Pest Management in Horticultural Ecosystems
Vol. 23, No. 1 pp 55-59 (2017)

Efficacy of bait free pheromone trap (Electrap™) for management of red palm weevil, *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae)

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ABSTRACT: The Red Palm Weevil (RPW) *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae) is a key pest of palms that has significantly expanded its geographical range in diverse agro-ecosystems during the last three decades. Food baited pheromone (ferrugineol) traps have been widely used in both RPW surveillance and also in mass trapping programmes for over two decades. Currently RPW pheromone traps have to be serviced (change of food bait and water) at bi-weekly intervals to sustain the trapping efficiency. In area-wide RPW- Integrated Pest Management (IPM) programmes, trap servicing is unsustainable and also not possible due to the enhanced cost associated with this practice. In this study the comparative efficiency of the service-less dry pheromone trap (Electrap™) against the traditional food baited traps, revealed that weevil captures in both the Electrap™ and the food baited traps (PicusanTrap™ and the bucket trap) were statistically similar. The Electrap™ offers a sustainable service-less trapping option for RPW management, especially in areas where the trap density has to be increased due to high weevil activity.

Keywords: Dry trap, Electrap™, pheromone traps, *Rhynchophorus ferrugineus*

INTRODUCTION

The Red Palm Weevil (RPW) *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae) also known as the Asian Palm Weevil is one of the world's most invasive pest species currently reported to infest 40 palm species (http: //www.savealgarvepalms.com/en/weevil-facts/host-palm-trees). The RPW has its home in South and South East Asia where it is a major pest of coconut (Lefroy, 1906). After it was reported on date palm in the Middle East during the mid 1980s (Zaid *et al.*, 2002), the pest rapidly expanded its geographical range (Giblin-Davis *et al.*, 2013) and is currently reported from nearly 50 countries in diverse agro-ecosystems worldwide including the Mediterranean basin countries where it is a key pest of the Canary Island palm. Weak quarantine measures at the local, regional and international level have resulted in the rapid spread of RPW both internally and also across international borders making it a trans-boundary pest. Difficulties in detecting infested palms in the early stage of attack makes it extremely difficult in controlling the pest. Infested palms exhibit tissue damage internally and extrusion of chewed up palm tissue with a typical fermented ordour. Severely infested palms may harbor overlapping generations of the pest and often topple due to extensive tissue damage (Abraham *et al.*, 1998; Dembilio and Jacas, 2012). The annual loss due to removal of severely infested palms in the GCC countries, at 1 and 5% infestation has been estimated to range from $5.18 to $25.92 million, respectively (El-Sabea *et al.*, 2009).

The RPW is currently managed employing an Integrated Pest Management (IPM) strategy where the use of food baited pheromone (ferrugineol) traps (FBPTs) forms an important component of the strategy (Abraham *et al.*, 1998). With the synthesis of the male produced aggregation pheromone by Hallett *et al.*, (1993), FBPTs have been widely used in both RPW surveillance and also in mass trapping programs for over two decades where captures are female dominant usually in a ratio of 1:2 (male : female). Additionally, the trapped weevils are known to be young, gravid and fertile indicating significant impact of trapping on the population reduction of the weevil in a given locality (Faleiro *et al.*, 2003). However, recent olfactometer based assays reveal that only a part of the adult RPW population is attracted to the pheromone (El-Shafie and Faleiro, 2017). In order to attain high weevil captures in RPW pheromone traps it is essential to adopt the best trapping protocols (Hallett *et al.*, 1999; Faleiro, 2006; Vacas *et al.*, 2016; Oehlschlager, 2016) with respect to the trap design, trap components (lure, bait and water), trap servicing, trap density etc. Black coloured RPW traps have been found to capture more weevils (Al-Saoud, 2013), while dome shaped traps are known to be superior as compared to the bucket traps (Vacas *et al.*, 2013). The aggregation pheromone is more attractive to RPW when combined with Kairomones or volatiles emitted from the host (Hallett *et al.*, 1999). RPW pheromone traps with dates mixed in water exhibit the best bait-lure synergy, consequently attracting a higher number of weevils as compared to other food baits (Faleiro and Satarkar, 2005). The food bait laced with insecticide is known to prevent escape of weevils for the traps that occurs in FBPTs without insecticide. Vacas *et al.*, (2013) reported that the addition of water to traps baited with palm tissues is essential, as this increased captures more than three fold compared with dry traps without water. Co-attractants based on fermenting compounds, ethyl acetate and ethanol, could improve the attractant level of ferrugineol and potentially replace non-standardised natural kairomones in RPW trapping systems (Oehlschlager, 2016; Vacas *et al.*, 2016).

Bi-weekly replacement of the food bait is essential to sustain the trapping efficiency and is the main constraint in increasing the trap density in an area wide program where a higher trap density often needs to be adopted due to enhanced weevil activity (Faleiro, 2006; Vacas *et al.*, 2016). Mass trapping programs are usually initiated at 1trap/ha as recommended by Oehlschlager, 1994 but has often to be increased (4-10 traps/ha) depending on the weevil activity in the field (Faleiro *et al.*, 2011), which is unsustainable and also not possible due to the enhanced cost associated with trap servicing. In this context, it has become imperative to search for service-less trapping options. The use of attract and kill technology using trap and bait free systems have been found promising (El-Shafie *et al.*, 2011; Faleiro *et al.*, 2016). Another alternative is the use of a dry trap without the food bait, water and insecticide. Communication in insects has for long been attributed to factors other than scent and hearing (Riley, 1894) and the Electrap™ functions on the principle that insects communicate by radiations emitted from oscillating molecules and is the first of its kind developed and patented for attracting and trapping RPW. In this study we tested the comparative efficiency of the black coloured dome shaped dry pheromone trap (Electrap™) against the traditional food baited bucket trap in a RPW infested date plantations in the Al-Ahsa date palm oasis of Saudi Arabia.

The general overview of the Electrap™ is presented below (Figure 1). In this trap insects are captured and disabled using pulsed emission from MASER (Microwave Amplification by Stimulated Emission of Radiation). Inside the core Electrap™device is placed the pheromone lure (Ferrolure) and the solid formulation of the kairomone (ethyl acetate). The invention has been granted a patent by the United Arab Emirates as well as the Gulf Cooperation Council.

Since long the possibility that insects communicate by radiations emitted from oscillating molecules has been proposed (Riley, 1894; Callahan, 1965;Shimron et al., 1985). The Electrap™ functions on the principleof MASER, where a fully inside mirrored 'Resonance Chamber'(core electrap device), loaded by natural light, incessantly reflects the light, starts a resonance process till the saturation of the light reflection inside the chamber, thereby emitting the infrared electromagnetic radio waves loaded by the lures molecules and attracting the insects.This mechanism of electromagnetic communication and olfaction in insects has been previously reported by several workers (Laithwaite, 1960;Callahan, 1965; Turin, 1966; Wright, 1977; Porcella, 2013). In The Electrap™the said Resonance

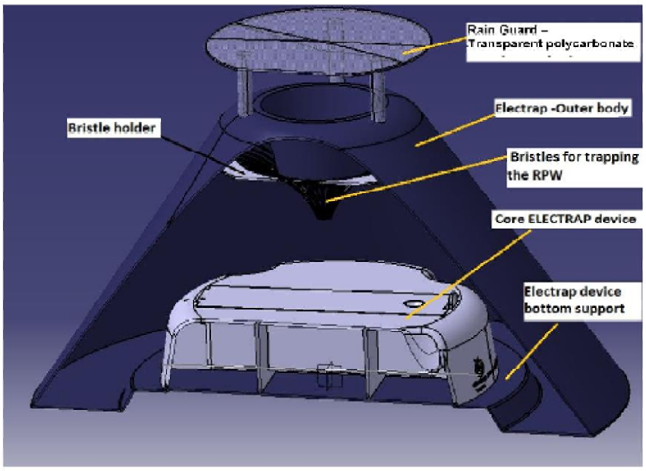

Fig. 1. General Cross section of the Electrap™ with the major components

Chamber is mounted horizontally in the trap and the semiochemicals (Pheromone and Kairomone) are placed inside which can last for 4 to 6 months without renewal.

MATERIALS AND METHODS

Two field trials were conducted between 31 January and 3 April, 2016. In trial-I (Three weeks: 31 January to 20 February, 2016), three treatments comprising T1: ELECTRAP™ (without the food bait); T2: Picusan Trap™ with pheromone (Ferrolure+) + Food bait (200g dates in 1L water) and T3: Traditional four window bucket (5L) trap with pheromone (Ferrolure+) + Food bait (200g dates in 1L water) were tested. Each treatment was replicated 10 times. Treatments were set 10 m apart within each replication while a distance 20m was maintained between two the replications. Trial-II was carried out in the same field (Six weeks: 22 February and 3 April, 2016). The same experimental protocols were followed as indicated above in trial-I. However the treatment involving the Picisan Trap™ in trial-I was eliminated and in trial-II, the Electrap™ (T_1) was tested against traditional four window bucket (5L) trap (T_2).

RPW population is known to be highly aggregated (Faleiro, 2006) that could result in experimental error with traps close to an infested palm capturing more weevils as compared to traps away from an emerging brood of weevils. To eliminate bias of treatments due to the aggregated / clumped distribution pattern of RPW, the treatments (traps) were moved sequentially from one spot to another every week in each block to eliminate spot bias if any. Observations on weevil captures were recorded at fortnightly intervals in all the traps, when also the food bait and water in the Picisan Trap™ and the traditional food baited bucket traps (T_2 and T_3 in trial-I and T_2 in trial-II) was renewed.

Data on weevil captures were compiled at the end of each experiment and subjected to statistical analysis (ANOVA p: 0.05) for trial-I, while for trial-II, weevil capture data were subjected to 't test'.

RESULTS AND DISCUSSION

Results presented in Figure 2 and 3 reveal that the mean weevil captures in the traps evaluated in both the trials were statistically similar. In trial-I, statistically similar weevil captures of 2.1, 1.9 and 1.1 weevils/trap were recorded in the PicusanTrap™, Electrap™ and the traditional bucket trap, respectively. Further, in trial-II trap captures of 2.0 and 1.9 were recorded in the bucket trap and Electrap™, respectively. Black-colored pyramidal (Picusan™) traps are known to significantly increase captures in food-baited pheromone traps (Vacas *et al.*, 2013). However, both the Picusan™ and the traditional food baited bucket trap have to be serviced to sustaing the trapping efficiency. It is relevant to point out that the Electrap™ does not need any servicing and its trapping efficiency is similar to the Picisan Trap™ and the traditional food baited bucket trap where the food bait and water has to be renewed at least once every two weeks. The Electrap™ invention emphasizes the role of electro-magnetic radiation in attracting RPW adults similar to the assembling of moths proposed by Laithwaite, 1960. Further, Callahan, 1965 showed evidence for a far infrared (FIR) electromagnetic theory of communication and sensing in moths.

Once RPW adults enter into the Electrap™, escape of the trapped weevils is prevented due to the presence of the one-way bristles crown at the entrance. Subsequently the trapped weevils die due to quick dehydration. The dismountable bottom support allows an easy periodical removal of the dead weevils. It is pertinent to mention that the Electrap™ besides being bait and water free is also without any insecticide as often used in the FBPTs to kill the trapped weevils.

El-Shafie and Faleiro, 2017 propose that RPW semiochemical mediated technologies which could be used in area-wide RPW-IPM programs need to focus on the development of pheromone traps that eliminate the need to periodic servicing (renewing water, food bait and insecticide). The Electrap™ is an advancement in this direction and offers a sustainable service-less trapping option for RPW especially in areas where the trap density has to be increased due to high weevil activity. This

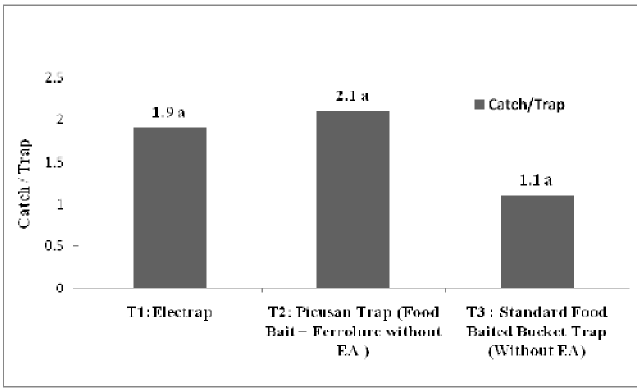

Fig. 2. Mean *R. ferrugineus* captures in different traps tested in Al-Ahsa, Saudi Arabia (31 January to 20 February, 2016)

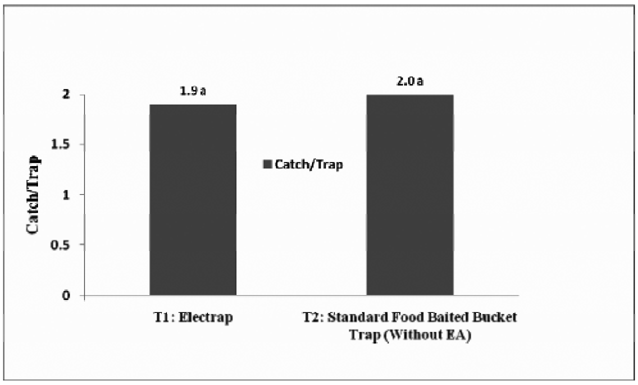

Fig. 3. Mean *R. ferrugineus* captures in different traps tested in Al-Ahsa, Saudi Arabia (22 February and 3 April, 2016)

invention based on patented electromagnetic diffusion system of semiochemical signalshas also been recently conferred with a United Nations Industrial Development Organization (UNIDO)http://www.unido.it/award2017/electrap/.The Electrap™ is the first efficient service-less dry pheromone trap that can be incorporated into the RPW-IPM programme to reduce the cost of the trapping programme especially in an area-wide operation. Further improvement to this service-less trapping option, would be the development of smart trapping device for automatic data collection and transmissionon the weevils captured for efficient decision making.

ACKNOWLEDGEMENTS

Facilities provided by the Centre of Date Palm and Dates, Al-Ahsa (Ministry of Environment, Water and Agriculture, Kingdom of Saudi Arabia) to carry out the trials under the FAO Project (UTF/SAU/043/SAU) are gratefully acknowledged.

REFERENCES

Abraham, V. A., Al-Shuaibi, M. A., Faleiro, J. R., Abozuhairah, R. A. and Vidyasagar, P.S.P.V. 1998. An integrated management approach for red palm weevil, *Rhynchophorus ferrugineus* Oliv., a key pest of date palm in the Middle East. *Sultan Qaboos University Journal of Science and Research (Agricultural Science)*, **3**: 77-83.

Al-Saoud, A. H. 2013. Effect of ethyl acetate and trap colour on weevil captures in red palm weevil (Coleoptera: Curculionidae) pheromone traps. *International Journal of Tropical Insect Science*, **33**(3): 202-206.

Dembilio, O. and Jacas, J. A. 2012. Bio-ecology and integrated management of the red palmweevil, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) in the region of Valencia (Spain). *Hellenic Plant Protection Journal*, **5**: 1-12.

El-Shafie, H. A. F. and Faleiro, J. R. 2017. Optimizing components of pheromone-baited trap for the management of red palm weevil, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) in date palm agroecosystem. *Journal of Plant Diseases and Protection*. DOI 10.1007/s 41348-017-0097-5. Published on line, 26 April, 2017.

El-Sabea, A. M. R., Faleiro, J. R. and Abo El Saad. M. M. 2009. The threat of red palm weevil *Rhynchophorus ferrugineus* to date plantations of the Gulf region of the Middle East: an economic perspective. *Outlooks on Pest Management*, **20**: 131-134.

El-Shafie, H. A. F., Faleiro, J. R., Al-Abbad, A. H., Stoltman, L., and Mafra-Neto, A. 2011. Bait-free attract and kill technology (Hook™ RPW) to suppress red palm weevil, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) in date palm. *Florida Ent*omologist, **9**: 774-778.

Faleiro J. R., Al-Shawaf, A. M., Al-Dandan, A. M., Al-Odhayb, A., Al-Rudayni, A., Abdallah, A. B., Peixoto, M.P., Vargas, R., Bottom, M., Chidi, S., Borges, R. and Mafra-Neto, A. 2016. Controlled Release Products for Managing Insect Pests. *Outlooks on Pest Management*, DOI: 10.1564/v27_jun_00.

Faleiro, J. R., Abo El-Saad, M. and Al-Abbad. A. H. 2011. Pheromone trap density to mass trap *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae/Rhynchophoridae/Dryophthoridae) in date palm plantations of Saudi Arabia. *International Journal of Tropical Insect Science*, **31**(1-2): 75-77.

Faleiro, J. R. 2006. A review of the issues and management of the red palm weevil *Rhynchophorus ferrugineus* (Coleoptera: Rhynchophoridae) in coconut and date palm during the last one hundred years. *International Journal of Tropical Insect Science*, **26**: 135-150.

Faleiro J. R., Rangnekar, P. A. and Satarkar, V. R. 2003. Age and fecundity of female red palm weevils, *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Rhynchophoridae) captured by pheromone traps in coconut plantations of India. *Crop Protection*, **22**: 999-1002.

Faleiro J. R. and Satarkar, V. R. 2005. Attraction of food baits for use in red palm weevil, *Rhynchophorus ferrugineus* Olivier pheromone traps. *Indian Journal of Plant Protection*, **33**(1): 23-25.

Giblin-Davis, R. M., Faleiro, J. R., Jacas, J. A., Peña, J. E. and Vidyasagar, P.S.P.V. 2013. Coleoptera: Biology and management of the red palm weevil, *Rhynchophorus ferrugineus*. pp. 1-34. *In* J. E. Peña [ed.], Potential Invasive Pests of Agricultural Crop Species. CABI Wallingford, UK.

Hallett, R., Oehlschlager, A. and Borden, J. 1999. Pheromone trapping protocols for the Asian palm weevil, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae). *International Journal of Pest Management*, **45**(3): 231-237.

Hallett, R. H., Gries, G., Gries, R., Borden, J. H., Czyzewska, E., Oehlschlager, A. C., Pierce, H. D. J R., Angerilli, N. P.D. and Rauf, A. (1993). Aggregation pheromones of two Asian palm weevils, *Rhynchophorus ferrugineus* and *Rhynchophorus vulneratus*, *Naturwissens chaften*, **80**: 328-331.

Lefroy, H. M. 1906. The more important insects injurious to Indian Agriculture. Govt. Press, Calcutta, India.

Laithwaite, E. R. 1960. A radiation theory of the assembling of moths. *The Entomologist*, **93**: 113-117.

Oehlschlager, A. C. 2016. Palm weevil pheromones-discovery and use. *Journal of Chemical Ecology,* **42**(7): 617-630.

Oehlschlager, A. C, 1994. Use of pheromone baited traps in control of red palm weevil in the kingdom of Saudi Arabia. Consultancy Report - submitted to Ministry of Agriculture, Saudi Arabia, 17pp.

Porcella, L. 2013. Electromagnetic Communication and Olfaction in Insects - Progresses in Studies and Applications on RPW Plague, http: //www.uaefirst.com/ electr-com-and-olfaction-in-insects.pdf, 11 pp.

Riley, C. V. 1894. Social insects from psychical and evolutional points of view. Annual address of the President of the Society, Washington, D. C. cover title Proceedings of the Biological Society of Washington, 9, 74.

Shimron, O., Hefetz, A. and Tengo, K. 1985. Structural and communicative functions of Dufours gland secretion in *Eucerapales tinae* (Hymenoptera: Anthophoridae). *Insect Biochemistry*, **15**(5): 635-638.

Turin, L. 1996. A spectroscopic mechanism for primary ol factory reception. *Chemical Senses*, **21**(6): 773-791.

Vacas, S., Primo J. and Navarro-Llopis, V. 2013. Advances in the use of trapping systems for *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae): traps and attractants. *Journal of Economic Entomology*, **106**: 1739-1746.

Vacas, S., Melita, O., Michaelakis, A., Milonas, P., Roxana Minuz, R., Riolo, P., Abbass, M. K., Bue, P.L., Colazza, S., Peri, E., Soroker,V., Livne, Y., Primo, J., Navarro-Llopis, V. 2016. Lures for red palm weevil trapping systems: aggregation pheromone and synthetic kairomone. *Pest Management Science*, 10.1002/ps. 4289.

Wright, R. H. 1977. Odour and molecular vibration: neural coding of olfactory information. *Journal of Theoretical Biology*, **64**(3): 473-474.

Zaid, A., De Wet, P. F., Djerbi, M. and Oihabi, A. 2002. Diseases and pests of date palm. In: Date Palm Cultivation. Zaid, A. (Editor). FAO Plant Production and Protection Paper no. 156, Rev. 1. FAO, Rome.

MS Received : 30 April 2017
MS Accepted : 26 May 2017