International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.9, No.05 pp 12-17, 2016

Field Evaluation of Red Palm Weevil *Rhynchophorus ferrugineus* Oliv. (Coleoptera:Curculionidae) Responses to its Fermenting Date Tree Volatiles.

Salem S.A[1]. ; Abd El-Salam, A.M.E[1]. and El-Kholy, M.Y[1&2].

[1]Plant Protection Department , National Research Centre, Dokki, Cairo, Egypt.
[1&2]Department of Biology, College of Science, Aljouf University, Sakaka, Aljouf, Kingdom of Saudi Arabia.

Abstract: The aim of the work is to study the effect of some agricultural practices such as pruning , which leading to injuries of trunk and mechanical wounds or hand removal dry bark or the wounds occurred during the infestation of date palm trees by *Rhynchophorus ferrugineus* Olivier . The recorded data showed that the high infestation rate occurred when the area of removal dry bark increased from 10x10 cm.^{2} to 30x30 cm^2.due to emanating from stressed ,wounded or dying trees of volatile oils . The correlation between the increasing of percentage infestation with RPW and other factors (pruning or mechanical wounds trunk) were highly significant . The females prefer to lay eggs on young trees (2 m.). The RPW infestation in date palm plantations were maximum in stem position 2m. length (5 years age) and live tissues. Meanwhile the lowest infestation rate was at the date trees with length about 7 m. . Growers managing nursery plantings of palms may have the greatest potential to control the RPW by an integrated program. It is important to know that some agricultural practices that which sometimes increase the rate of infestation and then injury level for preventing date plantations from RPW infestations. The percentage of infestation in control[1] and treatments in both seasons approximately was equal.

Keywords: Red Palm Weevil *Rhynchophorus ferrugineus* Oliv. (Coleoptera:Curculionidae), Fermenting Date Tree Volatiles.

Introduction

The red palm weevil *Rhychophorus ferrugineus* Oliv. is widely considered to be one of the most dangerous pests attack the palm plantation (1). The red palm weevil had expanded in more than 50 countries around the world. It is necessary to call the red palm weevil (The invisible enemy) as it spends its life cycle in the trunk of the palm. RPW has caused serious damage to date palms in orchard mainly the wounded and dying trees such as pruning process. The pest recorded in Egypt in 1993 (2). The females are laid eggs in the wounded trunk of the palms and the larvae push it selves inside the soft plant tissue , which leads to the formation of tunnels inside the palm. The symptoms of *Rhychophorus ferrugineus* Oliv. attack to date palm was summarized by (3). Infestation on date palm starts when females lay eggs on wounded trees, mainly the young date palms with trunks less than 20 years old being most preferred (4). Oozing out of thick yellow brown fluid from the tunnels, appearance of frass in and around the opening of tunnels studied by several researchers (5). Early detection of RPW infestation is very important in starting resistance and prevent the spread of pest (6,7,8). The curculionids were attracted by allelochemicals released by the fermenting tissues of wounded or

drying host-plants. For date tree finding, females orientate toward the volatile and non-volatile chemicals released by their host feed plants(9).

The study was carried out in order to clarification the chemicals of host plants which trigger the first sequences of host acceptance behavior in RPW. This pest is a specialist feed of the date palm trees tissues. These stimuli lead to the continued examination of the host, followed by thrusting the mouth parts to make small holes into the live tissue, then thrusting the ovipositor to lay eggs.

The objective of the present study was to evaluate the effect of volatile oils emissions (allelochemicals) releasing from wounded trees on the percentage of infestations by RPW.

Materials and Methods

A field experiments were established in June to November 2014&2015 on special farm at Menofyia Governorate. Palm trees in the farm are distributed only on the edges of roads and irrigation canals. The chosen of palm trees inside the farm were carless and did not resist red palm weevil before .Normally, The pruning process occurred annual with a rate of 10 to 15 leaves a palm tree. The pruning process stopped during the experimental time with one exception in control[2]. The main fruit crops in the experimental area are citrus and apple. Fertilization and irrigation system according to the need of main orchards. At the beginning of experiments (2014 ; 2015 seasons) , the infested palm trees with RPW were grouped according to the date trees length, which determined as follow: 2 m. ; 5m. and 7 m. from the surface of ground . The top infestation are neglected. The inspection of date palm trees under observations were carried out every two weeks by necked eye. Most of the trees were as fruiting stage with nearly distance of 5 m. between the two adjacent trees. The chosen of tree numbers for each year are 212 trees (2014) and 230 trees (2015), then labeled and divided into three groups according to its length. The total trees in the farm are about 1500 trees with one variety (Zaghloul). The removal of dry bark process was carried out at 1.5 m. above surface ground. The measuring of removal dry bark areas for each group (2m.; 5m. and 7m.length) are 10x10 cm^2 ; 20x20 cm^2 and 30x30 cm^2., each measure in single trunk . Five replicates are determined for each factor under studies (length; dry bark measure). The infestation injury symbol are calculated until if larvae fallen to penetrate trunk. After any inspection, eliminated the effects of the injury after a scan immediately even if the larvae did not penetrate the fabric of the neighborhood tree. The distance between the two experiments are about fifty meters. The ages of the chosen trees under observations are as follow: 2m. (5 years) ; 5 m.(10 years) and 7 m. (20 years). Two areas for each treatment during both seasons were determined as control [1&2]. For the first control (100 trees) the pruning process occurred annual, while the second control (100 trees) left without prune.

The obtained data were subjected to regular analysis of variance of randomized complete block design (RCBD). T test distribution outlined by Gomes and Gomez 1984(10).

Results and Discussion

First experiments:

The relationship between the surface area of the emission of volatile oils from the wounds and the length of the trees and their impact on female attraction.

The studies were carried out during the beginning of activity peaks (July to November) when the oozing balls had been hidden within a few trees. Volatile oils or odors emanating from stressed, wounded trees (pruning processes) or dying trees are attractive to red palm weevil females. The exact number and ratios of volatile compounds released still unknown and other group as palm esters have been found to be attractive. At the beginning of feeding, the adult releases the aggregation pheromone that is attractive to other adults at long distance. From the previous information's it means that the area of volatile oils distribution due to pruning processes play a great important factor for increasing the percentage of infestation. Data in Table (1) shows that the increase of % infestation rates correlating with tree heights. The number of infested trees ranged between 15 to 31 trees (2014 season) and from 16 to 39 trees (2015 season). The high number of infested trees (31 trees) was recorded in the first group trees (2 m. length) 31 trees. The same trend was observed in 2015 season and the data recorded was as follows: the high number of infested trees was counted and recorded are 39 trees (2 m.)

and the lowest number was 16 trees (7 m.). At the end of treatment (Nov. month), the data clearly indicated that the variation between the number of infested trees before and after treatment ranged between 25 to 45 trees (2014), while in 2015 season, the variation recorded was ranged between 39 to 48 trees. The statistical analysis indicated that there is no significant correlation recorded between the differentiation for both seasons. Also, from the obtained data revealed that there are three peaks observed in July; September and October. In 2015 season, the data observed and recorded in Table (1) clearly indicated that the females of RPW prefer search and attack plant with young age with less length (2 m.), these orientation may be due to the more release of volatile oils through the thin of dry bark layer. Other observations the number of peaks in 2014 seasons are in July; September and October, while at 2015 season, the peaks are in July; August and October (overlapping generations). The data revealed that the females more attractive to lay their eggs on wounded trunk (2 m. length) than other lengths. The activity of flying adults and peaks changing time due to the worm conditions occurred at summer months (2015) . The data agreement with the finding of Zaggate 1997(9), he said that the attracted of curculionids by allelochemicals emanating by the fermenting tissues of wounded host plant. Male adults on palms emitted an aggregation pheromone that attract adults of both sexes. This pheromone acted in synergy with plant allelochemicals. The obtained results are in harmony with the finding obtained by Salem, 2015.From the same Table (1), the statistical analysis indicated that the different between length tree and the number of infested trees are positive significant , mainly at 2014 season , while at 2015 season, there is no significant recorded. The tree length (5 m.) show moderate results compared with other length trees.

Table (1): Relation between date palm tree length and its infestation by Red palm weevil during two successive season 2014/2015.

Inspection Dates		2014"212trees"			2015"230trees"		
		Tree length			Tree length		
		2.0m.	5.0m.	7.0m.	2.0m.	5.0m.	7.0m.
		Mean No. infested trees/2 weeks			Mean No. infested trees/2 weeks		
Jun.	1st	4.0	3.0	3.0	5.0	4.0	4.0
	15th	3.0	3.0	2.0	6.0	4.0	3.0
Jul.	1st	7.0	5.0	4.0	7.0	4.0	2.0
	15th	6.0	6.0	4.0	8.0	5.0	2.0
Aug.	1st	6.0	5.0	5.0	8.0	6.0	4.0
	15th	6.0	6.0	3.0	5.0	5.0	5.0
Sep.	1st	8.0	5.0	4.0	8.0	7.0	5.0
	15th	8.0	5.0	4.0	8.0	7.0	4.0
Oct.	1st	9.0	6.0	5.0	9.0	5.0	6.0
	15th	10.0	5.0	1.0	8.0	7.0	6.0
Nov.	1st	5.0	3.0	3.0	7.0	8.0	7.0
	15th	4.0	2.0	2.0	8.0	8.0	7.0
Mean No. infested trees before treatment (Cont.)		31.0	19.0	15.0	39.0	22.0	16.0
Mean No. infested trees after treatment		76.0	54.0	40.0	87.0	70.0	55.0
Rate of increase in infestation trees		68.8	54.28	60.0	81.25	45.83	41.02

Second experiment.

The relationship between the rates of injury and palm weevil space living tissue of the trunk after the removal of dry bark.

By hand removal dry bark till the alive tissues in which increase the emanating the volatile oils is very important to save plants from females attractive during pruning processes if the pruning processes stopped . Table (2) shows and clearly indicated that the number of infested trees increased with the increase of measuring areas of removal dry bark. The area of 30x30 cm^2 has a highest number of infested trees compare with other lengths (2 m. ; 5 m. and 7 m.). In 2014 season, the number of infested trees in third group (2 m./ 30x30 cm^2) was 37 trees compared with 18 trees recorded in first group (10x10 cm^2.). The area of 10x10 cm^2 has a least number of infested trees in all groups. The relation between length plants and number of infested trees is highly significant due to the unable of females to fly more than three meters from ground surface, due to this observation, the top infestation was limited. In 2015 season the same trend of results was recorded and similar to the data in 2014. The available data in Table (3) revealed the following data: 90 infested trees represent 39.13% & 62 trees represent 26.95% and 49 trees represent 21.3% in first; second and third group respectively (2015). From data recorded in Tables (2 and 3) and from the statistical analysis of data it can be illustrated that the correlation between tree length and area dry bark removal was highly significant between the different items studied (length; age and area measures of removal area bark). The valuable data derived from the experiments is very important by recommended to neglect the annual pruning processes, but unfortunately the farmers do it. If some growers want to do it, they can do but in winter months to prevent the trees from the lesion attacks during activity period.

Table (2): Relation between date palm tree length ; measuring of removal area and percentage of date tree infestation by RPW (2014).

Inspection Dates		2014 (212 trees)										
		Date palm tree length										
		2.0m			5.0m			7.0m			Control (1)	Control (2)
		Dry Bark area (cm^2.)										
		10x10 $cm.^2$	20x20 $cm.^2$	30x30 $cm.^2$	10x10 $cm.^2$	20x20 $cm.^2$	30x30 $cm.^2$	10x10 $cm.^2$	20x20 $cm.^2$	30x30 $cm.^2$		
		Mean No. infested trees										
Jun.	1st	1.0	1.0	2.0	0.0	2.0	2.0	1.0	1.0	2.0	7.0	2.0
	15th	0.0	1.0	2.0	0.0	1.0	2.0	0.0	0.0	2.0	8.0	2.0
Jul.	1st	2.0	2.0	3.0	1.0	2.0	2.0	0.0	2.0	2.0	11.0	2.0
	15th	1.0	1.0	4.0	1.0	2.0	3.0	1.0	2.0	2.0	10.0	3.0
Aug.	1st	2.0	1.0	2.0	1.0	1.0	3.0	1.0	1.0	3.0	10.0	5.0
	15th	1.0	1.0	4.0	2.0	2.0	2.0	0.0	1.0	2.0	12.0	8.0
Sep.	1st	2.0	3.0	3.0	1.0	3.0	3.0	1.0	1.0	2.0	15.0	8.0
	15th	3.0	2.0	4.0	1.0	1.0	3.0	0.0	0.0	1.0	17.0	11.0
Oct.	1st	3.0	3.0	3.0	2.0	2.0	3.0	1.0	2.0	2.0	20.0	11.0
	15th	2.0	2.0	5.0	1.0	1.0	2.0	0.0	0.0	1.0	12.0	12.0
Nov.	1st	1.0	1.0	3.0	0.0	0.0	3.0	0.0	1.0	2.0	10.0	9.0
	15th	0.0	1.0	2.0	0.0	0.0	2.0	0.0	0.0	1.0	10.0	8.0
Total/area bark		18.0	19.0	37.0	10.0	17.0	30.0	5.0	11.0	22.0	142.0	81.0
Total/Length		74.0			57.0			38.0				
%infested/area bark		24.3	25.7	50.0	17.5	29.8	52.6	13.1	28.9	57.0		
%infested/in Cont.(1&2)											66.98	38.2

Table (3): Relation between date palm tree length ; measuring of removal area and percentage of date tree infestation by RPW.

Inspection Dates		2015 (230 trees)										
		Date palm tree length										
		2.0m			5.0m			7.0m			Control (1)	Control (2)
		Dry Bark area (cm^2.)										
		10x10 $cm.^2$	20x20 $cm.^2$	30x30 $cm.^2$	10x10 $cm.^2$	20x20 $cm.^2$	30x30 $cm.^2$	10x10 $cm.^2$	20x20 $cm.^2$	30x30 $cm.^2$		
		Mean No. infested trees										
Jun.	1st	0.0	2.0	3.0	1.0	1.0	2.0	2.0	2.0	2.0	9.0	2.0
	15th	1.0	0.0	2.0	1.0	1.0	2.0	2.0	1.0	2.0	8.0	1.0
Jul.	1st	1.0	1.0	3.0	1.0	2.0	4.0	1.0	1.0	3.0	10.0	2.0
	15th	1.0	2.0	3.0	2.0	1.0	3.0	1.0	3.0	2.0	12.0	3.0
Aug.	1st	3.0	3.0	4.0	3.0	1.0	3.0	2.0	1.0	3.0	13.0	3.0
	15th	4.0	4.0	4.0	2.0	2.0	4.0	2.0	2.0	2.0	14.0	4.0
Sep.	1st	2.0	4.0	5.0	2.0	3.0	4.0	1.0	1.0	1.0	13.0	5.0
	15th	2.0	3.0	6.0	1.0	1.0	3.0	0.0	1.0	0.0	16.0	7.0
Oct.	1st	1.0	2.0	4.0	2.0	2.0	3.0	0.0	0.0	1.0	12.0	7.0
	15th	3.0	3.0	5.0	0.0	1.0	1.0	1.0	1.0	1.0	19.0	8.0
Nov.	1st	2.0	2.0	2.0	0.0	0.0	1.0	0.0	1.0	2.0	20.0	10.0
	15th	0.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	22.0	11.0
Total/area bark		20.0	28.0	42.0	16.0	15.0	31.0	13.0	15.0	21.0	168.0	63.0
Total/Length		90.0			62.0			49.0				
%infested/area bark		22.2	31.1	46.7	25.8	24.2	50.0	26.5	30.6	42.9		
%infested/in Cont.											73.04	27.39

Discussion and Conclusion

The emission of volatile oils large density of the surface of live plants and its arrived by air to great distances lead to the attraction of females to attack living tissue to lay eggs. As observation in farm and by statistical analysis for data, the relationship between living tissues of bark and injury rates is a positive correlation. The relationship of these finding are important to growers which prefer to do the prune one time a year. At the time of winter months the lesion still in cocoons and the wounds through few days was recovery. Statistical analysis of the results shows that the relationship between the level of damage to the lesion and between each of the living area of the bark of the trees and the age and length palace, which is considered a favorite for females to lay eggs is considered a positive correlation.

Following the delete or carrying the pruning processes in winter months and the immediate control operations efforts were aimed at developing effective methods for controlling the infestation. Preliminary results regarding the possibility of suppression the rate of releasing of volatile oils from wounded date palm trees are presented in this study. Also, the results revealed that the important points in the study are as follows: (1): The study showed that it is preferred to refrain from removing the affected part of the trunk in case of mechanical resistance and leading to the removal of the affected part of the trunk so that access to the internal larvae. On if has mechanical resistance to be painted molecule removal insecticide appropriate and recommended or sometimes the use of clay instead of the pesticide. The use of clay, which some farmers use it for covering injured site after removing the larvae by mechanical resistance, so as to prevent the emission of volatile oils ,which attract females .(2): The use of insecticides immediately must be taken after the pruning processes. (3): Only the dry leaves can cut it during the winter season. (4): Actually, the pruning processing are

carried out during winter months (Dec. and Jan.) only before the time of beginning of active period of flying weevils, which exit from cocoons. (5): From the data illustrated from Tables 2 and 3) the number of infested trees in treatments (169 trees) and control [1](142 trees) the percentage of infestations in treatment 2014 season was 79.7%, while in control[2] was 66.98%. In 2015 season, the percentage of infestation was 73.04% and 27.39% in control[2]. After comparative analysis the data in experiments and control [2] in both two seasons, 2014 & 2015, which not received any agricultural practices, the injury level in experiment near to double comparing with control[2]. From Tables (2 &3) the data in control and experiments indicated that the pruning or other mechanical wounds caused a great damage to date trees due to the emanation of volatile oils.

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