FIELD EVALUATION OF SYNTHETIC PHEROMONE, ALLOMONE, PALM KAIRMONE AND ESTER IN CAPTURING ADULT RED PALM WEEVILS, RHYNCHOPHORUS FERRUGINEUS (OLIVIER) BY AGGREGATION PHEROMONE TRAPS IN DATE PALM PLANTATIONS

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Abstract

The red palm weevil (RPW), Rhynchophorus ferrugineus adults captured by attractants pheromone traps in date palm plantations were studied at Sharkia Governorate, Egypt. The tested treatments were pheromone (ferruginol), allomone (juice sugar beet), kairomone (ethyl acetate), ester (ethyl propionate) in traps alone or together compared with untreated traps control. The higher capture of females compared with the male. The best attraction to capturing RPW adults was trap baited with ferrugineol + sugar beet juice + ethyl acetate and ethyl propionate which recorded 782 adults. Ferrugineol + ethyl acetate and ethyl propionate, which caught 756 adults, followed by ferrugineol +ethyl acetate + sugar beet juice caught 682 adults, followed by ferrugineol and ethyl propionate, which caught 627 adults, followed by ferrugineol + ethyl acetate, which caught 559 adults, followed by ferrugineol + sugar beet juice which caught 486 adults, followed by ferrugineol which caught 417 adults, followed by ethyl propionate which caught 311 adults, followed by ethyl acetate, which caught 211 adults, followed by ferrugineol + ethyl acetate, which caught 559 adults, followed by ferrugineol + sugar beet juice which caught 486 adults, followed by, ferrugineol + ethyl acetate + sugar beet juice + ethyl acetate + ethyl propionate, which caught 756 adults, followed by ferrugineol and ethyl propionate, which caught 627 adults, followed by ethyl acetate, which caught 559 adults, followed by sugar beet juice which caught 486 adults, followed by untreated traps control. The obtained results indicated that the numbers of captured adults increased highly significantly in traps supplied with ferrugineol + sugar beet juice + ethyl acetate + ethyl propionate than other chemical materials. Accordingly, it is recommended to use the pheromone trap. The results obtained provide information that should help improve the control of R. ferrugineus by mass trapping systems.

Keywords: Red palm weevil; control; date palm; mass trapping; pheromone; ethyl acetate; molasses sugar beet; ethyl propionate.

Introduction

The red palm weevil (RPW), Rhynchophorus ferrugineus Olivier (Coleoptera: Curculionidae), is an internal tissue borer attacking palm trees in diverse agro-ecosystems worldwide (Milosavljević et al., 2019). This ten-fold lead in the host range and also increasing geographical expansion of RPW has been mainly after it gained foot hold on date palm Phoenix dactylifera L. in the Middle-East during the mid-1980s, where it entered and spread through infested planting material (Al-Dosary et al., 2016; Giblin-Davis et al., 2013). In Egypt, it has become the major pest of date palm. RPW was reported in 1992 first recorded in date palm plantations of Sharkia and Ismailia Governorate (Saleh, 1992). However, to avoid severe harm in the environment, caused by an overuse of insecticides, the possibilities of adopting sustainable strategies to control RPW are under evaluation, with particular attention being paid to the possibility of developing a mass trapping method (Go’ Mez-Vives et al., 2009). However, in 1993a male-produced aggregation pheromone was reported for RPW and identified as a racemic mixture of 4-methyl-5-nonanone and 4-methyl-5-nonanol at a ratio of 10-90, respectively (Hallett et al., 1993). The two components of RPW pheromone have been formulated with certain plant kairomones and this mixture has shown to be effective in monitoring and reducing the population of RPW from Asia and the Americas (Oehlschlager et al., 1993). In semiochemical-based mass trapping, traps are baited with chemical lures such as pheromones and/or attractants (El-Sayed et al., 2006 and Rosell et al., 2008). Volatile chemicals produced from fermenting palm tissues, known as ‘palm kairomone and ester’, such as ethyl acetate, ethyl propionate, (Giblin-Davis, 1994 and Rochat et al., 2000). Several studies report that most of these compounds strongly enhance the attractiveness of pheromone-baited traps (Faleiro, 2006 and Gries et al., 1994). In the case of RPW, previous studies on mass trapping commonly incorporate the use of ethyl acetate as a synergistic kairomone of the aggregation pheromone (Go’ Mez-Vives et al., 2009: Faleiro, 2006 and Soroker et al., 2005) but there is lack of data about the responses of the RPW to other allomone and pheromone. The present study aims to evaluate the capture efficacy of four types putting in funnel bucket traps provided with selected synthetic allomone, palm kairomone, palm ester, and commercial RPW aggregation pheromone lure in date palm plantations, under Sharkia, Egyptian environmental conditions, by using a more reliable method for calculating lures release rate based on gas chromatographic analysis.

Materials and Methods

Sampling Sites

This study was conducted at a selected date palm plantation in Abo Hammaed district, Sharkia Governorate, Egypt. The plantation, consisting of date palm trees, was approximately 15 feddans in size. A total number of 36 traps (3 traps/12 treatment) were installed in each block.

Trap design

The pheromone traps were designed using plastic funnel bucket pheromone traps in the present study as shown in figure (1). They used traps commonly consist of the plastic bucket (9 liters in size) with a funnel of 8 cm in diameter fixed above the bucket. The bucket was punctured around its wall with holes, each of 2.5 cm diameters just under its top, the bucket walls were perforated forming 4 holes. Four holes were made to allow adult weevils to enter inside the trap safely and easily. The side funnel had a small knob fixed
with a screw hook to hang the synthetic ferrugineol sac, allomone, selected synthetic palm kairromone, and ester bottles.

Experimental Design

Each trap contained ferrugineol as a synthetic pheromone lure. It is a mixture of [4 methyl-5-nanol and 4-methyl-5-nanonone (9:1)]. It is imported from Chem Tica Natural; Costa Rica, and released its active chemicals blames experimental Design 18. It is a mixture of {4 methyl-5-nanol and 4-methyl-5-nanonone (9:1)}. It is imported from Chem Tica Natural; Costa Rica, and released its active chemicals.

Field evaluation of synthetic pheromone, allomone, palm kairromone and ester in capturing adult red palm weevils, *Rhynchosporum ferrugineum* (Olivier) by aggregation pheromone traps in date palm plantations. It is a mixture of {4 methyl-5-nanol and 4-methyl-5-nanonone (9:1)}.

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Least Significant Difference test 5% (COSTAT software, 1990).

**Results and Discussion**

**Developing synthetic pheromone, Kairmone, allomone and ester with different attractant:**

The results of the study revealed four promising compounds, i.e. treatment (1). Data was recorded during 12 months. Results presented in Tables (1 and 2) clarifies that the bait that gave the highest captured insects was attractive (1) which consisted of water + insecticide + aggregation pheromone+ (allomone) 2 L of a 10% v/v aqueous sugar beet juice + yeast + (kiromone) 10% v/v emulsions of ethyl acetate + (ester) 10% v/v emulsions of ethyl propionate. This bait collected 782 adults, followed by attractive (2) which consisted of water + insecticide + aggregation pheromone+ (kairomone) 10% v/v emulsions of ethyl acetate + (ester) 10% v/v emulsions of ethyl propionate collected that 756 adult weevils, followed by attractive (3) consisted of water + insecticide + aggregation pheromone + (allomone) 2 L of a 10% v/v aqueous solution of sugar beet juice yeast captured 682 adults, followed by attractive (4) which consisted of water + insecticide + aggregation pheromone + (ester) 10% v/v emulsions of ethyl propionate collected 627 adults, followed by attractive (5) which consisted of water + insecticide + aggregation pheromone + (kairomone) 10% v/v emulsions of ethyl acetate collected 559 adults, followed by attractive (6) which consisted of water + insecticide + aggregation pheromone + (allomone) 2 L of a 10% v/v aqueous solution of sugar beet + yeast collected 486 adults, followed by attractive (7) which consisted of water + insecticide + (ester) 10% v/v emulsions of ethyl propionate collected 417 adults, followed by attractive (8) which consisted of water + insecticide+ (kairomone) 10% v/v emulsions of ethyl acetate collected 311 adults, followed by attractive (9) which consisted of water + insecticide + aggregation pheromone + (allomone) 2 L of a 10% v/v aqueous solution of sugar beet + yeast collected 211 adults, followed attractive (10) consisted of a 10% v/v aqueous solution of sugar beet + collected 111 adults, followed attractive (11) consisted of water + insecticide + aggregation pheromone only, (90 adults were captured). Whereas, the least bait in capturing adults in combination (12) empty trap. Thus, it will be interesting to use these attractive (1), in mass trapping and/or monitoring of *R. ferrugineus* in palm trees as one of the stone corners of IPM.

Results for all evaluated attractives indicated highly significant differences in RPW catch for attractive (1, 2 and 3) compared with other 9 attractives.

Data agreed with obtained by (Hallett et al., 1993) who stated that emission of the pheromone alone from a trap does not attract many weevils as compared to a red palm weevil pheromone trap with a fermenting food source. (Gries et al., 1994 and Rochat et al., 2000) they studied that air collections and SPME head-space analysis already carried out from decaying tissues of *Elaeis spp.* *Jacaranda spp.*, coconut palm and sugar cane showed that high percentages (60–90%) of the volatiles trapped comprise ethyl acetate and ethyl alcohol; nevertheless, other compounds such as ethyl propionate, ethyl butyrate, and ethyl lactate were also found in smaller amounts. Moreover, literature evidence shows that molecules produced by young palm tissues could also be attractive to weevils. working on volatiles produced from the coconut palm, *Cocos nucifera* L., found two compounds that showed short-range attractant properties for the RPW in laboratory bioassays: 4-nonalactone and 4-hydroxy-3-methoxy styrene. On the other hand (Hallett et al., 1999) they founded that natural palm baits have poor attractant power by themselves but strongly synergize the effect of the aggregation pheromone. (Rochat et al., 2000) they reported that the trap catch experiments using pheromone molasses traps complemented with ethyl propionate recorded several catches similar to the one obtained using ethyl acetate. Moreover, the use of the two esters in combination determined more captures than ethyl propionate alone, suggesting that the blend of esters mimics more strongly the palm odor than the individual esters. Palm esters such as ethyl acetate and ethyl propionate have been identified by GC-MS from the volatiles of fermenting palm tissues. In the case of the American palm weevil, *R. palmarum*, it has been demonstrated that the volatiles produced during the fermentation processes can play a role as kairomones triggering the primary attraction of insects to oil palms. (Soroker et al., 2005) they founded these aspects support the commonly accepted fact that RPW is attracted by dying and damaged parts of palm. the higher proportion of females captured in the traps complemented with ethyl acetate and ethyl propionate might be due to the higher sensitivity of females to these esters, as evidenced by the EAG experiments. Nevertheless, in this contest, the role of a pheromone and molasses complex in influencing the attractant action of the synthetic esters cannot be underestimated. The high number of adults captured demonstrates the sustainability of the use of the mass trapping technique in an urban environment, following the results of mass trapping experiments carried out in field conditions. Longo (2006) reported similar results for the trap catches, the number of captured females was greater than the number of males in all the treatments tested, with a proportion of 1/1.56 males/females. This value is different from the sex ratio of 1.08/1 males/females observed on infested palms of urban areas of Sicily. (Abdallah et al., 2008; Guarino et al., 2011) Several authors found that ethyl acetate also appeared to have an important role in the effectiveness of traps and increase the attraction of red palm weevils when used along with pheromone and food bait. Salvatore Guarino et al. (2010) studied that the means (SE) of adults of RPW captured weekly in pheromone molasses traps complemented with ethyl acetate alone, ethyl propionate alone and ethyl acetate and ethyl propionate in combinations were respectively 33.05± 2.83, 28.65, 3.24 and 39.54, 4.14. The trap catch experiments using pheromone molasses traps complemented with ethyl propionate recorded several catches similar to the one obtained using ethyl acetate. Moreover, the use of the two esters in combination determined more captures than ethyl propionate alone, suggesting that the blend of esters mimics more strongly the palm odor than the individual esters. The ester that elicited the strongest responses was ethyl propionate (*F* 54.47; *P* < 0.001; df 4; ANOVA). The means (SE) of adults captures per trap during each sampling period reached a peak of 49.5± 6.0 on the 20 August 2018; the lowest number of adults captured (22.9± 2.5) was registered on the 7 July 2018. Globally, the total number of adult RWP captured was 3544, with a proportion of male/female of 1/1.56 (χ2 169.9; *P* < 0.001). The number of females captured was consistently greater than the number of males in all treatments. The means (SE)
of adults of RPW captured weekly in pheromone molasses traps complemented with ethyl acetate alone, ethyl propionate alone and ethyl acetate and ethyl propionate in combinations were respectively 33.05%, 2.83%, 26.85%, 3.24% and 39.54%, 4.14. The analysis of variance revealed that the pheromone +molasses traps complemented with the two esters in combination captured more adults than the pheromone +molasses traps complemented with ethyl propionate alone (F 2.51; P 0.027; df 102). Traps complemented with only ethyl acetate caught a statistically intermediate number of weevils. (Vacas et al., 2013) they studied that the addition of water to traps baited with palm tissues was found to be essential, which catches increasing more than threefold compared with dry traps. (Faleiro et al., 2019) they showed that weevil captures in both the dry trap and the food baited traps were statistically similar. The above semiochemical mediated techniques offer sustainable trapping solutions for RPW management, and could be deployed especially in areas where the trap density has to be increased due to high weevil activity.

In the field experiments the selected synthetic pheromone, allomone, palm kairomone, and ester showed: (1) differences among the treatments; (2) a greater attractant to ethyl propionate; (3) a higher captured of female compared with male. In Ismailia governorate, RPW capturing evaluated over six weekly observations on pheromone- and molasses-baited traps, showed that more adults were caught by traps supplemented with ethyl propionate and ethyl acetate than by traps supplemented with only ethyl propionate. Similar catches were recorded in the traps supplemented with ethyl propionate or ethyl acetate.

The Costat statistical analysis program was used also to detect the fluctuation of the RPW during the 12 months of the experiment in the 36 previously mentioned traps. Table (1) shows that the highest number of weevils was registered in the April, 2018 of data collection, while the least registered number of weevils was during the January, 2019 month.

Sex Ratio of R. ferrugineus Captured in Aggregation Pheromone Traps:

Results are shown in Table (1) revealed that the total numbers of attracted weevils were 782 during the 12 weeks of the experiment. Males’ captures registered 321 while females’ captures reached 461, with a sex ratio of 1: 1.4. Similar results were reported by Al-Saoud (2015), where he indicated that the sex ratio between males and females was 1:2.1. The present results are agreement with those obtained by some authors such as (Abbas, 2000) who reported that the number of females attracted aggregation pheromone traps was generally twice. The sex ratios of male to female were 33.67 and 33.7: 66.3 during the two successive seasons, respectively. The sex ratio of males was increased to its maximum ratios at the end of November. (El-Sebay, 2003) found that female density was higher than male density and constituted 52.8-57.8% of the total population in the field more than male at a ratio of 1.35: 1. (Al-Saoud, 2004, Abdallah and Al-Khati, 2005; Al-Saoud, 2010 and 2013 and Al-Saoud et al., 2010) found that the sex ratio (males: females) of RPW was (1:1.33), (1:1.56), (1:1.75), (1:1.44), (1:2), (1:0.64), (1:1.66) and (1:1) during the period from July 2003 to February 2004, respectively and (Olfat, 2015) showed that the % of males of R.ferrugineus was 38.20% and reached its maximum in March (44.4%). Metwally and Basheer (2019), reported that the sex ratio was: 1:0.99 (female: male) during two seasons. Mohammed et al. (2015) found that significant difference was found between males and females; the sex ratio was about 1 male: 2.6 females; this proved the ability of the tested pheromones to capture more females than males weevils in the traps which makes trapping a potential tool for managing this economic insect. Salama et al. (2018). Studied that the ratio of females to males captured was 1.3♀: 1.0 ♂ (2016) and 1.0♀:1.0 ♂(2017).

Conclusion

Demonstrate that in the results of this study support monitoring the activity of RPW is essential for keeping a close watch on the establishment and subsequent build-up of the pest. Early detection, on the other hand, is crucial to avoid the death of palms; the application of mass trapping implemented with palm esters as an important tool for and is the key to the success of any the management of RPW populations and to prevent the infestation of ornamental plants in urban environments, where other techniques such as chemical control could have strong consequences on environmental pollution and human health. A better understanding of the attractive capacity of the palm ester mixtures and the relatively optimal doses could not only provide fundamental ecological knowledge but also make it possible to improve pheromone-baited trap efficiency in RPW control. Generally, the results indicated that the suitable trap supplied with ph+ kairomone +al+ ester with funnel bucket with 4 holes and topless hanging on ground level in date palm plantations area, all over the year, and these traps should be maintained regularly. Replacing pheromone with a new fresh one every two weeks. All of the ethyl acetate, sugar beet solution, ethyl propionate and soap water was provided when required are recommended for mass trapping and monitoring of the red palm weevil.

Table 1 : Total Number of RPW weevils attracted to essential attractive types pheromone, allomone, Kairmone and ester attractive.

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<th>Atr 2</th>
<th>Atr 3</th>
<th>Atr 4</th>
<th>Atr 5</th>
<th>Atr 6</th>
<th>Atr 7</th>
<th>Atr 8</th>
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<th>Atr 12</th>
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M=male  F=female  S.E.±=standered error  Combination(1):Water + insecticide + aggregation pheromone+ (allomone) 2 L of a 10% v/v aqueous solution of sugar beet +yeast+ (kiromone) 10% v/v emulsions of ethyl acetate + (ester) 10% v/v emulsions of ethyl propionate; Combination(2):Water + insecticide + aggregation pheromone+ (kairmone) 10% v/v emulsions of ethyl acetate + (ester) 10% v/v emulsions of ethyl propionate ; Combination (3):Water + insecticide + aggregation pheromone + (kairmone) 10% v/v emulsions of ethyl acetate + (allomone) 2 L of a 10% v/v aqueous solution of sugar beet +yeast. Combination (4): Water + insecticide + aggregation pheromone + (ester) 10% v/v emulsions of ethyl propionate ; Combination (5):Water + insecticide +aggregation pheromone + (kairomone) 10% v/v emulsions of ethyl acetate ; Combination(6): Water + insecticide + aggregation pheromone + (allomone) 2 L of a 10% v/v aqueous solution of sugar beet +yeast; Combination(7):Water + insecticide + (ester) 10% v/v emulsions of ethyl propionate; Combination (8) : Water + insecticide+ (kairmone) 10% v/v emulsions of ethyl acetate ; Combination(9): Water + insecticide + (allomone) 2 L of a 10% v/v aqueous solution of sugar beet + yeast ; Combination(10): Water + insecticide +aggregation pheromone and Combination (11): Control (empty trap).

**Table 2:** Mean number and SD of RPW in each of the 11 tested essential attractive combination in funnel pheromone traps.

<table>
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<th>Std. Deviation</th>
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<td>±10.65</td>
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<td>Atr.10</td>
<td>37hi</td>
<td>±1.66</td>
</tr>
<tr>
<td>Atr.11</td>
<td>30ij</td>
<td>±1.06</td>
</tr>
<tr>
<td>Atr12(control)</td>
<td>0j</td>
<td>±0.00</td>
</tr>
</tbody>
</table>

Means followed by the same letter are not significantly different according to F-test=36.559*** (L.S.D.0.05=43.75). *statistical analysis during the first weeks only.

**Acknowledgements**

The authors are grateful to Prof. Mohamed Kamel Abbas of plant protection research institute, agriculture research center for helpful comments that improved an earlier version of this manuscript.

**References**


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