

Efficacy of the Lufenuron Bait Station Technique to Control Mediterranean Fruit Fly (Medfly) *Ceratitis capitata* in Citrus Orchards in Northern Tunisia

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ABSTRACT

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The effectiveness of the lufenuron bait stations as a component of an integrated pest management program (IPM) was tested in three citrus orchards in the North of Tunisia against the Mediterranean fruit fly (Medfly) *Ceratitis capitata* during the three years 2005, 2006, and 2007. The technique was based on the use of the insect growth regulator lufenuron transferred via a gel bait for adult flies to prevent the hatching of eggs laid in fruits and induce a subsequent population reduction. The evaluation of the effect of the treatments was based on the assessment of adult Medfly population reduction expressed by weekly recording of male captures in McPhail traps baited with the synthetic lure trimedlure and insecticide together with the evaluation of fruit damage. Results indicated that adult males Medfly captures showed reductions of 12.72% during 2005, 34.99% during 2006 and respectively 78.85%, 62.84% and 62.86% in fields 1, 2 and 3 during 2007 compared to standard chemical treatments. Fruit damage assessment showed generally significant differences between the two treatments in the reduction of the percentage of fruit punctures.

Key words: Bait, *Ceratitis capitata*, chemosterilant, citrus, lufenuron, Tunisia

The Mediterranean fruit fly (Medfly), *Ceratitis capitata*, is a major and destructive pest of fruit crops in the Mediterranean and the Near East regions. Over 360 plant species have been listed as

hosts to that pest (16). Citrus crops are among the most susceptible hosts through the world. The high reproductive potential and adaptability of this pest combined with the scarcity of natural enemies and its wide host range cause great concern to growers (5).

The damages caused by Medfly result first from oviposition in fruits followed by

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larvae feeding in addition to decomposition of plant tissue by invading secondary micro-organisms. Larval feeding damage in fruits is the most important. Mature attacked fruits may develop a water soaked appearance. Young fruits become distorted and usually drop. The larval tunnels provide entry points for bacteria and fungi that cause the fruit to rot (22). Infestation is discerned on the fruit by a mark surrounding the oviposition puncture this mark after increasing in size. Rotting of the underlying tissue causes a depression on the surface. The fruit drops prematurely. Even if a fruit has only been pierced, it is totally unworthy for sale.

In order to reduce the Medfly populations to low levels, chemical control using Malathion bait sprays (ground and aerial) has been the most common method used in most countries (19). Nevertheless, the harmful effect of broad-spectrum insecticides on the environment and the risk of the development of insecticide resistance further restrict the use of this control method against Medfly. Consequently, the research and the development of an effective control method as an alternative to chemical control is needed because this pest causes real damage to many important agricultural crops (5). These methods include the use of the pest's natural enemies (parasitoids, predators and pathogens) sought for use as biological control agents (11, 12, 3, 20, 13), the Sterile Insect Technique (19, 18, 14), the use of plant extracts known as essential oil (4), and recently the use of insect growth regulators as chemosterilants agents (6, 17, 8, 13).

The insect growth regulators used as chemosterilant agents is a new method used to control economically destructive or disease-causing insects by preventing larvae hatching from eggs laid by females that have ingested lufenuron bait, or by

females which have mated with males that have eaten lufenuron bait. Insect growth regulators are grouped into three types of compounds, depending on their action. First, chitin synthesis inhibitors which work on the enzymatic control of ecdysis, second juvenile hormone analogues which interrupt the transformation process at egg and pupal stage, and thirdly ecdysone agonists which accelerate the molting process., Lufenuron is the most used and field tested chitin synthesis inhibitor against *Ceratitis capitata*. This compound showed good potential in the control of the Medfly populations. Lufenuron can interrupt Medfly reproduction and prevent the hatching of eggs (6, 15, 16, 23).

In Tunisia, Medfly is increasing in the north of the country (Tunisia). It may complete seven or eight generations per year (10, 9), five of them are during the summer. The pest causes significant damage in Tunisian citrus orchards. In this context, many biological control alternatives have been suggested in order to reduce the insect population infestations. In this respect, the use of the parasitoid *Diachasmimorpha longicaudata* on the Medfly larvae, the mass trapping technique and the biological control methods using neem, azadiractin and spinosad have been the main alternative methods tested against Medfly in citrus fruit orchards (2). However, there are renewed attempts to elaborate an Integrated Pest Management (IPM) strategy in Tunisian citrus orchards. The aim of this present research is to evaluate during three years the potential of the lufenuron bait station technique to control Medfly on citrus orchard as an alternative method to chemical treatments used by farmers.

MATERIALS AND METHODS

Experimental Fields. Trials were conducted in three citrus fields located in

Kholidia in the north of Tunisia. The first has 1 ha area and planted with Maltais variety. A plot of 0.5 ha was chosen for the lufenuron bait stations (first treated field). A second plot of 0.5 ha, without lufenuron bait stations, received the conventional Malathion treatments at a rate of one treatment per 10 days and served as the control. The two plots were separated by Cypress enclosures. Trees spacing was 4 m x 4 m with a density of 625 trees/ha and an average tree height of 3 m. Bait stations were installed during 2005, 2006, and 2007.

The second field had also 1 ha of area planted with Maltais variety. Half of the area was treated with the lufenuron bait stations whereas the second half had the conventional farmer's chemical treatment. The two plots were separated by a distance of about 0.5 km. Trees spacing was 6 m x 6 m with a density of 300 trees/ha and an average tree height of 5 m. The trials were conducted during three years (2005, 2006, and 2007).

The third field had 1 ha area planted with Thomson variety. It was planted with a tree- spacing of 6 m x 6 m leading to a density of 300 trees/ha. The experimental area was equally divided between the bait station and conventional chemical treatment, and the plots were separated by a one hectare area planted with Maltais variety. The trials were conducted during 2006 and 2007.

Baits, traps and insect monitoring.

Yellow plastic bait stations (Syngenta Crop Protection AG) containing a bait-gel based on lufenuron (A-14619 A RB 03, bait with 3% lufenuron) were used at a density of 20 units/ha. The gel contained lufenuron and a feeding stimulant consisting of an optimized mixture of protein and sugar. In addition, a tube containing male and female attractants was present in each bait station. Flies landing

on the gel came into contact with their feet, in which the sensitive taste receptors caused a feeding response resulting in uptake of the bait containing the insect growth regulator lufenuron. Bait stations were suspended equidistantly in the trees and were kept in the field for the whole season.

The monitoring of the adults flies was accomplished using two plastic McPhail traps baited with male attractant, the parapheromone Trimedlure, and insecticide. These traps were hung in the trees at a height of 1.5 m. and were checked weekly. The caught insects were counted and trap captures were compared between the control and the treated areas in each field in order to assess the Medfly population reduction.

Fruit damage assessment. In order to determine the percentage of fruit damage due to Medfly, five trees were selected in the treated and control areas to follow the progress of Medfly puncture. The total fruit number of each selected tree was counted and thus the total number of sampled fruit in each field was determined (total fruit number from the five selected trees). On each tree, fruits were checked for Medfly puncture and infested fruits were marked to be recognized during the subsequent control. The percentage of fruit damage was calculated by dividing the cumulative number of infested fruit by the total number of sampled fruit in each plot. This percentage was then compared between the treated and the control area at each year. Moreover, an other assessment of the percentage of damaged fruit was conducted at the harvest on four trees taken randomly in the control and treated areas. The whole charge of the trees was counted and the percentage of fruit damage was calculated at the harvest.

Statistical analyses. The reduction of Medfly population was calculated by the method of Abbot expressed by the formula $TR = \frac{C-T}{C} \times 100$ (1), where C = rate of Medfly captures in the control field, T = rate of Medfly captures in the treated field and TR = rate of population reduction. Results were expressed as percentage of fruit damage. Data was compared using the Student T-Test at a risk level of 5% (21, 7).

RESULTS

Lufenuron effect on Medfly population. The impact of lufenuron on the Medfly population was measured by the male fly population reduction in McPhail traps between the treated and the control fields (Figs. 1 to 5). In the year 2005, a reduction rate of 12.7% was obtained between the two fields (Fig. 1). In 2006, the effect was more pronounced and a reduction of 35% was observed (Fig. 2). For the year 2007 where the trial was enlarged, reduction rates of Medfly

population were 79%, 63%, and 63% in fields 1, 2, and 3 respectively (Figs. 3, 4, and 5).

Regarding to Medfly captures, differences were observed between the treated and the control orchards. In the year 2005, the mean of Medfly captures/trap in the treated field was 13.2 against 103.8 in the control area. For the year 2006, the mean Medfly captures/trap was 43.08 against 123.13 in the control plot. In 2007, the means of insect captures were respectively 17.82, 41 and 5.5 insects/trap in the treated field against 22.61, 65.25, and 8.75 insects/trap in the control field. Significant statistical differences were detected in means of Medfly captures between treated and control areas during 2005 and 2006. Nevertheless, no statistical differences were observed in the first and third fields but for the second field, the captures were significant between the control and the treated plot.

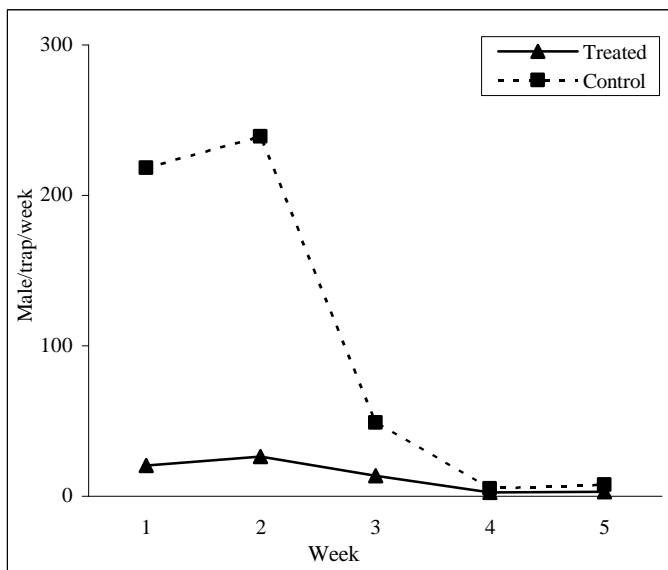


Fig. 1. Medfly captures/trap/week in the treated and control fields during 2005.

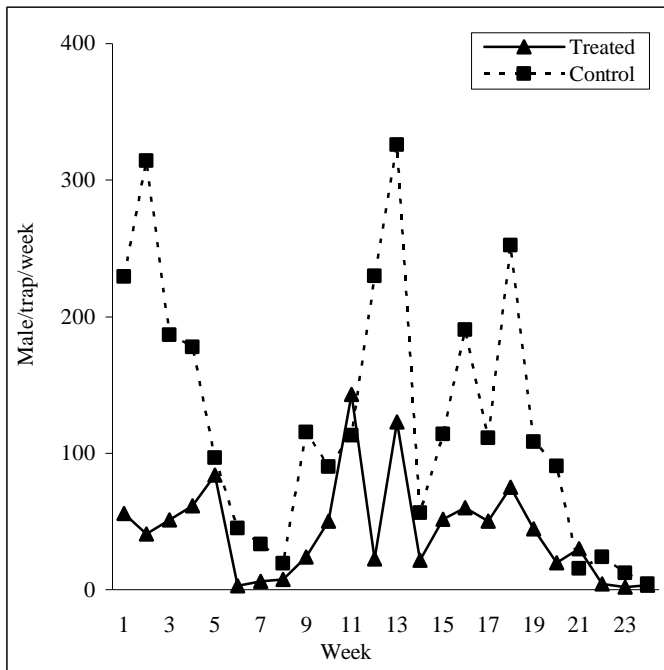


Fig. 2. Medfly captures/trap/week in the treated and control fields during 2006.

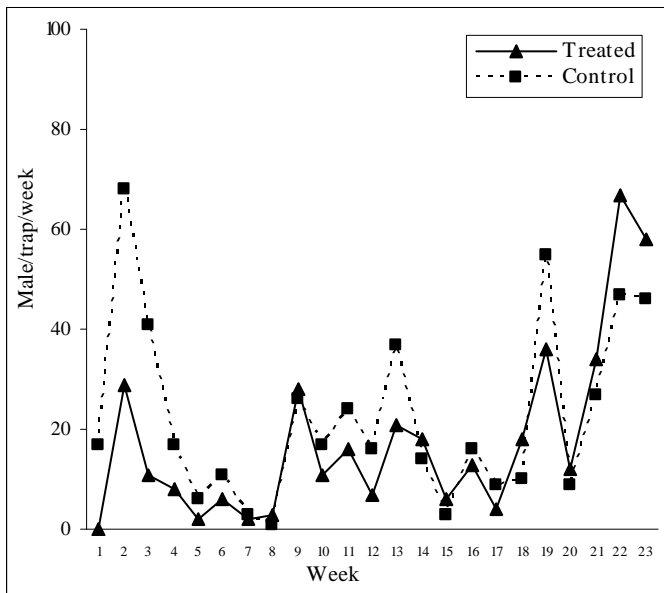


Fig. 3. Medfly captures/trap/week in the first field during 2007.

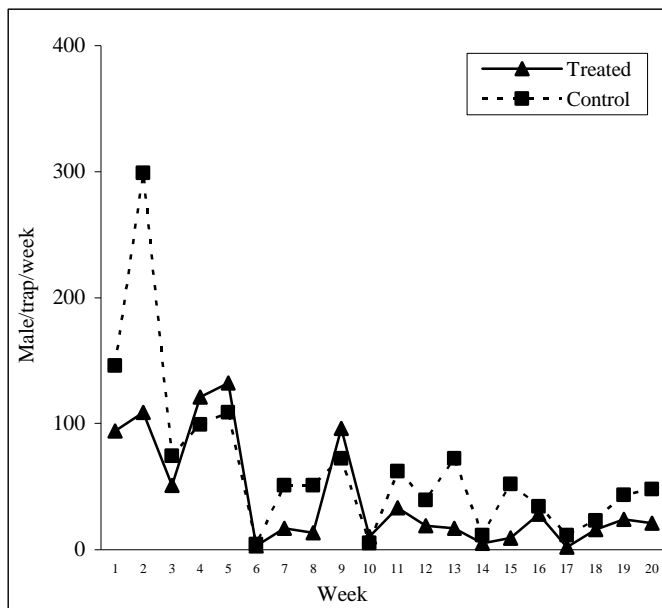


Fig. 4. Medfly captures/trap/week in the second field during 2007.

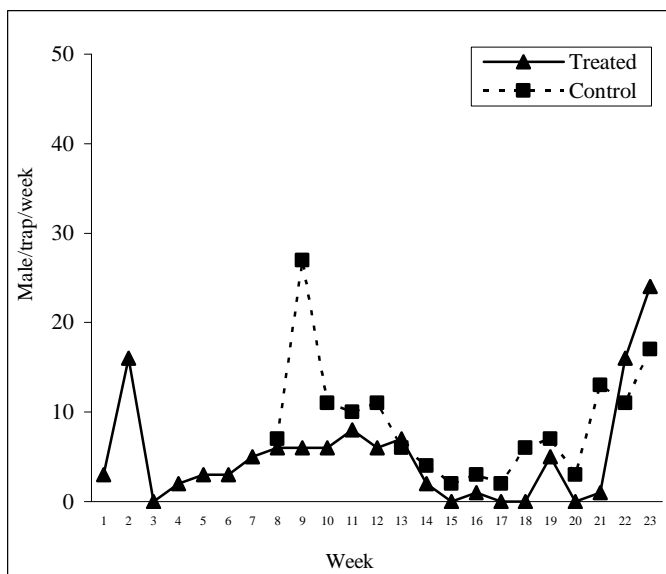


Fig. 5. Medfly captures/trap/week in the third field during 2007.

Lufenuron effect on puncturing fruit damage. The impact of the treatments on the percentage of punctured fruits was assessed during three years of the study (Table 1). During the year 2005, total means punctured fruits oscillated between 82.75 and 93.3 respectively in the

treated and control fields (31.25 at the beginning and 121 at the end of the trial in the treated field against 36 and 134 in the control area). No statistical differences were obtained. The effect of the bait station technique is thus comparable to the conventional farmer's treatment.

Table 1. Mean punctured fruits at the beginning and the end of the trial and the overall mean of punctured fruits during 2005, 2006, and 2007*

	Mean of punctured fruits at the beginning of the trial	Mean of punctured fruits at the end of the trial	Overall mean of punctured fruits
Year 2005			
Treated	31.25 a	121 a	82.75 a
Control	36 a	134 a	93.3 a
<i>P value</i>	0.362	0.6	0.367
Year 2006			
Treated	41.75 b	29.5 b	19.28 b
Control	18.75 a	9.5 a	9.40 a
<i>P value</i>	0.035	0.05	0.0007
Year 2007			
Field 1			
Treated	0.5 a	7.25 a	3 a
Control	0 a	12.5 a	4.03 a
<i>P value</i>	0.36	0.06	0.33
Field 2			
Treated	2.25 b	31.25 b	10.08 b
Control	0 a	9.74 a	3.06 a
<i>P value</i>	0.04	0.004	0.0001
Field 3			
Treated	0.5 a	5.5 a	2.36 a
Control	0 a	7.5 a	2.75 a
<i>P value</i>	0.14	0.11	0.59

* Within columns, means followed by the same letters are not significantly different ($P=0.05$) according to Student Test.

Lufenuron effect on the percentage of damaged fruits. Results shown in Fig. 6 revealed that the percentage of punctured fruit is comparable between the treated and control field each year despite the little differences observed during the first and the last year (field 3). Indeed, for the year 2005, the percentage of punctured fruit was 42.9% in the treated field against 51.1% in the control area. Furthermore, during the year 2007, we observed 9.68% of fruit damage in the treated area against 13.14% in the control plot.

The statistical analyses of data during the three years (Student Test at $P < 0.05$) showed no significant differences in the percentages of punctured fruits between the treated and the control areas except for the years 2005 and 2007 (field 3). Moreover, in the treated field, significant differences in the percentage of fruit punctures were obtained between the first and last year of the trial. Simultaneously, decreases of fruit punctures were observed in the control field (Fig. 6).

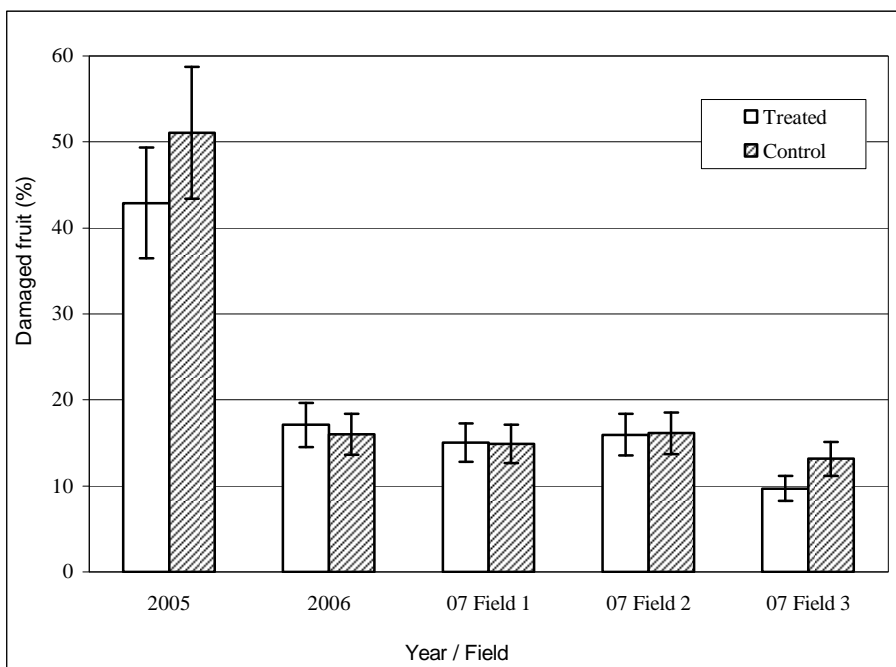


Fig. 6. Percentage of fruit damage in the treated and control fields during 2005, 2006 and 2007.

DISCUSSION

Results obtained from this study showed clearly that the lufenuron Bait Station technique could be involved as an appropriate strategy for the control of the Medfly in Tunisia. The Match Trap technique may offer a viable, efficient and economic alternative. It could be incorporated with some of these existing methods in an IPM approach. As reported in this paper, important reduction of the insect population and a visible decrease of the percentage of fruit damage had been made after three years trials in citrus orchards in north of Tunisia, comparable to standard farmer treatments. It may be that the small size of the trial plots (1 ha surrounded by citrus orchards) influenced the results due to influx of fertile flies from surrounding orchards. Working on larger plots of 5 ha, or even several hundred hectares in a wider campaign area, would

provide more significant improvements in the level of control.

Evaluations of fruit damage were limited to fruit stings. Since lufenuron acts to stop eggs hatching and not to stop female flies from stinging fruits, it is possible that the larval population in the fruits decrease. Future trials could include incubation of damaged fruits to count pupation and adult emergence to detect these effects.

Similar work conducted in Spain using the insect growth regulator lufenuron under two application methods spraying and hanging traps showed a reduction of Medfly population of 80.4% in the sprayed field and a reduction of 77.6% in the solid bait field. Moreover, percentage of punctured fruit was 38.8% in the inner zone against 68.6% in the outer zone (16). Furthermore, (5) showed that the lufenuron used as chemosterilizing agent at a dose of

1,000-ppm against *C. capitata* led to an important sterilizing activity as hatching inhibitors. In Morocco, El Moubariki (8) indicated that the system Match Medfly RB03 in small plot trials showed an efficacy comparable to the conventional chemical control. The rates of Medfly captures and the mean number of pupae produced by punctured fruits were greater in the control field than in the treated area. He signaled that this technique could be associated to the Sterile Insect Technique (SIT) in order to be more efficient (for example in the Project Clean Fruit). In this case, the number of released males required would be reduced. Citrus fruits are an important and valuable export commodity for Tunisia but high infestation rates with the Mediterranean fruit fly are

causing significant economic losses. After this study promising results are obtained and the lufenuron baiting technique could be suggested as an alternative control method in Tunisian citrus orchards. Nevertheless, demonstrations on larger areas are needed to further improve the suppressive potential of this technique. Further research might focus on the dose rate and performance in different crops under field Tunisian conditions.

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RESUME

Bachrouch O., Mediouni-Ben Jemâa J., Alimi E., Skillman S., Kabadou T., et Kerber E. 2008. Efficacité de la technique d'appât au Lufenuron dans la lutte contre la mouche méditerranéenne des fruits *Ceratitis capitata* dans les vergers d'agrumes du Nord de la Tunisie. Tunisian Journal of Plant Protection 3: 35-45.

L'efficacité du piège à lufenuron en tant que composante d'une stratégie de lutte intégrée a été testée contre la mouche méditerranéenne des fruits *Ceratitis capitata* dans trois vergers d'agrumes situés au nord de la Tunisie durant les années 2005, 2006 et 2007. La technique se base sur l'utilisation d'un régulateur de croissance des insectes, le lufenuron, contenu dans un gel-appât pour empêcher l'éclosion des œufs pondus dans les fruits et engendrer une réduction ultérieure du niveau des populations de la cératite. L'évaluation de l'effet des traitements a été mesurée par la réduction du niveau des populations exprimée par le dénombrement hebdomadaire des mâles capturés dans les pièges de type McPhail appâtés avec l'attractif sexuel le trimedlure et l'insecticide et l'évaluation des dégâts sur fruits. Les résultats indiquent que des réductions du niveau de capture des adultes de la cératite de 12.72% durant 2005, 34.99% durant 2006 et respectivement 78.85%; 62.84% et 62.86% dans les vergers 1, 2 et 3 en 2007 comparé au traitement chimique conventionnel. L'évaluation de l'infestation des fruits montre des différences généralement significatives entre les deux types de traitement dans la réduction du pourcentage des fruits piqués.

Mots clés : Appât, *Ceratitis capitata*, citrus, lufenuron, stérilisant chimique, Tunisie

بشروش، ألفة وجودة مديوني-بن جماعة وعزالدين علمي وستيفان سكيلمان وطارق قبادو وإمار كاربار. 2008. نجاعة استعمال تقنية طعم لوفينورون في مكافحة الذبابة المتوسطة لثمار لفواكه *Ceratitis capitata* في حقول القوارص/الحمضيات/الموالح في شمال تونس.

تمت دراسة فاعلية تقنية مصادد ليوفنورون (Lufenuron) كمكون لبرنامج مكافحة المتكاملة ضد الذبابة المتوسطة لثمار الفواكه *Ceratitis capitata* في ثلاثة حقول قوارص/حمضيات/موالح في شمال تونس خلال ثلاث سنوات 2005 و 2006 و 2007. اعتمدت هذه التقنية على استعمال منظم النمو ليوفنورون المحول إلى طعم هلامي جاذب للبالغات قصد منع فقس البيض الموضوع داخل الثمار والتقليص من مستوى مجموعات الحشرة. تم تقييم هذه التقنية باحتساب نسبة خفض مستوى مجموعات الحشرة من خلال عدّ الذكور الممسوكة في مصادد من نوع McPhail والتي تحتوي على جاذب جنسي (ترايميدلور) ومبيد حشري، كما تم تقييم أضرار إصابة الثمار. أشارت النتائج إلى حدوث انخفاض مستوى مجموعات بالغات الذكور الممسوكة بنسبة 12.72% خلال موسم 2005 و 34.99% خلال موسم 2006 وبنسب 78.85% و 62.84% و 62.86% على التوالي في حقول القوارص 1, 2, 3 خلال موسم 2007 وذلك بالمقارنة بطريقة المعالجة الكيميائية القياسية. وأظهر تقييم إصابة الثمار، على نحو عام، أن هناك فروقات معنوية بين طريقتي مكافحة المستعملتين في تخفيض نسبة الثمار المتقوية.

كلمات مفتاحية: تونس، الذبابة المتوسطة لثمار الفواكه، طعم، قوارص، ليوفنورون، معقم كيميائي

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