Journal of Oasis Agriculture and Sustainable Development
www.joasdjournal.com

RESEARCH ARTICLE

JOURNAL OF OASIS AGRICULTURE AND SUSTAINABLE DEVELOPMENT

www.joasdjournal.org

JOASD

p-ISSN: 2724 – 699X
e-ISSN: 2724-7007

Management of *Ceratitis capitata* (Diptera: Tephritidae) in Tunisian oases by mass trapping methods

Sameh Ben Chaaban[1] , Abir Hafsi[2], Kamel Mahjoubi[1], Noureddine Nasr[3] & Brahim Chermiti [3]

[1]*Centre Régional de Recherche en Agriculture Oasienne, DegacheRue de Tozeur,2260Tunisie*
[2] *Institut Supérieur Agronomique de Chott-Mariem,Laboratoire d'Entomologie et de Lutte Biologique,Université de Sousse4042SousseTunisie*
[3] *FAO FAO-SRO-North-Africa (FAOSNE),1002 Tunis Belvédère,Tunisie*

Article info

Article history:
Received 05/06/2022
Accepted 12/12/2022

Keywords: Ceratrap®, *Ceratitis capitata*, host plant, oases

***Corresponding author**
samah_bchaaban@yahoo.fr

Conflict of Interest: The authors declare no conflict of interest

Abstract

In Tunisia oases, the Mediterranean fruit fly (medfly) *Ceratitis capitata* affect heavily fruit production. The efficiency of the mass trapping technique based on the use of Cera Trap® was evaluated in two types of oases in the south of Tunisia against *C.capitata*. Our results showed that in the traditional oasis (mixed orchard), the medfly moves from one fruit specie to another according to their receptivity periods. The population density of medflies started low and peaked three times (16 Jun, 23 Jun, and 7 July) corresponding to the maturation period of apricot fig and peach fruits. The field study showed that medfly population density and rate of fruit damage were significantly lower in figs than in peaches and apricot. Modern oases have later apricot fruit maturity periods than traditional oases, and their medfly populations peaked at 19 Mai. Ceratrap® reduces 2, 2, and 6 times the population density of Mediterranean fruit fly and the rate of damaged fruits compared to untreated plots. These two parameters were twofold less in modern oases than in traditional oases. These results suggest that the use of traps at the density of 70 per ha is sufficient to protect crops under high population densities of *C. capitata* characterizing the traditional oases agricultural systems.

1. INTRODUCTION

Tunisian oases are isolated semi-natural agricultural production systems surrounded by a desert matrix. Date palms, fruit trees, and herbaceous plants constitute the three main layers of vegetation in these ecosystems. The study of the biodiversity of fruit trees in Tunisian oases showed a high richness of species and cultivars: apricot, pomegranate, fig, apple, peach, vine, olive, and pomegranate (Bouzaida and Kerdaoui, 2016).

Sadly local biodiversity has been affected by market forces, which have pushed farmers to cultivate only date palms and to neglect tree fruits in spite of their importance. Furthermore, the second cultivated layer (fruit trees) in oases is in danger of being destroyed by drought salinity and phytophagous attacks and especially the Mediterranean fruit fly (medfly) *Ceratitis capitata* (Diptera: Tephritidae) that represents one of the key pests of tree fruits in oases (Buyckx,1994). *Ceratitis capitata* is one of the most serious pests in the world, as it is highly polyphagous and attacks more than 300 fruits and vegetable spices, both cropped and wild (Liqofuido et al., 1990). In Tunisia this pest cause damage on all winter and summer fruits (Sheikh et al. 1975, Boulahia-Kheder and Jerraya 2009). Is considered as one of the most destructive pests of citrus and peach crops (Mediouni- Ben Jemaa et al., 2010 Bouagga et al., 2014).

Fruit flies monitoring is a key part to control these insects in integrated pest management systems (Malavasi and Zucchi, 2000). Monitoring allows knowing the exact moment for a proper control measure when population is still low. In recent years, the need for environmentally friendly control methods against medfly as an alternative to chemical sprays is growing. Mass

trapping is one of these alternatives methods that can reduce negative effects of pesticides sprays on environment, Human health, and non-target insects because used insecticides are limited to the liquid or solid compound inside the trap (Peñarrubia, 2010; Hafsi et al., 2016). Efficacy of different traps and attractants were tested in citrus crops in Spain (Greece) (Navarro-Llopis et al., 2008) and Tunisia (Hafsi et al., 2015), and results showed the efficacy of this technique under low and high population levels of medfly.
Although the Ceratrap® mass trapping system has been found to control medfly in Tunisian citrus orchards (Hafsi et al., 2015), the efficacy of this trap and attractant was not tested in fig peach and apricot corps under oases climate conditions. The first aim of this work was to compare Ceratrap® treated orchards with untreated orchards that were used as control plots on medfly numbers and fruit damage in fig peach and apricot crops.

2. MATERIAL AND METHODS

2.1. Field experiments

A field trial was carried out from Mars to September 2015 in free pesticide oases in the governorate of Tozeur, south Tunisia (8° 08′E; 33° 55′N). In this study, two types of oases were considered the first one was the modern type located in the Degache biotope and the second one was the traditional one located in the Tozeur biotope.
In Degache biotope, date palm cultivation is the main crop with a mean planting space of 10 x 10 m, followed by the other fruit trees mostly with apricots and pomegranates. Apricots (*Prunus armeniaca* L. Bargoug var) characterized as early-maturing fruits were considered for the study. This orchard was divided in two blocs separated by almost 300m and containing each 80 apricot trees. The first one received mass trapping (Ceratrap®70 traps /ha) the second one was considered as untreated control plot.
Tozeur biotope, was a traditional oasis planted with mixed varieties of fruit trees of apples (*Malus sylvestris* Mill.), pears (*Pyrus communis* L.), apricots (*Prunus armeniaca* L.), peaches (*Prunus persica* L.), olives (*Olea europae a*L.), figs (*Ficus carica* L.), pomegranate (*Punica granatum* L.), and grape (*Vitis vinifera* L). The fruiting period in the experimental orchard begins from May to November. For this study, we consider apricot, peaches, and figs very susceptible to attacks of medfly. For each crop (apricot, fig, and peach), two plots were chosen, the first one received mass trapping (Ceratrap® alimentary liquid attractant applied at 70 traps/ha) treatment and the second one was considered as an untreated control plot.

2.2. Food attractant

The mass trapping experiments were performed using Ceratrap® attractant solution (Bioibérica SA, Barcelona, Spain) containing 95% of hydrolysed proteins and 5% of additives. These lures have a lifespan of four months. Traps were hung at 1.5 to 2 m on the south-east side of the trees and the number of traps installed varied according to the density of trees in each plot. In peach, apricot and fig orchards 70 Ceratrap® traps/ha were installed.
McPhail traps baited with both lures were deployed in apricot trees at a density of 40 traps/ha on April 10 2015, and were maintained in the field for three months. The quantity of the Ceratrap® and PheroNorm® lures in the McPhail traps were checked monthly in order to note when the quantity decreased to half this quantity was decreased to half the original volume.

2.3. Medfly males flight activity

Males of *C. capitata* were monitored using Delta traps with sticky board baited with the parapheromone Trimedlure (Koppert) that was replaced every 3 weeks. In each treated and control plot, three Delta traps were distributed uniformly. Traps were checked weekly and captured males were counted and removed.

2.4. Fruit damage assessment

Evaluations of fruit damage caused by females of *C. capitata* were carried out at harvest. In each plot, 5 trees were randomly selected and marked. From each one, 80 fruits were chosen (20 fruits from each side), brought to the laboratory, and examined for medfly damage. The rate of fruit damage was calculated as the number of fruit with at least one oviposition puncture or containing one larva over the total number of examined fruits.

2.5. Statistical analyses

The number of *C. capitata* males caught in Delta traps in date and each treatment in peach, apricot and fig orchards was compared using a generalised linear model (GLM) with Poisson error (Log link). The rate of fruit damage was analysed and compared between treatments in peach, apricot, and fig orchards using a GLM with binomial error (logit link).

3. RESULTS

3.1. Medfly male's flight activity

Medfly adult population density differed significantly among crops (apricot, peach, and fig) (Dev=17100; df= 3, 155; P<0 001) and treatments (Dev=16393; df= 2, 154; P= 0.015). The interaction between these two parameters was not significant (Dev=15982; df= 6, 151; P= 0.329).

plots and started to increase thereafter reaching a maximum of 564 and 320 flies/trap/week on 24 June respectively. Beyond this date medfly, male population increased significantly until the harvesting.

In fig orchards (Fig. 1c), the highest number of captures 405 and 325 flies/trap/week were

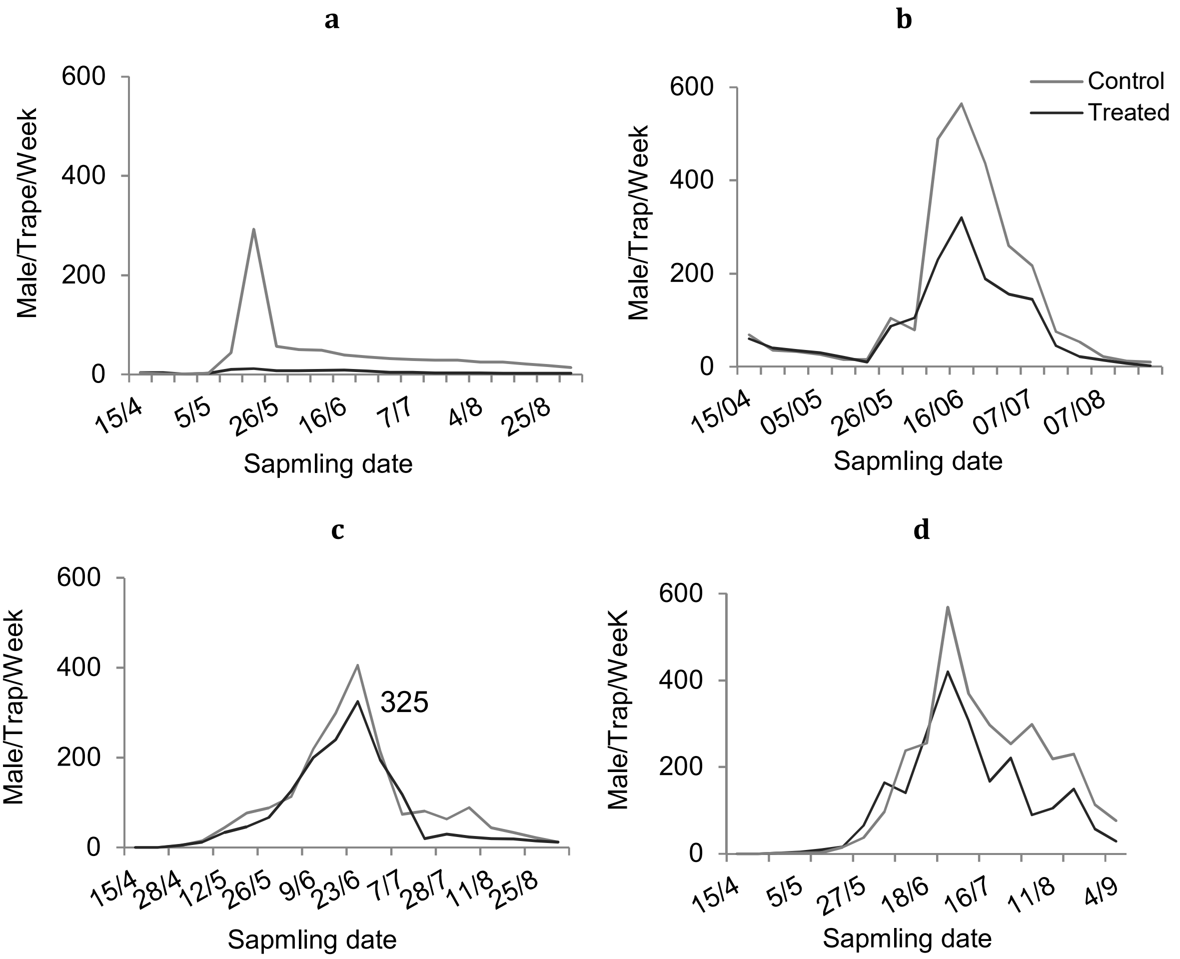

Fig. 1 Number of *C. capitata* males (mean) captured weekly per trap in modern oasis of Degache on apricot plots (a) and in traditional oasis of Tozeur on apricot (b), fig (c), and peach (d).

In Degache Oasis, medfly males caught in the Jackson trap were low in treated and control plots during April 2015 (Fig. 1). After this date medfly male population was twenty-five times higher in the control plot than in Ceratrap® plots. Medfly male population reached a maximum of 292.51 and 11.67 males/trap/week respectively in Ceratrap® and control plots.

In Tozeur oasis, the adult population of medfly on apricot on peach and on fig plots was 40, 27 and 21 % lower in Ceratrap® than in control plots, respectively. In apricot orchards, medfly males caught in the Jackson trap differ significantly between treatments (Dev=16393; df=2, 154; P= 0.015). The male population of this insect was low until 25 Mai 2015 in control and Ceratrap®

registered on 23 June respectively in Ceratrap® and in control plots.

In peach crops (Fig. 1d), Males' were caught between 28/4 September and 23 November. The peak was observed in 25/9 reaching respectively 320 males per trap per week in Ceratrap® versus 436 in the control plot. The adult population of medfly on apricot, peach, and on fig plots was 40, 27, and 21 % lower in Ceratrap® than in control plots, respectively.

For apricot crops medfly males caught in Jackson traps differed significantly between modern and traditional oases (Dev=17100; df= 3, 155; P<0.001) (Fig. 1a, b).

3.2. Fruit damages assessment

The number of punctured fruits by medfly females differed significantly among crops (Dev= 16.08; df= 3, 35; P<0.001) and treatments (Dev= 78.38; df= 2, 38; P<0.001). The interaction between these two parameters was not significant (Dev= 13.34; df= 6, 32; P= 0.43). For the apricot, in Ceratrap® plots (Fig. 2) the rate of damaged fruits at harvesting was 32% in traditional oases and 5% in the modern oasis. This arises from the traditional oasis's greater adult abundance. Peach was the most attacked variety by medflies in the historic oasis of Tozeur, with a mean percentage of attacked fruits of 70%, followed by apricots at 32% and figs at 23%. In Ceratrap® plots, the highest rate of fruit damage was recorded in peach crops with 43% while the lowest was recorded in modern oases of Degache with 5%.

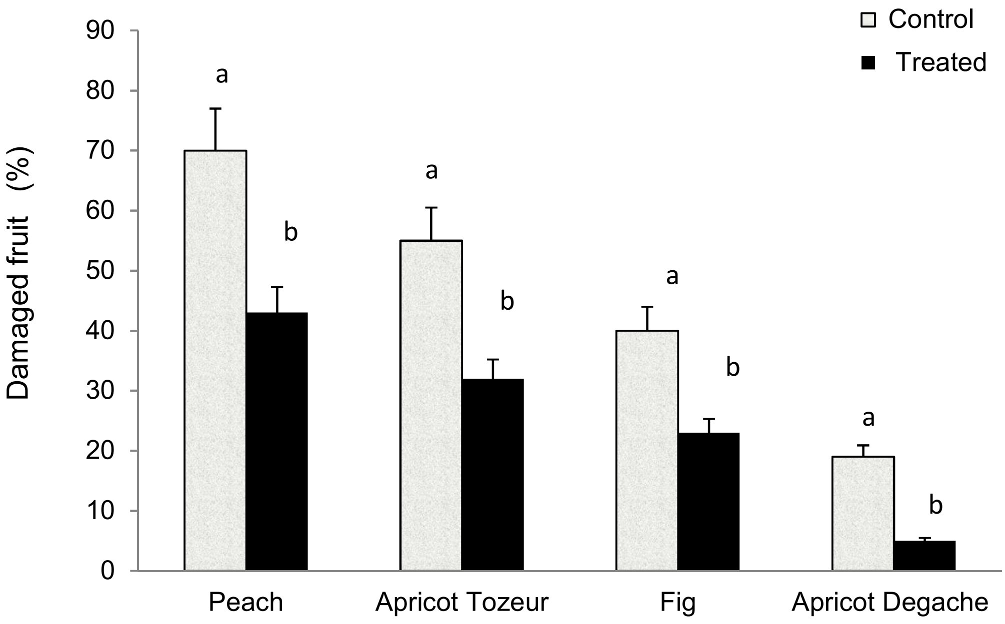

Fig. 2. Rate of fruit damage (% ± SE) in treated and control apricot peach and fig plots in traditional (Tozeur) and apricot in modern oases (Degache).

4. DISCUSSION

During the assessed period population density of medfly started low and peaked four times (19 Mai, 16 Jun, 23 Jun, and 7 July) corresponding to the maturation period of apricot fruits in modern and traditional oases of fig and of peach. Fluctuations observed in population dynamics of medfly is were not only related to climatic conditions especially temperature (Vayssières et al. 2009; Martínez-Ferrer et al. 2010), but also can be attributed to hosting plant suitability and availability (Scriber 1981; Smiler 1993).

Field studies showed that the most suitable host fruit to medfly in our study case was peach with the highest population density (569 flies/trap/week) and rate of fruit damage (43%). Taking into account these three fruit species in previous studies peach fruit is the most suitable host for medfly larvae in the laboratory (Hafsi et al. 2016b) and females in the field (Charlery de la Masselière et al. 2017).

In mixed orchards, the medfly moves from one fruit species to another according to their receptivity periods (Clemente and Garcia 1952). Indeed, the traditional oasis of Tozeur is composed of early and late fruit species. Population fluctuations observed from July until October 2015 reflect seasonal fruit availability with early maturing fruit species such as apricot that can explain the high trapping rate of medfly during May and June 2015 in the traditional oasis while peach fruits are characterised by a relatively longer maturation period. The existence of early maturing fruit species in mixed orchards may serve the overwintering individuals to establish insect populations and to produce new generations. However, the existence of late-maturing fruits seems to provide the insect with a safe breeding refuge late in the season (Martínez-Ferrer et al. 2010). In the case of apricot our studies showed that the population level of medfly males and the rate of fruit damage were lowest in modern oases than in traditional oases. This can be explained by the maturity

period of apricot fruits that is later in modern oases planted with the “Bargoug” variety than in traditional oases.
Mass trapping aims to reduce as much as possible the foraging adult medfly population in the treated area by hanging on tree traps baited with lures and toxicants to catch them Several studies have proved the efficiency of this method for several fruit tree species (Ros et al. 2002; McQuate et al., 2005; Martinez-Ferrer et al., 2010).
In Tunisia, several field trials were performed in attempt to assess the possibilities of introducing the *C.capitata* mass trapping technique in orchards and to familiarize growers with traps (Braham 2007; Ben Jemâa et al., 2010; Hafsi et al., 2015; Tlemsani et al., 2015). Different traps and food attractants were tested in citrus, peach and apricot orchards. Results showed their efficacy (Boulehia-Kheder et al., 2012; Bouagga et al., 2014; Hafsi et al., 2015; Hafsi et al. 2016, Elimem, 2021). Our Results prouved that a density of 70 Ceratrap®traps per ha was able to control medfly at high population levels. The population density of medfly males in apricot peach and fig plots treated by Ceratrap® was 2, 2 and 6 times lesser than untreated plots. Consequently the lowest rate of damaged fruits (apricot peach and fig) was observed in the plots treated with the IPM approach. Previous studies showed that the use of Ceratrap® attractant could significantly reduce the medfly population (Hafsi et al. 2015; Tlemsani et al. 2015; Elimem, 2021, Ben Chaaban, 2018). The efficacy of mass trapping technique was influenced by a diversity of external factors, particularly the host fruit species.
For an effective control against *C. capitata*, any strategy should start prior to fruit ripening (Demirel 2007). Thus, our results suggest adjusting the density of traps per ha depending on the suitability of host crops to medfly females and population adult density.
In addition to their efficacy against medfly Taking into account that Ceratrap® was a selective attractant limiting side-effects on beneficial insects (Hafsi et al. 2015) CeraTrap® attractant is less expensive than alternatives such as Biolure® and can be employed in the field for several weeks without the need for re-baiting (El Arabi et al. 2010). This attractant can be deployed effectively in a simple perforated PET bottle that is easy to manufacture using empty drink bottles at an extremely low cost. Developing effective and inexpensive monitoring tools constitutes a necessary initial step toward rational pest management in developing countries (Rodríguez 1998).

4. CONCLUSION

The present paper reveals the efficiency of the control of Med-fly in Tunisian in the two types of oases in Tunisian. More research will be done to determine the best trap density per hectare for controlling *C. capitata* in oases based on the suitability of host crops for medfly females and population adult density during fruit ripening.

Acknowledgements

We wish to thank Mr. Abdelkader and Mr. Abdallah for lending their orchards for the field trial. The Integrated Management of Fruit Flies in Tozeur oases is a FAO funded project.

References

Abbott, W.S. (1925). A method of computing the effectiveness of an insecticide. Journal Economic Entomology, 18, 265-267.

Alemany, A., Miranda, M.A., Alonso, R., Escorza, C.M. (2004). Efectividad del trampeo masivo de hembras de *Ceratitis capitata* (Diptera: Tephritidae) a base de atrayentes alimentarios " Efecto-borde" y papel de los frutales abandonados como potenciadores de la plaga. Boletín de sanidad vegetal Plagas, 30, 255-264.

Ben Chaaban, S., Mahjoubi, K., Ben Maachia, S., Nasr, N. (2018). Evaluation of integrated control based on 669 the Cera Trap® and Moskisan® mass trapping system against Ceratitis capitata (Diptera: Tephritidae) on 670 citrus fruits in Tunisian oases. Journal of New Sciences, 57 (3), 3707-3715.

Ben Jemâa, J.M., Bachrouch, O., Allimi, E., Dhouibi, M.H. (2010). Field evaluation of Mediterranean fruit fly mass trapping with Tripack® as alternative to malathion bait-spraying in citrus orchards. Spanish Journal of Agricultural Research, 8(2), 400-408.

Bouagga, S., Nayem, H., Ben-Hlima, K.M., Jammazi, A., Djeoual, K., Al-Zaidi, S. (2014). Evaluation of attract and kill system to combat *Ceratitis capitata* on peach trees in Tunisia. Journal of Agriculture Science Technique, A4, 612-619.

Boulahia Kheder S., Jerraya A. (2009). Premiers résultats sur la capture de masse en tant que moyen alternatif de lutte contre la mouche méditerranéenne des fruits *Ceratitis capitata* (Diptera : Tephritidae) en Tunisie. Annales del'INRAT, 8, 168-180.

Boulahia-Kheder, S., Trabelsi, I., Aouadi, N. (2012). From chemicals to IPM against the

Mediterranean fruit fly *Ceratitis capitata* (Diptera Tephritidae). In: Larramendy ML, Soloneski S (eds) Integrated pest management and pest control-current and future tactics. In Tech, Croatia, pp 310-320.

Bouzaida, M.A., Kerdaoui, M. (2016). Tunisian Oasis System: Between the Traditional and the Modern Case Study of Kébili Region Tunisia. International Journal of Development Research, 5, 2278-0211.

Braham, M., Pasqualini, E., Ncira, N. (2007). Efficacy of kaolin spinosad and malathion against *Ceratitis capitata* in Citrus orchards. Bulletin of Insectology, 60, 39-47.

Buyckx, E.J. (1994). Unfecundated dates host of the Mediterranean fruit fly (Diptera: Tephritidae) in the oases of Tozeur Tunisia. OILB SROP, 17 (6).

Cheikh, M., Howell, J.F., Harris, E.J., Ben-Salah, H., Soria, F. (1975). Suppression of the Mediterranean Fruit Fly in Tunisia with Released Sterile Insects. Journal of Economic Entomology, 68, 237-243.

Clemente, F.G., Garcia, S.P. (1952). Algunas notas sobre la ecología de *Ceratitis capitata* en el Levante español sobre naranjos. Boletín Patologia Vegetal Entomolgia agrícola 19, 37-48.

De La Masseliere, M.C., Facon, B., Hafsi, A., Duyck, P.F. (2017). Diet breadth modulates preference-performance relationships in a phytophagous insect community. Scientific Reports, 7, 1-9.

El-Arabi, S., Miloudi, M., Marin, C., Sierras, N. (2010). CeraTrap is a mass trapping system for the control of the Mediterranean fruit fly *Ceratitis capitata* in *Citrus* fruit crop Integrated control in citrus fruit crops. IOBC/wprs, 62, 207-212.

Food and Agriculture Organization (FAO) (1995). Economic evaluation of damage caused by and methods of control of the Mediterranean fruit fly in the Maghreb: An analysis covering three control options including the sterile insect technique. Report of an expert group (No. IAEA-TECDOC--830). Joint FAO/IAEA Div. of Nuclear Techniques in Food and Agriculture. Vienna, Austria.

Hafsi, A., Harbi, A., Rahmouni, R., Chermiti, B. (2015). Evaluation of the efficiency of mass trapping of *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) in Tunisian citrus orchards using two types of traps: Ceratrap® and Tripack®. Acta Horticulturae, 1065, 1049-1056.

Hafsi, A., Abbes, K., Harbi, A., Duyck, P.F., Chermiti, B. (2016). Attract-and-kill systems efficiency against *Ceratitis capitata* (Diptera: Tephritidae) and effects on non-target insects in peach orchards. Journal of Applied Entomology, 140, 28-36.

Hafsi, A., Facon, B., Ravigne, V., Chiroleu, F., Quilici, S., Chermiti, B., Duyck, P.F. (2016). Host plant range of a fruit fly community (Diptera: Tephritidae): does fruit composition influence larval performance?. BMC Ecology, 16 (40), 1-12.

Lasa, R., Cruz, A. (2014). Efficacy of commercial traps and the lure CeraTrap® against *Anastrepha obliqua* (Diptera:Tephritidae). Florida Entomologist, 97, 1369-1377.

Leza, M.M., Juan, A., Capllonch, M., Alemany, A. (2008). Female-biased mass trapping vs bait application techniques against the Mediterranean fruit fly *Ceratitis capitata* (Dipt Tephritidae). Journal of Applied Entomology, 132, 753-761.

Liquido, N., Cunninghan, R.T., Nacagawa, S. (1990). Host plants of Mediterranean fruit-fly (Diptera Tephritidae) on the island of Hawii. Journal Economic Entomology, 83, 1863-1878.

Malavasi, A., Zucchi, R.A. (2000). Moscas-das-frutas de importância econômica no Brasil: conhecimento básico e aplicado. Holos Editora, Ribeirão Preto.

Martinez-Ferrer, M.T., Navarro, C., Campos, J.M., Marzal C., Fibla J.M., Bargues, L., Garcia-Maria, F. (2010). Seasonal and annual trends in field populations of Mediterranean fruit fly *Ceratitis capitata* in Mediterranean citrus groves: comparison of two geographic areas in eastern Spain. Spanish Journal of Agricultural Research, 8, 757-765.

Martinez-Ferrer, M.T., Campos, J.M., Fibla, J.M. (2012). Field efficacy of *Ceratitis capitata* (Diptera: Tephritidae) mass trapping technique on clementine groves in Spain. Journal Applied Entomology, 136, 181-190.

Mcquate, G.T., Peck, S.L., Barr, P.G., Sylva, C.D. (2005). Comparative evaluation of spinosad and phloxine B as toxicants in protein baits for suppression of three fruit fly (Diptera: Tephritidae) species. Journal of Economic Entomology, 98, 1170-1178.

Navarro-Llopis, V., Alfaro, F., Dominguez, J., Sanchis, J., Primo, J. (2008). Evaluation of traps and lures for mass trapping of Mediterranean fruit fly in citrus groves. Journal of Economic Entomology, 101, 126-131.

Riou, C. (1990). Bioclimatologie des oasis. Options Méditerranéenne A 11 : 207-220.

Rodríguez, C., Tadeo, E., Rull, J., Lasa, R. (2015). Response of the sapote fruit fly *Anastrepha* *serpentina* (Diptera: Tephritidae) to commercial lures and trap designs in sapodilla orchards. Florida Entomologist, 98, 1199-1203.

Ros, J.P., Wong, E., Olivero, J., Castillo, E. (2002). Mejora de los mosqueros atrayentes y sistemas de retención contra la mosca mediterránea de la fruta *Ceratitis capitata* Wied Como hacer de la técnica del trampeo masivo una buena herramienta para controlar esta plaga. Boletín de sanidad vegetal Plagas, 28, 591-597.

Scriber, J.M., Slansky, F. (1981). The nutritional ecology of immature insects. Annual Review Entomology, 26, 183-211.

Smirle, M.J. (1993). Larval performance of two leafroller species on known and potential hosts. Entomologia Experimentalis et Applicata, 67, 223-231.

Tlemsani, M., Kheder, S.B. (2015). Comparison of Four Trapping Systems for the Control of the Medfly *Ceratitis capitata.* Tunisian Journal of Plant Protection 10, 131-140

Vayssieres, J.F., Korie, S., Ayegnon, D. (2009). Correlation of fruit fly (Diptera Tephritidae) infestation of major mango cultivars in Borgou (Benin) with abiotic and biotic factors and assessment of damage. Crop Protection, 28, 477-488.