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Effect of trimedlure diluted with certain oils against Mediterranean fruit fly, *Ceratitis capitata* males under filed conditions

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Abstract
The Mediterranean fruit fly (MFF), *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) is one of the most important pests destructing fruits round the world. Dilution of trimedlure with different oils (paraffin, soya bean, sun flower and castor) was evaluated under field conditions in two districts (Mansoura and Aga) in Dakahlia governorate, Egypt. Treatments were injected in cotton wicks as dispensers of Jackson traps. The obtained data of the two districts concluded that adding paraffin or castor oils to trimedlure with a concentration of 25% attracted the highest numbers of MFF adult males all over eight weeks; while, the lowest treatments were those of adding 50% of soya bean or castor oils to trimedlure. The most stable treatments all over eight passed weeks were those of diluted with paraffin oil; while, the most inhibited treatments by the time passed were those of diluted with soya bean oil. Adding of the selected oils to trimedlure reduced its density and increased its viscosity. Statistically, density of the tested treatments had an adverse effect on their efficiency as attractants for MFF adult males. On contrary, viscosity of the tested treatments had an extrusive effect on their efficiency.

Keywords: trimedlure, dilution, oils, mediterranean fruit fly

Introduction
The Mediterranean fruit fly (MFF), *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) is one of the most important pests destructing fruits of over 350 species of fruits, nuts and vegetables round the world [1-3]. In Egypt, the important reason for MFF to build up its generations is the existence of its hosts; so, it occurred all over the year and increased during the fruiting seasons of the orchards [4-9]. Females of MFF lay their eggs inside fruits and the hatching maggots devour into the pulp and secondary infestations with bacterial and fungal diseases mostly exist and the infested fruits drop down; so, this pest causing a serious decline in both quantity and quality of fruit yield [2, 10, 11].
The threat of MFF establishment has always been a high priority for countries engaged in international trade due to the fly quarantine importance, and an ongoing search for new and improved semiochemical based control and detection methods remain a high priority [12-16].
Fruit fly detection and control programs typically rely on traps baited with male sex attractant lures. Trimedlure is widely used as the "standard" synthetic male MFF attractant [17]. It is a sex-specific attractant that widely used in detection, monitoring and control programs around the world. Trimedlure is deployed in solid dispensers that are placed in Jackson traps [18]. Two grams of trimedlure is formulated in a polymeric plug-type dispenser that provides controlled release of the attractant for about eight weeks in Jackson traps [15, 19-21]. The disruption effect of MFF males was examined with different emission levels of trimedlure [13].
Previous studies had been done to evaluate the efficiency of diluted sex attractants of fruit flies [14, 15, 22-24]. In Egypt, the price of trimedlure is high and the used quantity of it in monitoring and control methods of MFF is large. So, the present study was conducted to dilute trimedlure by certain oils (paraffin, soya bean, sun flower and castor oils) to find out the best effective oil and its best effective concentration which reduces the quantity of the used trimedlure and hence less costs. Moreover, the probable relationship between certain physical properties of the tested treatments and attraction of MFF males was also tested.

2. Materials and Methods

2.1 Materials and treatments

Trimedlure was diluted with different four oils (paraffin, soya bean, sun flower and castor). Each oil was added to trimedlure with concentrations of 25 and 50%. All preparations in addition to un-diluted trimedlure [as commercial trimedlure C (98% purity, manufactured in the USA)] were injected in dispensers constructed from cotton wicks (4 cm long x 1 cm diameter). Each treatment was injected with amount of 3 cm^3 per cotton wick. The impregnated cotton wicks were installed in Jackson traps [25].

2.2 Locations of the experiments

The present experiments were carried out in two orchards located in Dakahlia governorate. The first orchard was cultivated with mandarin, *Citrus reteculata* (L.) in the Experimental Farm of the Faculty of Agriculture, Mansoura University, Mansoura district. The second orchard was cultivated with navel orange, *Citrus sinensis* L. in Aga district. In each district, about 25 feddans (1 feddan = 4200 m^2) were selected for the present study.

2.3 Experimental design

In each district, five traps (as replicates) for each treatment were hanged randomly in shaded sites in fruit trees at a height of about two meters. The distance between every two traps was about 50 meter to avoid interaction among the tested treatments. Sticky cardboards inside traps were inspected weekly and replaced with new cardboards. The number of attracted male flies was recorded per each trap per day (FTD). Evaluation of traps baited with different treatments was started from 28th of December in Mansoura district and started from 31st of December 2017 in Aga district. Experiments in the two districts were continued over eight 8 successive weeks.

2.4 Estimating physical properties of the tested treatments:

From the fresh preparations, fifty milliliters of each treatment were transferred to a laboratory for estimating density and viscosity cP at 25°C of the tested treatments. These samples were measured by The Egyptian Petroleum Research Institute using DV-III Ultra Programmable Rheometer and ASTM Density ASTMD 445-12 Pycnometer.

2.5 Statistical analysis

The obtained data were analyzed by using one-way ANOVA followed by least significant difference (LSD) at probability level of 0.05. Regression analysis was also performed. All analyses were performed using CoHort Software (2004) [26].

3. Results

In mansoura district: When adding soya bean or paraffin oils to trimedlure with a concentration of 25%, they attracted the highest numbers of MFF adult males all over the first month with no significant difference between them; while, the lowest treatment was that of adding paraffin oil with a concentration of 50% (Table, 1). After two months, adding paraffin oil to trimedlure with a concentration of 25% proved to be the significantly highest attractant to MFF adult males; while, the lowest treatments were those of adding 50% of soya bean or castor oils to trimedlure with no significant difference between them. All of the other tested treatments (represented in Table, 1) showed moderate ranks.

Table 1: Response of MFF males to trimedlure diluted with different oils in comparison with un-diluted one under field conditions in mandarin orchards at Mansoura district.

Weeks	Un-diluted trimedlure	Paraffin oil		Soya bean oil		Sun flower oil		Castor oil		LSD P=5%
		25%	50%	25%	50%	25%	50%	25%	50%	
1	5.0	3.90	2.50	4.70	3.76	6.19	5.30	3.96	5.69	0.79
2	2.60	2.60	1.20	3.00	2.02	2.60	1.57	2.02	2.66	0.58
3	2.08	3.37	1.89	3.09	2.23	1.80	2.37	3.11	1.63	0.44
4	0.23	0.46	0.37	0.51	0.54	0.54	0.51	0.31	0.11	0.19
Mean 1-4	2.47	2.58	1.48	2.82	2.14	2.47	2.44	2.35	2.52	0.28
5	0.09	0.14	0.09	0.26	0.26	0.23	0.11	0.34	0.09	0.15
6	0.56	0.73	0.63	0.60	0.46	0.76	0.70	0.67	0.30	0.82
7	1.29	2.40	2.24	2.36	1.32	2.36	1.36	1.60	1.20	0.34
8	1.60	1.57	0.85	0.51	0.14	0.91	1.51	0.71	0.88	0.25
Mean 5-8	0.89	1.21	0.95	0.93	0.55	1.07	0.92	0.83	0.62	0.14

In Aga district: Adding castor oil with concentrations of 25 or 50% to trimedlure attracted the highest numbers of MFF adult males all over the first month with no significant difference between them. Un-diluted trimedlure, adding paraffin (with 25%), soya been (with 50%) and sun flower (with 25%) oils were the lowest treatments in attracting MFF adult males all over the first month with no significant difference between them. After two months, adding 25% of soya been or castor proved to be the significantly highest attractants to MFF adult males; while, the lowest treatments were those of un-diluted trimedlure and adding 50% of soya bean oil to trimedlure with no significant difference between them (Table, 2).

Table 2: Response of MFF males to trimedlure diluted with different oils in comparison with un-diluted one under field conditions in mandarin orchards at Aga district.

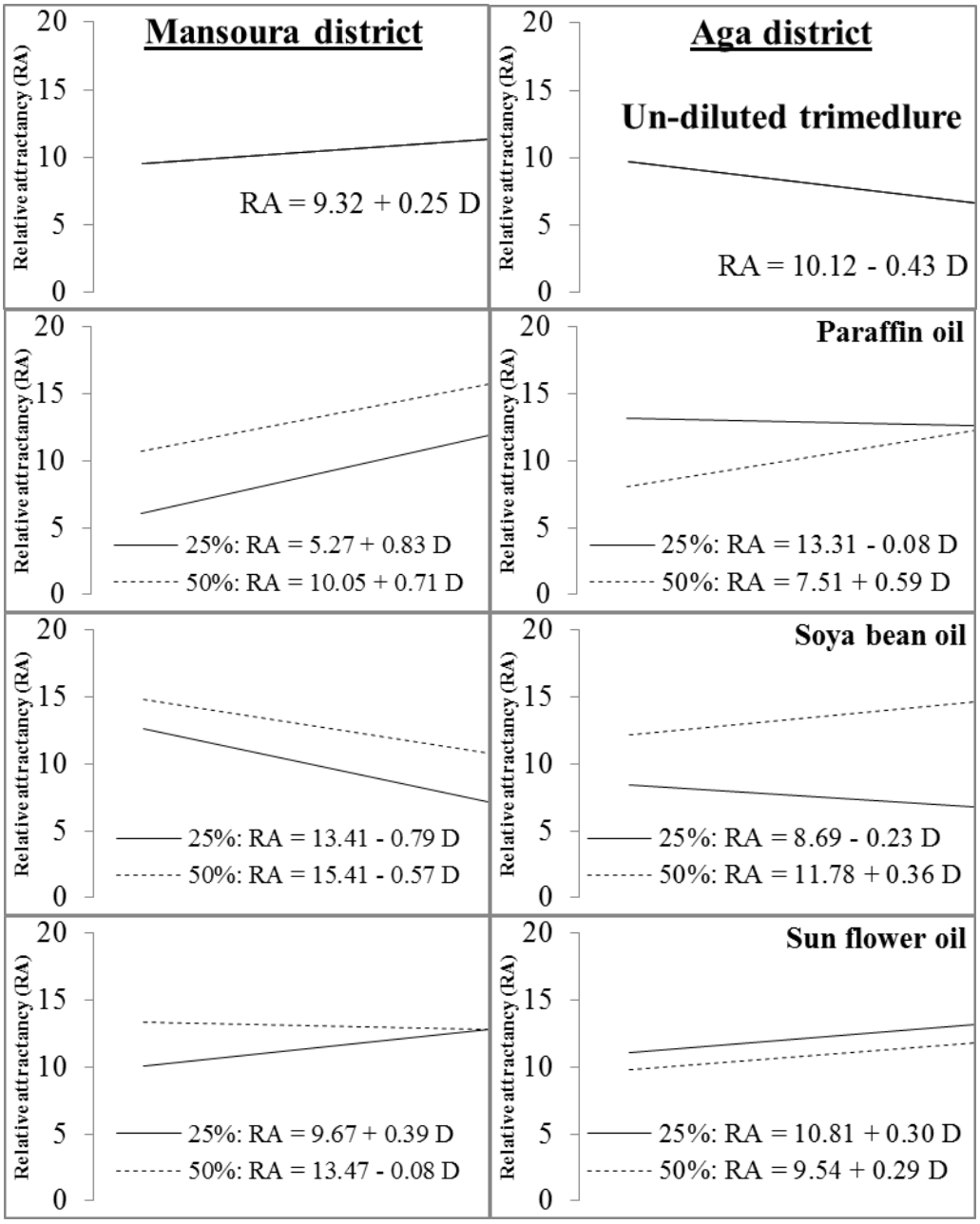
Weeks	Un-diluted trimedlure	Paraffin oil		Soya bean oil		Sun flower oil		Castor oil		LSD P=5%
		25%	50%	25%	50%	25%	50%	25%	50%	
1	1.80	1.36	2.36	2.30	1.60	2.30	2.0	3.13	2.0	0.48
2	1.42	1.66	2.40	2.63	1.82	1.51	2.63	2.26	3.88	0.56
3	1.40	2.03	1.83	1.86	1.26	1.20	2.40	2.49	2.57	0.60
4	0.74	0.51	0.77	0.71	0.48	0.69	0.40	0.48	0.69	0.42
Mean 1-4	1.34	1.39	1.84	1.87	1.29	1.42	1.85	2.13	2.23	0.32

5	0.60	0.65	1.45	1.20	0.25	0.95	0.90	0.75	0.25	0.46
6	0.53	1.23	1.16	1.20	0.90	0.96	1.03	1.29	1.13	0.18
7	1.24	2.08	2.22	2.92	1.92	3.20	3.44	4.08	1.04	0.38
8	1.31	2.37	2.05	2.74	1.05	1.68	2.37	2.48	2.20	0.31
Mean 5-8	0.92	1.58	1.73	2.01	1.03	1.70	1.93	2.15	1.31	0.19

As shown in Figure (1), the most stable treatments all over eight passed weeks were those of paraffin oil. Whereas, the weekly increase of its relative attractancy reached 0.83 and 0.71% in Mansoura district when it added to trimedlure with 25 and 50%, respectively. In Aga district, b-regression values were -0.08 and 0.59% for 25 and 50% of added paraffin oil to trimedlure.

In contrary, the most inhibited treatments by the time passed were those of soya bean and castor oils. In Mansoura district, the relative attractancy of soya bean oil when it added to trimedlure by 25 and 50% decreased weekly by 0.79 and 0.57%; while, in the case of castor oil decreased by 0.69 and 0.05%, respectively. In Aga district, b-regression values of soya bean oil when it added to trimedlure by 25 and 50% were 0.25 and 0.36, respectively; while, in the case of castor oil these values were -0.96 and 0.06, respectively (Fig. 1).

Trimedlure was relatively more stable when sun flower oil added to it with 25 (b = 0.39 and 0.30) and 50% (b = -0.08 and 0.29) in comparison with un-diluted trimedlure (b = 0.25 and -0.43) in Mansoura and Aga districts, respectively (Fig., 1).



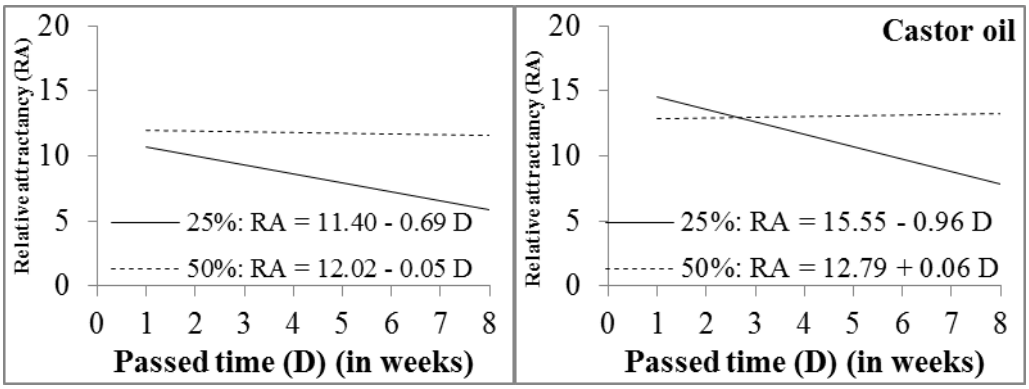


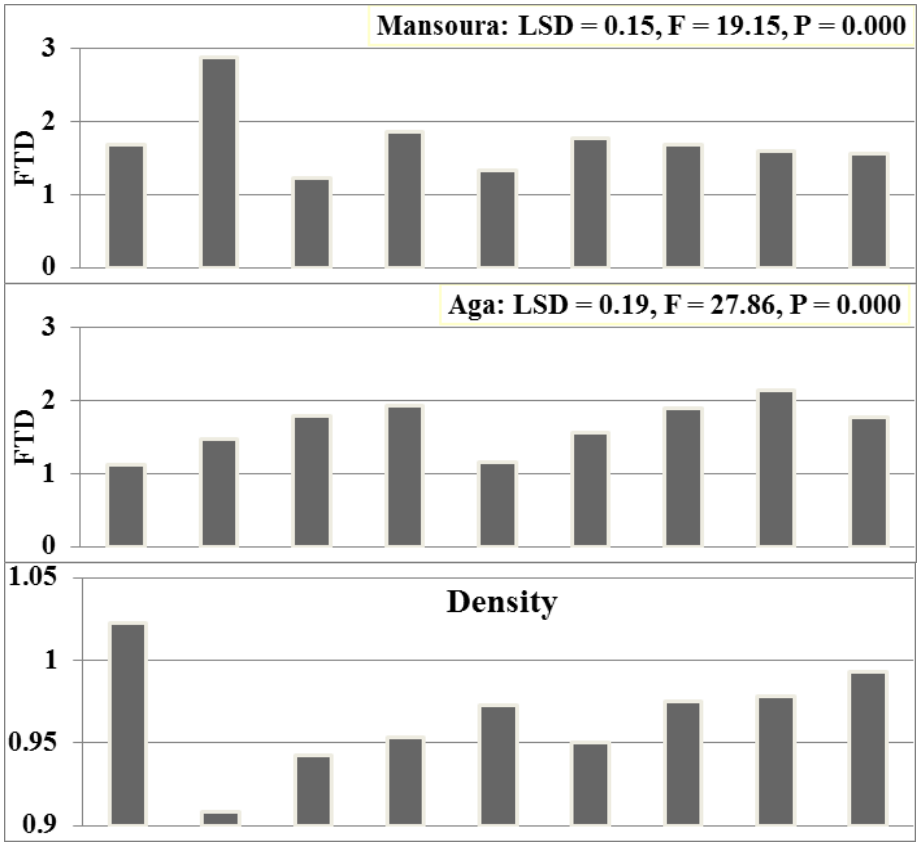
Fig 1: Relative stability of trimedlure (Un-diduted or diluted with certain oils) for attracting MFF adult males (Mesured as relative attractancy) under field conditions in Mansoura and Aga districts.

In Mansoura district, adding paraffin oil to trimedlure with a concentration of 25% proved to be the significantly highest attractive treatment to MFF males; whereas, the mean FTD all over eight weeks was 2.89. In contrary, adding both of paraffin and soya bean oils to trimedlure with a concentration of 50% were the lowest attractive treatments to MFF males (mean FTDs were 1.22 and 1.34, respectively) with no significant difference between them (Fig., 2).

In Aga district (Fig., 2), when adding castor oil to trimedlure with a concentration of 25% it proved to be the highest attractive treatment to MFF males (mean FTD = 2.14). In contrary, un-diluted trimedlure and when adding soya bean oil to it with a concentration of 50% were the lowest effective treatments in attracting MFF males (FTDs were 1.13 and 1.16, respectively) with no significant difference between them.

On another hand, density of un-diluted trimedlure was the highest (1.0223). Adding of the selected oils to it reduced the values of density; whereas, the lowest density (0.9083) was recorded when adding paraffin oil with a concentration of 25%. All of the rest treatments ranked moderate values of density (Fig, 2).

Viscosity cP at 25°C of un-diluted trimedlure was the lowest (12.66). When adding the castor oil to trimedlure increased the viscosity to its highest value (277.7) with the concentration of 25% and to 98.55 with the concentration of 50%. The other tested treatments showed moderate ranks of viscosity (Fig, 2).



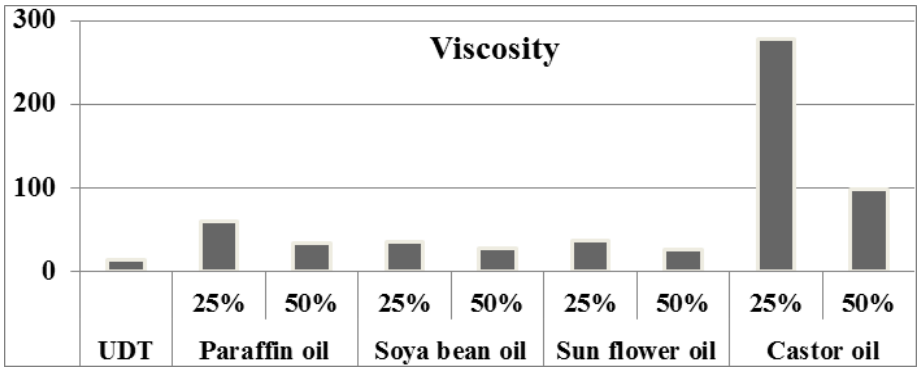


Fig 2: Mean captured MFF males to trimedlure diluted with different oils with comparison with un-diluted one (UDT) in response to physical properties (density and viscosity) of the tested treatments under field conditions in mandarin orchards at Mansoura and Aga districts.

As shown in Figure (3), density of the tested treatments had an adverse effect on their efficiency as attractants for MFF adult males. Whereas, each increase of density by one unit decreased the daily catch of flies by 8.19 (R^2 = 31.02%) and 2.00 (R^2 = 3.51%) males per trap per day in Mansoura and Aga districts, respectively.

On contrary, viscosity of the tested treatments had an extrusive effect on their efficiency as attractants for MFF males. In Aga district, each increase of treatment viscosity by one unit increased FTD by 0.002 (R^2 = 34.56%). In Mansoura district, viscosity had approximately no effect on the efficiency of the tested attractants (Fig., 3).

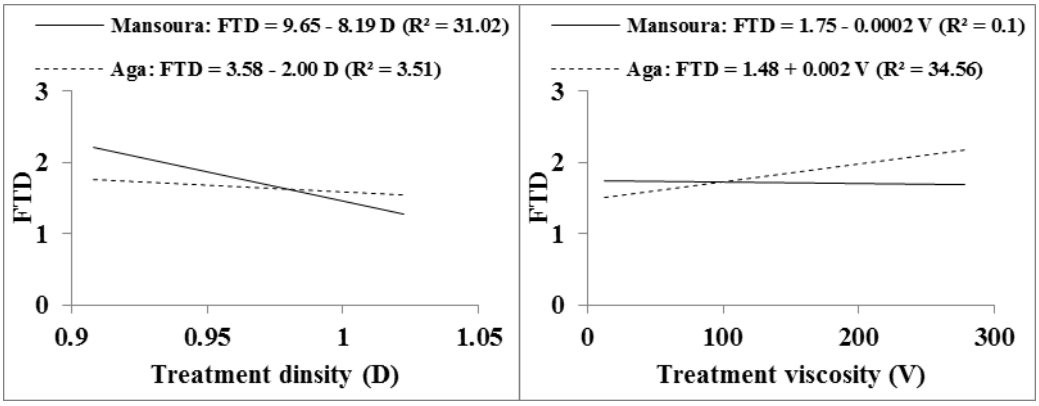


Fig 3: The relationship between captured MFF males and each of dinsity & viscosity of the dilluted trimedlure in different oils.

4. Discussion

Trimedlure is widely used as the "standard" synthetic male MFF attractant [17]. In order to reduce the cost of monitoring and controlling of MFF, dilution of trimedlure with four different oils (paraffin, soya bean, sun flower and castor oils) had been evaluated to reduce the quantity of trimedlure. Two concentrations of each oil (25 and 50%) were added to trimedlure and compared with un-diluted trimedlure.

The obtained data showed that adding paraffin or castor oils to trimedlure with a concentration of 25% attracted significantly higher numbers of MFF adult males all over eight weeks in comparison with un-diluted trimedlure under field conditions; while, the lowest treatments were those of adding 50% of soya bean or castor oils to trimedlure. These findings are in agreement with those obtained by El-Abbassi and El-Metwally (2013) and El-Metwally (2017) [14, 15]. They stated that adding paraffin oil to trimedlure with a concentration of 25% was effective as the 98% concentration (un-diluted trimedlure) in attracting MFF males under field conditions. Also, the present findings are in agreement with results reported by Jang *et al*. (2005) [12] who reported that doses of (-) ceralure B1 of 87.5% and 75% were as effective as the 98% concentration in attracting MFF males.

According to Navarro Llopis *et al*. (2011) [13], the disruption effect of MFF males was not observed when different emission levels were examined for trimedlure; however, fly catches did not significantly increase with the increase trimedlure release rate up to six times. This lack of saturation in response to higher pheromone concentrations could explain why trimedlure do not produce flight disruption in MFF. In the same trend, El-Metwally and Amin (2015) and Ghanim (2013) [23, 24] reported that dilution of methyl eugenol (the sex attractant of peach fruit fly, *Bactrocera zonata* (Saunders)) in paraffin oil till 50% did not significantly affect the captured males.

The present study revealed that the most stable treatments all over eight passed weeks were those of diluted with paraffin oil; while, the most inhibited treatments by the time passed were those of diluted with soya bean oil. Similar results are obtained by El-Metwally (2017) and El-Metwally *et al.* (2017) [15, 27]; they reported that captured males of MFF to trimedlure declined by lapse of time. Also, El-Metwally and Amin (2015) [23] reported that the effectiveness of methyl eugenol as an attractant for *B. zonata* decreased by the time passed under field conditions. The same authors added that methyl eugenol diluted with paraffin oil was more stable against passed time in comparison with that diluted with sunflower oil.

According to Slodowicz *et al*. (2017) [28], the physicochemical parameters that influence the release of pheromone components from the wax monolithic dispensers can be modulated as required by the geographical and/or meteorological conditions of the field, as well as according to the insect species or the purpose of the experiment. In the

present study, adding of the selected oils to trimedlure reduced its density and increased its viscosity. Density of the tested treatments had an adverse effect on their efficiency as attractants for MFF adult males. On contrary, viscosity of the tested treatments had an extrusive effect on their efficiency. Similar findings were obtained by Slodowicz *et al*. (2017) [28]; evaluated the linear and non linear regressions between the pheromone components release rates and matrices viscosity. They found that viscosity showed an extrusive effect on the pheromone component release rates.

As a conclusion, adding paraffin oil to trimedlure with a concentration of 25% attracted significantly higher numbers of MFF adult males and give trimedlure relatively most stable against time under field conditions. So, it can reduce the coast of using trimedlure by about 25%.

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