Evaluate The Efficacy Of A New Trap (ELECTRAP TM) to Mass Catching Red Palm Weevil ((*Rynchophorus Ferrngineus*) (Olivier) (Coleoptera: Curculionidae) Comparing With Traditional Trap In Date Palm Orchards

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Abstract

The efficacy of Electrap was evaluated to capture RPW adults under different field infestations, and a comparison of efficiency between the Electrap and the traditional traps was made, We also determined the importance of the traps in controlling management program, and the cause of effectiveness of the traps and determined male - female ratio, the experiment was conducted on 11/Sept/2017 and finished on 11/Jan/2018 (four months).The Electraps and the traditional traps were placed in four sites with high, medium and low RPW infestation, All traps were randomly placed in the middle area between trees, under direct sun light, keeping at least 100 meters or more between each two traps. After two months all pheromones and kairomones capsules were replaced in Electrap and traditional traps by Electrap capsules in site (A), traps' readings were taken biweekly.

Results showed the statistical superiority of the Electrap against the traditional trap under the influence of different infestation percentiles, in the four experimental sites, regardless of the level of RPW field infestation, using the Tukey test at.05 and.01 levels. Electrap caught up to 6 times more than the traditional trap. On the other hand, traps have an important role in controlling programs as well as Electrap that six Electrap caught 549 adults during four months (89% percentile) Compared to 66 adults caught by traditional trap (11% percentile) in the first experimental site A. Also, the effect of Electrap pheromones and kairomones replacement in both traps didn't significantly improve capturing of traditional trap. Pheromones and kairomones capsules should be renewed after two to three months to keep full acting potential, The female- male ratio was detected from 5.7:1 to 3:1. Finally, the theoretical calculation revealed that one Electrap may control 732 infestation spots/month ,and 22thousand infestation spot/30electrap/10 hectres.

Key words: Electrap, RPW, female ratio, the traditional traps pheromones and kairomones

Introduction

Red Palm Weevil (*Rynchophorus ferrngineus*)(Wattanapongsiri, A. 1966) is the most invasive, dangerous and deadly pest on 40 palm species(Sami Al-Saroj,2017) in most palms planted areas in the world
(Abraham, et. al. 1998). South and South East Asia is the home of RPWthat was considered as a major pest of coconut (Lefroy, 1906). Weak quarantinemeasures permitted the rapid spread of

RPW to more than 50 countries (Giblin-Davis *et al.*, 2013) ,the RPW was reported on date palm in the Middle East during the mid 1980s (Zaid *et al*., 2002), millions of RPW infested palm trees was died,losses contineous every year and millions of money were lost, 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) ,in Jordan which resemble A little date palm planted area owned half million trees has lost more than 10 thousand trees and losses still happened(Mashal,M.Obaidate,B.,2015)
RPW (all stages: egg, larva, pupa, and adult) spend their lives inside the palm itself, resulting in trunk destruction then tree death (Faleiro J. R., *et al*., 2003) Adult males and females fly out of the damaged trees to find new succulent hosts, mating and depositing thousands of eggs to generate a new infestation causing more losses , (Faleiro, J.R., et al.,2011, Riley, C. V. 1894.). The RPW females deposit about 300 eggs in separate holes on the palm trunk. Eggs hatch in 2 to 5 days into legless grubs which bore into the interior of the palms feeding on the soft succulent tissues, discarding all fibrous material. The larval period varies from 1 to 3 months. The grubs pupate in an elongate, oval, cylindrical cocoon, made out of fibrous strands. At the end of the probation period, which lasts 14 to 21 days, adult emerge and fly out of the tree searching for a new host, mating and repeating the infestation(El-Sabea, A. M. R., 2009)

Control strategies of RPW depend on monitoring, protection and treatment using an Integrated Pest Management as sanitation, cultural, mechanical, biological, physical and chemical practices (Dembilio,O. And Jacas, J.A. 2012). Monitoring is the first step in controlling programs to detect the infestation very early before causing tree destruction (Faleiro. 2006, Oehlschlager, A. C.1994), Monitoring is conducted mainly by direct Inspection of the trees or indirectly by using pheromone traps using aggregation pheromones (Hallett, R. H.1993). The trap has many functions: detecting the first entry of the insects in the orchard, detecting the population dynamics to determine the suitable time of control, (Faleiro, J.R., 2006). The traps also have an important role in mass trapping (Hallett, R., *et al*. 1999) by placing lots of traps (one trap/1000m2) that capture and kill adults before mating and depositing eggs and introducing a new generation which exaggerates the infestation, (Mashal,M.Obaidate,B. 2015).

Many pheromone traps were used to capture adult weevil, traditional traps (food baited traps) (Faleiro J. R. And Satarkar, V.R. 2005) as PicusanTrap^{TM} and the bucket trap, These traps consist of pheromone 625+ and carmine capsules (Oehlschlager, A.C. 2016) fermented fruits, yeast, insecticide, water in the pail, (Faleiro J. R. And Satarkar, V.R. 2005) Manipulation of the traditional traps are difficult due to continuous field needed services as frequent water, adding as well as the other components and the regular trap cleaning that is contaminated by mold, house flies and other insects and vertebrates dispersing very bad scents substances(fig7) (Vacas, S., *et al*. 2013), Most of the time the traditional traps in the field become inefficient due to water drying, due to the evaporation, and capsules expiring; the capturing Insects entering and getting out from the trap container without dying. On the other hand, the traditional traps used in Jordan consist of the body of the trap; 10 liter white plastic pail (with six vents, two at the lid and four on the side), one liter plastic pail are placed inside the trap, the fermented fruits placed inside the small pail, pheromone lure capsule (625+) (El-Shafie, H. A. F. And Faleiro, J. R. 2017) and kairomone bottle (ethyl acetate), ten to fifteen grams of yeast, insecticide powder and water. This trap captures Adults by attracting to highly strong scent dispersed from the components of the trap (Wright, R.H.1977). Adults enter through the rounded vents and then are killed by either drowning in water or by poisoning from the insecticides. There has to be a monthly renewal of Pheromones and kairmones capsules. However, renewal of water, yeast, and

fermented fruits is conducted on dryness of these substances (Vacas, S., *et al*. 2013). All the more, the trap needs periodic service to be efficient all the time.

ELECTRAP((fig2) was invented to overcome all these obstacles and simplify the trap manipulation process. Once you place the traps in the orchard, there would be no need for services, except changing the pheromone and kairmone capsules

This new black trap, which has a flying saucer shape, was invented to capture RPW adults(fig3). and disable them and let them die(fig4) using pulsed emission from MASER (Microwave Amplification by Stimulated Emission of Radiation (Callahan, P.S. 1965, Laithwaite, E. R. 1960) Inside the Electrap device core the specially designed Phero-Kairo 925+, a pheromone lure (Ferrolure) (Oehlschlager, A.C.2016) and the formulation of the kairomone (ethyl acetate) are placed. No adding of water, insecticide, food bait, and yeast. The invention has already been granted a patent by the UAE as well as the GCC.

This experiment was conducted to evaluate the efficacy of the Electrap to capture RPW adults and to make a comparison between the Electrap and the traditional traps which are already used in Jordan and to determine the importance of traps in control management programs, also to determine the main cause of effectiveness of the traps whether it is caused by the chemical composition of the pheromone and the kairomones or caused by the composition of the trap itself, and finally to detect male-female ratio of the captured weevils.

Material and method

Experiment Sites Selecting

Four sites were selected in Jordan Valley (area infested by RPW). The sites were chosen according to the infestation density of RPW; high, medium and low, with specific conditions as follows:

- Site A - the infestation reached more than 50 % of the trees; 20 trees have got an injection treatment with many insecticide applications.
- Site B - the infestation reached more than50 % of the trees, all infested trees got an injection and fumigant treatment.
- Site C - infestation reaches more than 20% of the trees, all infested trees have got an injection and fumigant treatment for all infested trees.
- Site D - infestation less than 20% of the trees, it has got to cut and sprayed treatment.

The Experiment

The experiment was designed for the following sections to achieve the objective of the experiment

1- The efficacy of the Electrap in capturing RPW compared to traditional trap.
This field trial part started in the four sites (A, B, C, and D) on 11Sept/2017 and finished in 11Jan/2018 (four months).

2- The efficacy of Electrap in capturing RPW compared to traditional trap using the same Pheromones and Kairomones Electrap capsules.

This part of the trial was conducted on site A started on 29 Oct/2017, and finished on 11 Jan/2018(72 days).

3- The longevity of Electrap capsules pheromones and Kairomones.
This part of the trial was conducted in the four sites. Started on 11Sept/2017 and finished on 11/Jan/2018 (four months).

Traps

The Electraps((fig2) and the traditional traps(fig6) were placed in the four sites as follows:

1. Site A - six electrap + six traditional traps
2. Site B - five electrap + five traditional traps
3. Site C - three electrap + three traditional traps
4. Site D - three electrap + three traditional traps

On 11/Sept/2017 all traps were randomly placed in the middle between trees under direct sunlight, keeping at least 100 meters or more between each two traps to avoid scent interference, to prepare the Electrap for use; Pheromone and Kairomone capsules were placed in Electraps inside the Resonance Chamber (fig1). These capsules can last for 3 to 6 months without renewal (company instructions). Without addition of water, insecticides or food bait inside Electraps.

The traditional traps were prepared for use in the four locations. Pheromone (625+) capsule and Kairomone (150ml of ethyl-acetate) were placed under the lid of the trap (10 liters white plastic pail) / food bait (fruits)(fig5). 10 grams of yeast, water and insecticide were placed inside the traps. Monthly renewal of Pheromones and Kairomones capsules while water and fermented fruits are renewed when dry.On location at all capsules were renewed after two months for all traps (Electraps and traditional traps).

The Data Collecting

Traps readings were taken biweekly, all captured adults were collected, taken to the laboratory and read to determine the male-female ratio. Data were gathered from 11Sept/2017 to 11Jan/2018 and analyzed by one way ANOVA analysis for Correlated Samples using Tukey Test HSD [. 05] for the. 05 level, HSD [. 01] for the.01 levels and description analysis.

Results and Discussion

The efficacy of the Electrap in capturing RPW compared to the traditional traps.

The first table strongly indicates the clear differences between the average numbers of RPW caught by the Electrap and the traditional trap in the four experimental sites. Data show the superiority of the Electrap against the traditional trap under the influence of different infestation percentiles in the four experimental sites regardless to the level of RPW field infestation. This is confirmed statistically as shown in table two using Tukey test at.05 and .01 levels, between readings of Electraps and traditional traps.

Table one: Means of RPW Caught by Eectrap and Tradional Trap in The Four Experimental Sites

Exp sites	A		B		C		D	
Date	E (M1)	T (M2)	E (M3)	T (M4)	E (M5)	T (M6)	E (M7)	T (M8)
24/09/2017	10.8	2	17	2.7	14.2	2.1	0.3	0
08/10/2017	8.8	1	14.1	1.7	11.5	1	0.3	0
15/10/2017	5.7	1.25	12.4	0.6	8.5	1	0.3	0
29/10/2017	5.8	0.2	11.5	0.6	6.8	1.1	0	0
13/11/2017	12.5	0.2	7.6	2.6	5.2	1.5	0	0
30/11/2017	12.1	4.8	7.5	1.2	4.5	1.5	0	0
15/12/2017	12.2	2.75	6.8	0.04	4.3	1	0	0
30/12/2017	11.8	1.2	4.2	0	4.1	0	0	0
11/01/2018	10.57	1.2	3.9	0	4	0	0	0

Each number represents the mean of RPW caught by six traps in site A and three traps in B, C and D experimental sites. E = Electrap – T = Traditional trap

The results of the statistical analysis in table two show that the Electrap captured significantly more than the traditional trap in the three sites A, B and C, whereas in the fourth site (D) the orchard infestation was almost eradicated after one month from the beginning of the experiment and the Electrap stopped capturing insects while the traditional traps did not capture any weevil in D site from the beginning.

Table two: Results Of Analyzed Data In The Four Sites Using *Tukey HSD Test* [.01

Significant AT	Non Significant at
M1 vs M2 P<.01	M1 vs M3
M1 vs M4 P<.01	M1 vs M5
M1 vs M6 P<.01	
M1 vs M7 P <.01	
M1 vs M8 P<.01	

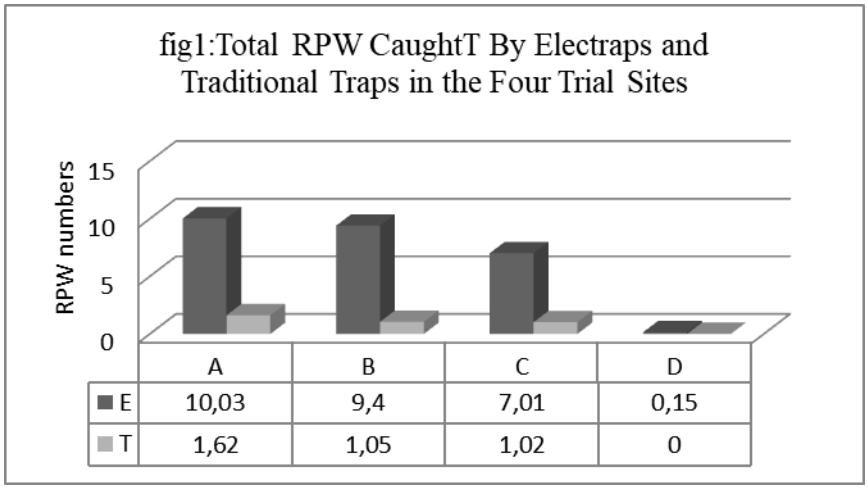
Tukey HSD Test [. 01] =25.93

M = means; HSD = the absolute difference between any two samples means required for significance at the designated level. HSD[.01] for the .01 level.

It was noted that the capturing rate was directly proportionate to the severity of the infestation in the four experimental sites. The rate of capturing adults was highest in the infested farm, then the averages were gradually reduced to zero as at site D. So that, the traps are an important method for capturing and determining the level of field infestation, as well as in control programs.

On the other hand, the Electrap was more efficient in capturing insects than the traditional traps, (traditional traps were supplied with pheromone, kairmones, food bait, yeast, water, and pesticides while the Electrap were just supplied with pheromone and kairmones capsules). This conclusion is shown in Fig1 which represents the average mean in the four experimental sites predicting the ability of both trap types to capture the RPW adults, regardless of the level or

severity of the RPW infestation in the fields or the time of reading during the year which correlated with the flight movement of the weevil inside the orchard. The graph showed a clear significant difference between the traditional trap and Electrap with the great superiority in capturing of the last which is 6 times more than the traditional trap.



E = Electrap – T = traditional trap

At the conclusion, traps have an important role in controlling program as well as Electrap as shown in fig 3 which predicts the efficiency of the traps to capture adults RPW, It was found that six Electraps captured 549 adults during four months (89% percentile) Compared to 66 adults captured by traditional traps (11% percentile) in the first experimental site (A).

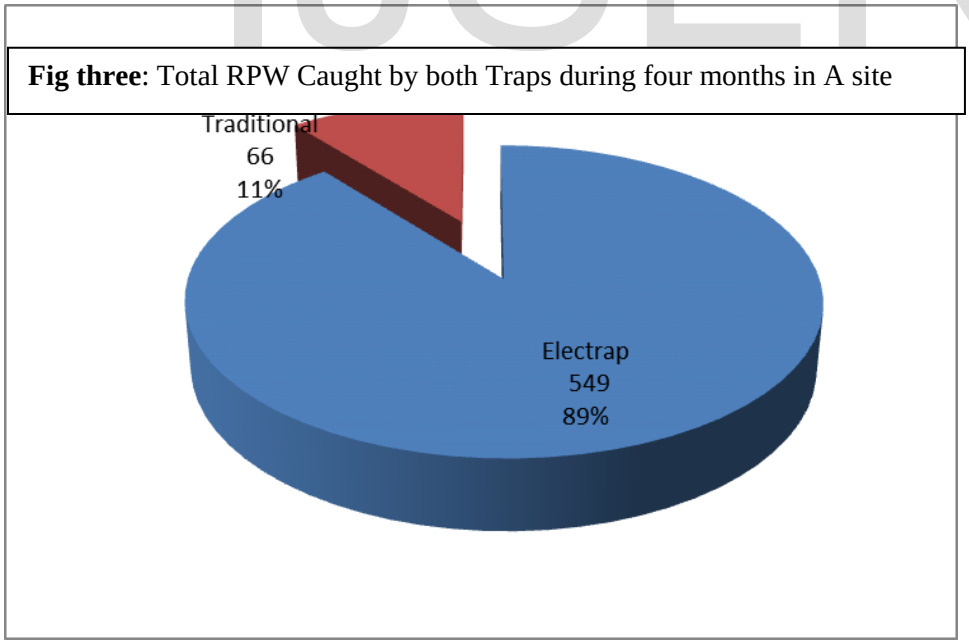


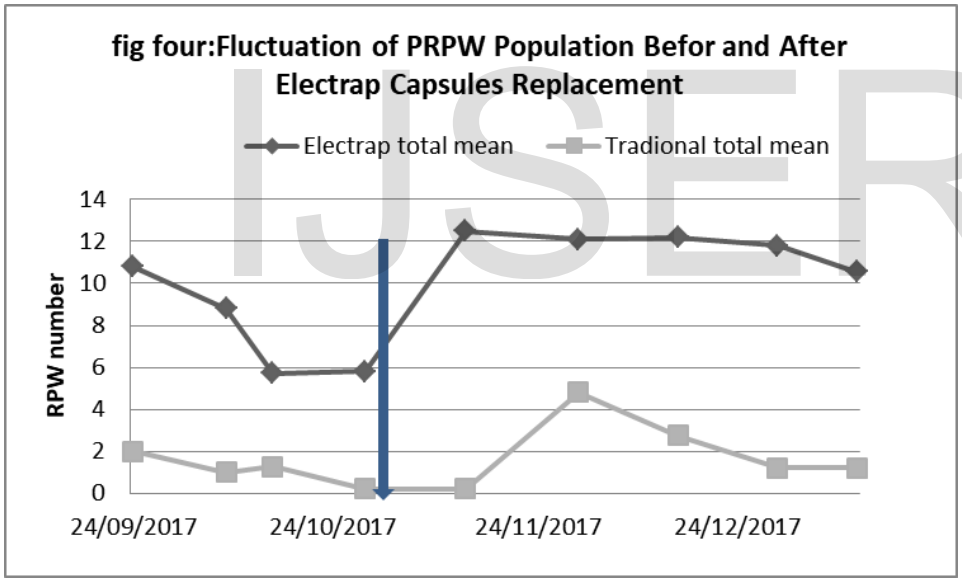
Fig three: Total RPW Caught by both Traps during four months in A site

Determining the source of efficiency of the Electrap which distinguishes it from the traditional trap

Figure 4 represents the experimental of replacing all the pheromone and kairomone capsules of the traditional traps and Electraps with the pheromone and kairomone capsules of the Electrap after two months of starting the experiment at the site A. Curves in Figure 4 showed the effect

of this change on the trap capturing efficiency. The curves showed a rapid capturing improvement of the Electraps which continued to the end of the experiment while the capturing improvement of traditional trap was little as shown in the first reading (after interfering arrow in Fig 4). Then, the reading returns to the same level as before. This conclusion indicated that the technical operating system of the Electrap in spreading the semiochemical code through the space is specially and very efficient and not only due to the concentration and composition of pheromone and carmine capsules (vocals, S. *et al*. 2016). Also the mechanical capturing operation of Electrap is very efficient. In fact, once RPW adults enter into the Electrap, it could not escape due to the presence of the one-way bristles crown at the entrance. Subsequently, the trapped weevils die due to quick dehydration. Then the dead insects are removed after the traps are filled with dead weevils.

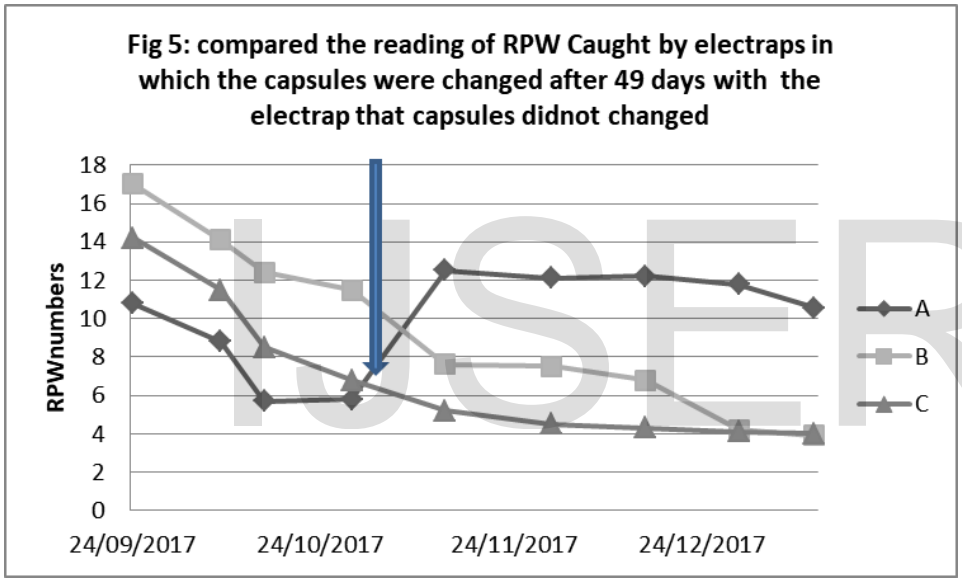
On the other hand, the principle of the operation system (abbreviated by MASER) (Porcella, L. 2013)where a fully inside mirrored 'Resonance Chamber' (core Electrap device), loaded by natural sunlight, incessantly reflecting the light, starts a resonance process till the saturation of the light reflection inside the chamber (Wright, R.H. 1977, Laithwaite, E. R. 1960), thereby emitting the infrared electromagnetic radio waves loaded by the lures molecules and so attracting the insects(Vacas,S. *et al*. 2016).



Effect of permanence and longevity of Pheromone and Kairmone capsules on the efficiency of the Electrap captures

Fig 5 represents the effect of renewing the capsules of pheromones and kairemone on the efficiency of RPW capture for a long run (three to six months as company instructions). The arrow in the diagram in fig, 5 represents the interference of capsules renewal in A site while no change of capsules in B, C sites. Curve A showed the rapid improvement in Electrap capturing, while there was a dramatic decline in adult capturing as shown in B and C curves. Although, the result may be explained by the decrease in population of RPW due to continuous controlling of RPW in B and C sites, but also these same control measures were applied on site A. However, the general trend of the curve A showed the occurrence of autumn peak of RPW population

dynamics in November which is emphasized by the improvement in trap capturing in site A after renewal of the capsules. So, as a conclusion, there is a loss in the effectiveness of capsules after a maximum of two months (under high field temperatures reached more than 40 degrees Celsius and for three months under 30 degrees Celsius), To solve the problem of the degredation of pheromone and kairomone lure after two months , the company CIQ(crop IQ TECHNOLOGY LTD) Exclusively manufactured in synergy with FIRST - UAE a new RPWpheromone+kairomone v.41 microencapsulated IQ PHERO-KAIRO 925+925 mg IQ RPW lure *+(9 parts 4-methyl-5-nonanol & 1 part 4-methyl-5-nonanone)*IQ RPW-Kairomone (Ethyl acetate - Kairomone) on January 2018, the company made the validity of the new capsules is 36 months at -2 Celsius Field Efficacy: 5/6 months at +40 Celsius(Safety Data Sheet ,January 20, 2018), while this capsules should be evaluated as a second phase of evaluation in next months.



Sex ratio

Figure six shows, about the male/female ratio, that the female percentile was significantly higher than that of males, ranging from 5.7:1 at the beginning of the experiment to 3:1 in the end which adreed with Landolt, P.J.(1997) which coincides with the onset of winter, the increasing of males percentage with the incoming winter will encourage the mating and produce a new generation to enter the winter, On the other hand, more female captured by traps contributes more to controlling RPW than capturing males, as female mate many time with one or more male, then female lay eggs with an average of 250 eggs which will hatch to new RPW individuals. A total of 54,900 RPW could have lived and caused 54,900 infestations.

Controlling capacity

To evaluate Electrap efficiency as a part of any RPW control program, a theoretical calculation applies as follows:

- 549 total RPW captured by Electrap (fig 4)/6traps*4month = 22.875 rpw/trap/month

- 22.875 RPW/trap/month*80% females (fig 6) * 200 (eggs/adult)*40% (expected natural mortality for different insect stages) = 732 RPW individuals or infestation spot/trap/month.

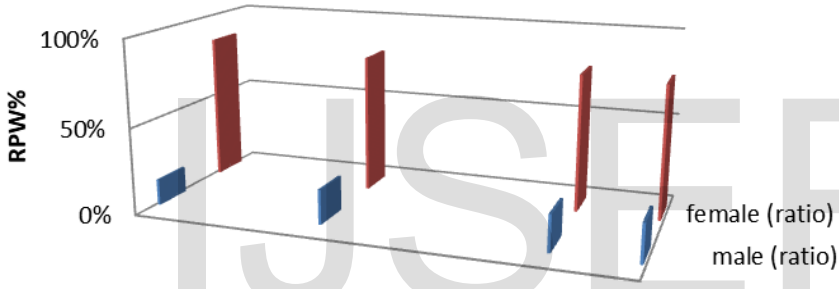
So that, if the farmer is placing 30 Electrap/10hectares (Jordan orchard unit), this will lead to a rapid decrease of the infestation as follows:

- 30*732 = 21960 RPW individuals or infestation spots/30traps/month/10hectares.

This 22000 female, if not captured by the traps it will lead to 22000 infestation spots (on the same tree or different trees) and, under suitable conditions, it will cause a disaster and outbreak of the insect population in the orchard and cause high losses within the infested and the nearby area.

Therefore, traps as Electrap has a very essential role and strongly help in controlling weevil and it should be a part of any controlling program for RPW

Figure Six :Male Female Ratio Of Rpw Caugt By Traps



	29/10/2017	22/11/2017	22/12/2017	02/01/2018
male (ratio)	15%	20%	21%	22%
female (ratio)	85%	80%	79%	77%

Conclusions

1. The results of the Electrap assessment and their comparison with the traditional trap show that the Electrap is very efficient in capturing RPW adults, reaching up to 6 times more efficient than the traditional trap, although the traditional trap is full supplemented by the pheromone, kairomone capsules, food bait, yeast, insecticide, and water.

2. Electrap is simply operational, easy to handle and processing.

3. Electrap is dry and does not need a continuous field service such as traditional traps that can lose any efficiency if the water dried inside.

4. Although the Electrap costs more than the traditional trap, the nature of the Electrap body makes it able to withstand the weather conditions and stay in the orchard for as long as possible. A part of the mentioned hour savings in maintenance costs.

5. It is advisable to change the pheromones and kairmones every two to three months so as not to lose the full capacity of capturing.

6. Theoretically: one Electrap may control 732 infestation spot/month ,and 22 thousand infestation spot/30electrap/10 hectares.

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Pictures (from left to the right)FIG1:((pheromone and kairmone capsules mounted in Electrap champer)fig2:(the Electrap body)fig3:(landing of RPW on Electrap cascade)fig5:(RPWcaught inside the Electrap)fig6:(preparing of traditional trap)fig7(tradirional trap setting)fig8:(contaminated tradition trap after two weeks from setting).