaking, the effect of agricultural practices treatments was of noticeable value from one side because they are obligatory applied each year but pruning should be followed immediately by dusting agricultural sulfur to protect the pruned fronds from attracting female adults to lay their eggs on fresh cut palm tissues. From the other side, this treatment is absolutely environmentally safe and very much preserves the biological control agents (parasites, predators and pathogens) in the environment.

Table 2. Grouping of one, two and three successive year treatments on the percentage reduction of *R. ferruginseus* infestation in palm orchards at Menofia governorateduring 2016-2017 and 2018seasons.

Treatments	% Reduction of infestation					
	One year		Two years		Three years	
	%	Grouping	%	Grouping	%	Grouping
Horticultural Treatments:						
1- Offshoots removal	27.73 (18)	C	34.87 (16)	B	38.88 (15)	B
2- Pruning with dusting agricultural sulfur	15.06 (21)	C	17.65 (20)	C	19.24 (19)	C
3-Offshoots removal and pruning with dusting agricultural sulfur	34.06 (17)	B	39.50 (14)	B	45.69 (13)	B
Chemical Treatments:						
4- Local painting with hydrated lime , spraying orange oil and pheromone traps	80.57 (7)	A	85.08 (6)	A	89.58 (3)	A
5- Local injection with recommended insecticide	61.35 (12)	A	71.01 (10)	A	79.16 (8)	A
Combined Treatments:						
6- Treatments, 3 + 4	86.03 (5)	A	88.24 (4)	A	96.39 (1)	A
7- Treatments, 3 + 5	68.78 (11)	A	78.15 (9)	A	91.78 (2)	A

*** The number between brackets is the rank of the treatments**
**** Insignificant differences between the same letters of grouping**

Local painting with hydrated lime and local spraying with orange oil eliminate the environmental pollution and could help in infestation reduction. These treatments when combined together with attracting flying adults using pheromone traps could surplus the complete coverage spray, especially when applied year after another.

Repeating these combined treatments year after another magnified the effect of these treatments and resulted in satisfied reduction. Actually, all these treatments – including the local chemical injection treatments – are safe to the environment, man and animal health.

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طرق آمنه بيئياً وغير تقليدية لمكافحة سوسة النخيل الحمراء فى حدائق النخيل بمصر

صلاح محروس هاشم و هدى رجب خليل على
معهد بحوث وقاية النباتات – مركز البحوث الزراعية

تم تقييم عدد ٧ معاملات للمكافحة الآمنه بيئيا والغير تقليدية فى منطقة الخطاطبة بمحافظة المنوفية على نخيل البلح ضد افة سوسة النخيل الحمراء خلال أعوام ٢٠١٦، ٢٠١٧ و ٢٠١٨ وكانت النتائج المتحصل عليها كالتالى: اولا : العمليات البستانية: وشملت التالى: ١- ازالة الفسائل: واظهرت خفض فى الاصابة بنسب ٢٧.٦٣ و ٣٤.٨٧ و ٣٨.٨٨% خلال اعوام الدراسة ٢٠١٦، ٢٠١٧ و ٢٠١٨ على الترتيب . ٢- التقليم مع التعفير بمسحوق الكبريت الزراعى : واظهرت خفض فى الاصابة بنسب ١٥.٠٦ و ١٧.٦٥ و ١٩.٢٤% خلال الاعوام الثلاث على الترتيب . ٣- ازالة الفسائل و التقليم مع التعفير بمسحوق الكبريت الزراعى معا : ونتج عنها خفض فى الاصابة بنسب ٣٤.٠٦ و ٣٩.٥٠ و ٤٥.٦٩% تباعاً على مدار سنوات الدراسة الثلاث . ثانيا: العمليات الكيميائية: وشملت المعاملتن التاليتين : ١- الطلاء بالجير مع رش زيت البرتقال ونتج عنها خفض فى الاصابة بنسب ٨٠.٥٧ و ٨٥.٠٨ و ٨٩.٥٨% خلال سنوات الدراسة الثلاث علي الترتيب . ٢- الحقن الموضوعى بميد موصى به من مجموعة الاميداكلوبريد ونتج عنه خفض فى الاصابة بمعدل ٦١.٣٥ و ٧١.٠١ و ٧٩.١٦% خلال سنوات الدراسة الثلاث تباعا . ثالثا: المعاملات المشتركة: وشملت المعاملتن التاليتين : ١- ازالة الفسائل ،التقليم مع التعفير بمسحوق الكبريت الزراعى ، الطلاء بالجير مع رش زيت البرتقال وكذلك استخدام المصائد الفيرمونية ونتج عنها خفض فى الاصابة بنسب ٨٦.٠٣ و ٨٨.٢٤ و ٩٦.٣٩% خلال اعوام الدراسة ٢٠١٦ و ٢٠١٧ و ٢٠١٨ على الترتيب . ٢- ازالة الفسائل ،التقليم مع التعفير بمسحوق الكبريت الزراعى و الحقن الموضوعى بميد موصى به من مجموعة الاميداكلوبريد ونتج عنه خفض فى الاصابة بمعدل ٦٨.٧٨ و ٧٨.١٥ و ٩١.٧٨% خلال سنوات الدراسة الثلاث على الترتيب .