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Coating Effect of Trimedlure and Methyl Eugenol by Some Polymers on Male Attraction of the Mediterranean Fruit Fly and Peach Fruit Fly under Field Conditions

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THE EGYPTIAN fruits are attacked by two tepheritid pests; the peach fruit fly, *Bactrocera zonata* (Saunders), and the Mediterranean fruit fly, *Ceratitis capitata* (Wiedmann) causing considerable damage. The ultimate goal of this study is to investigate the response of Mediterranean and peach fruit flies males to trimedlure (TML) and methyl eugenol (ME) coated by different polymers. The impregnated cotton wicks of TML and ME were coated with different types of polymers including chitosan 0.5%, sodium alginate 0.5%, styrene acrylate 8.0% (St Acrylate) and Polyvinyl alcohol 0.5% (PVA 0.5%). The study was carried out by using Jackson trap at different orchards at Dakhlia and Menofia governorates. The attracting efficiency of TML and ME for attracting both of *C. capitata* and *B. zonata* males are improved when coating by using some polymers. The TML that coated by St Acrylate 8% polymer was significantly the highest one for attracting *C. capitata* males, while, the ME that coated by PVA 0.5% was significantly the highest one for capturing *B. zonata* males. The study suggests that attention should be paid to improve trapping quality by using the mentioned polymers.

Keywords: Coating Polymers, Chitosan, Styrene acrylate copolymer, *Ceratitis capitata* – *Bactrocera zonata*, Trimedlure - Methyl Eugenol.

Introduction

The majority of Egyptian fruits is attacked by two of the most harmful tepheritid pests; the peach fruit fly, *Bactrocera zonata* (Saunders), and the Mediterranean fruit fly, *Ceratitis capitata* (Wiedmann) that infesting many commercial fruits, mango, guava, apricot, peach, apple and citrus all over the year causing considerable damage which inflicts significantly economic losses [1]. The most widely used traps of fruit flies management contain para-pheromone or pheromone lures that are male specific. The para-pheromone trimedlure (TML) captures medfly and Natal fruit fly, while, the para-pheromone methyl eugenol (ME) captures a large number of Bactrocera species including peach fruit fly [2].

Controlled Release (CR) technology is a recent technology, which has considerable potential in the fields of medicine, pharmacy, and agriculture [3]. The aims of CR formulations are to protect the supply of the agent, to allow the automatic release of the agent to the target at a controlled rate, and to maintain its concentration in the system within the optimum limits, over a specified period of time, thereby providing great specificity and persistence [4].

The parameters that affect the properties of such CR formulations depend upon the nature and type of the polymer used. Functionalized polymers were used to increase the efficiency of pesticides and herbicides, allowing lower doses to be used and to indirectly protect the environment by reducing pollution and clean-up existing pollutants [5]. The aims of polymers as organic ingredients of nano-formulations are consisting in; increasing the apparent solubility of poorly soluble active ingredient; and releasing the active ingredient in a slow/targeted manner and/or protecting the active ingredient against premature degradation [6]. Natural polymers are often preferred to synthetic

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polymers because of their nontoxic, low cost, free availability, and biodegradability characteristics. However, several natural biopolymers, especially the class of polysaccharides, have some inherent disadvantages, such as poor mechanical strength, uncontrolled water uptake, and microbial contamination [7].

Chitosan (CS) as one of the most abundant natural polysaccharide polymers is produced by deacetylation of chitin. It has been widely adopted for the manufacture of controlled-release materials in the food, drug, biochemical, and agricultural areas [8]. Also, sodium alginate (NaAlg) is a bioerodible. natural polymer that has been widely used in CR applications of drugs and pesticides because it forms strong gels in aqueous media and is bioerodible. [3].

On the other hand, synthetic polymers (including Styrene Acrylate Copolymer and PVA) are produced from non-renewable petroleum resources [9] and are characterized by their good physicochemical and mechanical properties but they are not sufficiently biocompatible, most likely due to the presence of residues of initiators and other compounds/impurities [10]. Fruit flies management applications require utilization various quantities of male lures that including TML or ME for survey, detection, monitoring and MAT applications. In order to minimize the high economic cost of used TML & ME quantities through extending lure longevity or reduction the used quantities, this study was a trail to investigate the effect of some polymers on CR of TML & ME efficiency for attracting male fruit flies under field conditions**.**

Material and Methods

The study was designed to investigate the effect of some natural and synthetic polymers on CR of TML & ME efficiency for attracting male fruit flies of MFF and PFF under different field conditions of weather and host**.**

MFF

The present experiments were carried out in three experimental sites in Egypt. The 1st site was located at Mansoura district, Dakahlia Governorate in an area of about 10 feddan cultivated with citrus (Navel orange) starting on December 7th 2014 and continued for successive 6 weeks. The second site was located at Aga district, Dakahlia Governorate, cultivated with citrus (Navel orange) in an area 10-12 feddan starting on February 4th 2015 and continued for successive 7 weeks. The 3rd site was located at Ashmoun district, Menofia Governorate in an area of about 9 feddan cultivated with citrus (Valencia orange) beginning from March 24th 2015 and continued for successive 9 weeks.

PFF

Two experimental sites were in Egypt, the 1st site was located at Mansoura district in an area of 10 feddan cultivated with citrus (Navel orange) beginning on the December 7th 2014 and continued for successive 6 weeks, while, the 2nd site located was at Menouf district, Monofia Governorate**,** in an area of about 8 feddan cultivated with guava (*Psidium guajva* L.) beginning on December 8th 2014 and continued for successive 8 weeks.

Tested male lures and polymers

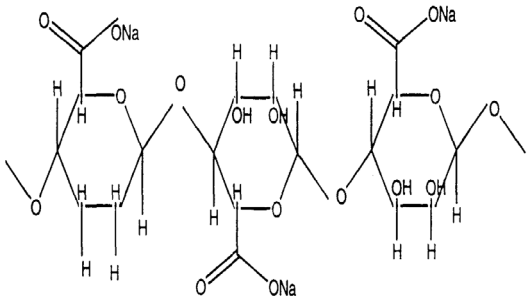
For attracting *C. capitata* males, a commercial Trimedlure © (98% purity, manufactured in the USA). While, a commercial Methyl Eugenol (98% purity, Yasho Industries, India) was used for capturing *B. zonata* males. Dental cotton wicks (4 cm long x 1 cm diameter) were used as dispensers of each of TML and ME. The cotton wicks were injected with 3 ml of the desired lure by medical syringe individually. All the impregnated cotton wicks were dipped on the tested polymers. Beside the mentioned tested polymers, dental cotton wicks were injected only by both of TML and ME as standard treatment.

The tested polymers include; (i) Sodium Alginate (NaAlg) 0.5%, (ii) Styrene Acrylate copolymer latex (St Acylate) 8% was prepared according to our previous reported published article [11], (iii) Chitosan 0.5% (iv) and Polyvinyl alcohol 0.05% (PVA).

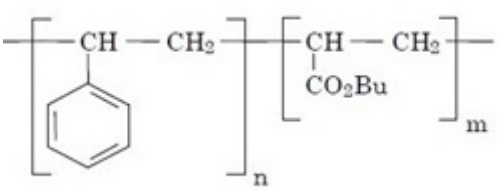
All the tested polymers were prepared by the Department of Polymers and Pigments, National Research Centre, Dokki, Cairo, Egypt. The structure of the prepared polymers is illustrated in Scheme 1.

Description of the experimental plot

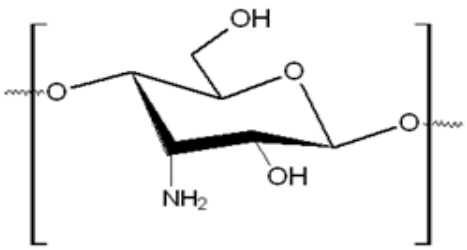
Each experimental site was divided into five blocks. For capturing *C. capitata* and *B. zonata* males, the impregnated cotton wicks were fixed on Jackson sticky traps [12] in rate of 5 replicates for each treatment and arranged in a complete randomized blocks design. All traps were distributed uniformly and hanged at a height of 1.50-2.00 m on the southern external branches of trees (in a shadow and aerated places on trees).



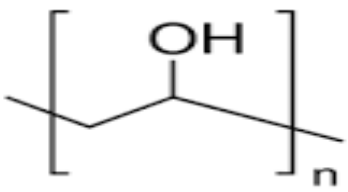
Sodium Alginate (i)



Styrene- Butyl acrylate
copolymer latex (ii)



Chitosan (III)



Poly vinyl alcohol

Scheme 1. (i) Sodium alginate (ii) Styrene -Butyl Acrylate copolymer latex (iii) Chitosan (iv) Polyvinyl alcohol.

The distance between every two adjacent traps was 50 meters to avoid interactions among traps. The traps were inspected weekly and number of attracted male flies on each sticky cardboard insert was counted, recorded and replaced with a fresh sticky cardboard. The number of captured flies per trap per day (CTD) was considered the parameter of efficiency.

Statistical analysis

The statistical analysis was done as one way ANOVA and means separated was conducted by using L.S.D. at the probability of 5% [13].

Results and Discussion

Field response of MFF and PFF males to their male lures that coating with different types of polymers are tabulated as mentioned below.

A: Field response of MFF males to TML coated by different polymers

Data represented in Tables 1, 2 and 3 show the mean numbers of MFF males attracted to traps loaded with TML coated with different polymers under field conditions in three locations.

At Mansoura district

Data represented in Table 1 show response of the Mediterranean fruit fly, *C. capitata* to TML coated by different types of polymers under field conditions in citrus orchards at Mansoura district. Throughout 6 weeks of trail, significant differences are shown among the tested treatments. The TML coated by the polymer Chitasan 0.5% attracted the high number of *C. capitata* male flies on the 2nd week of inspection with mean CTD value of 143.25 males/trap/week, while the lowest values of CTD were recorded on the last week of experimentation period. The general mean number of attracted flies showed that there were significant differences between TML coated by the various polymers and the standard treatment (TML only), whereas, the TML coated by Chitasan 0.5% recorded the highest mean CTD of attracted flies (62.66 males/trap/day), followed by other treatments as follows, Na alginate 0.5% and St Acylate 8%, with mean CTD values of 60.91 and 60.29 males/trap/day, respectively, while, both of the TML coated by PVA 0.05% and the standard control came last with mean CTD values of 37.8 and 31.6 males/trap/day, respectively.

At Aga district

The presented data in Table 2 indicated that all the treatments differed insignificantly during the 1st and 6th weeks, while, the mean CTD values

of tested polymers varied significantly during the rest weeks. The highest mean CTD values were recorded during the 6th week , the TML coated by St Acylate 8% attracted the highest number of *C. capitata* males (36.00 males / trap / day), while, the lowest mean CTD values for all treatments were recorded on the 4th week. Generally, the general mean CTD values differed significantly, the TML that coated by St Acylate 8% was the highest one followed by PVA 0.5%, the standard treatment, Chitasan 0.05% and Na alginate 0.5% with respective mean CTD values of 9.88, 7.65, 6.57, 6.20 and 4.23 males / trap / day.

At Ashmoun district

The presented data in Table 3 indicated that all the treatments significantly varied during 1st, 2nd, 4th, 7th and 9th weeks, while, all the treatments insignificantly differed during the other weeks of the experimentation period. The highest number of attracted flies was observed during the 1st and 2nd week of experimentation. Generally, the TML that coated by St Acylate 8% polymer was significantly the highest one with mean CTD value of 7.02 males/trap/day.

Generally, the obtained results appeared a variation on the population density of *C. capitata* flies on the studied experimental sites. The weather factors, specially temperature and availability of host may be responsible about the fluctuations of attracted flies during the inspected weeks on all the experimental sites. However, the TML coated by St Acrylate had the highest rate of relative attractancy (23.81, 28.61 and 29.71 % at the districts Mansoura, Aga and Ashmoun, respectively) compared to other the treatments (Fig. 1). The other treatments of TML that coated by Na alginate 0.5%, Chitasan and PVA. 0.5% recorded somewhat the same rate of relative attratancy, while, the standard treatment that contained TML only came last with a means of relative attractancy of 12.48, 19.03 and 13.42 % of the total attracted flies.

TABLE 1. Mean number of MFF male captured in traps loaded with TML coated with different polymers in citrus orchards at Mansoura district.

Weeks of inspection	Polymer				The standard treatment (Control)	L.S.D.at 5%
	Na alginate 0.5%	St Acylate 8%	Chitasan 0.5%	PVA. 0.5%		
1st	101.25 **a**	75.25 **abc**	82.00 **ab**	54.75 **bc**	43.5 **c**	37.94
2nd	139.75 **a**	137.75 **a**	143.25 **a**	100.25 **ab**	65.75 **b**	48.32
3rd	41.75 **ab**	55.25 **a**	63.75 **a**	20.5 **b**	27.25 **b**	25.82
4th	73.50 **a**	74.00 **a**	73.25 **a**	39.75 **b**	45.00 **ab**	30.00
5th	7.00 **b**	17.25**a**	13.00 **ab**	10.75 **bc**	8.25 **c**	6.10
6th	2.25 **a**	2.25 **a**	0.75 **ab**	1.00 **ab**	0.25 **b**	1.69
Mean	60.91**a**	60.29 **a**	62.66 **a**	37.80 **b**	31.67 **b**	18.31

Means in the same raw followed by the same letters were not significantly at 0.05 level.

TABLE 2. Mean number of MFF male captured in traps loaded with TML coated with different polymers in citrus orchards at aga district.

Weeks of inspection	Polymer				The standard treatment (Control)	L.S.D.at 5%
	Na alginate 0.5%	St Acylate 8%	Chitasan 0.5%	PVA. 0.5%		
1st	9.40 **a**	8.80 **a**	5.40 **a**	6.00 **a**	7.00 **a**	5.54
2nd	2.20 **ab**	3.80 **a**	2.20 **ab**	1.40 **b**	1.00 **b**	1.65
3rd	2.20 **ab**	4.80 **a**	3.80 **ab**	3.60 **ab**	1.80 **b**	2.01
4th	1.40 **b**	1.00 **b**	2.80 **a**	0.60 **b**	0.60 **b**	1.12
5th	1.60 **b**	3.80 **ab**	3.60 **ab**	5.60 **a**	3.40 **b**	2.19
6th	28.20 **a**	36.00 **a**	20.40 **a**	30.00 **a**	26.00 **a**	16.13
7th	8.60 **a**	11.00 **a**	5.20 **b**	6.40 **b**	6.20 **b**	3.77
Mean	4.23 **c**	9.88 **a**	6.20 **b**	7.65 **b**	6.57 **b**	1.96

Means in the same raw followed by the same letters were not significantly at 0.05 level.

TABLE 3. Mean number of MFF male captured in traps loaded with TML coated with different polymers in citrus orchards at ashmoun district.

Weeks of inspection	Polymer				The standard treatment (Control)	L.S.D.at 5%
	Na alginate 0.5%	St Acylate 8%	Chitasan 0.5%	PVA. 0.5%		
1st	8.20 **b**	12.80 **a**	9.40 **ab**	12.60 **a**	12.60 **a**	4.18
2nd	9.00 **ab**	7.40 **b**	11.60 **a**	10.40 **ab**	9.00 **ab**	4.02
3rd	5.80 **a**	3.60 **a**	5.00 **a**	3.60 **a**	3.80 **a**	3.80
4th	10.00 **a**	6.00 **b**	2.60 **c**	5.00 **bc**	3.20 **bc**	3.98
5th	2.60 **a**	2.00 **a**	2.20 **a**	1.20 **a**	2.40 **a**	1.92
6th	1.20 **a**	0.80 **a**	1.40 **a**	1.60 **a**	0.20 **a**	1.52
7th	2.20 **ab**	4.00 **a**	2.20 **a**b	2.20 **ab**	1.40 **b**	2.03
8th	3.20 **b**	10.40 **a**	3.20 **b**	5.20 **b**	2.20 **b**	4.04
9th	1.00 **c**	16.20 **a**	0.80 **c**	9.6 **ab**	3.20 **bc**	7.12
Mean	4.37 **b**	7.02 **a**	4.22 **b**	4.85 **b**	3.17 **b**	1.90

Means in the same raw followed by the same letters were not significantly at 0.05 level.

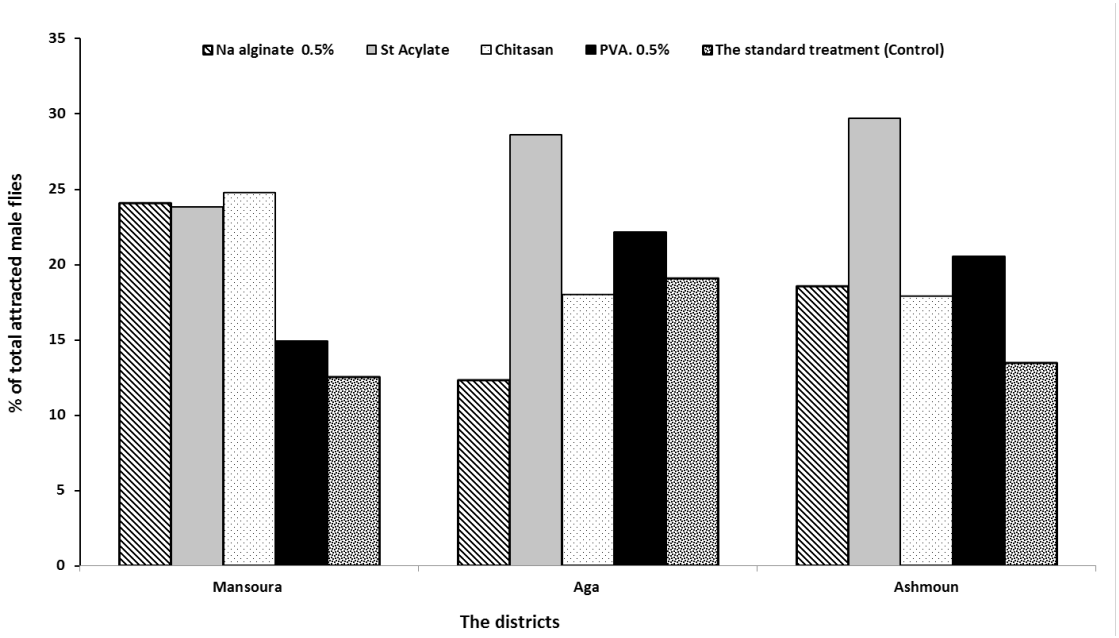


Fig. 1. The mean relative attarctancy % of MFF males to different TML coated by different polymers at different districts.

B: Field response of PFF males to ME coated by different polymers

Data represented in Tables 4 and 5 show the mean CTD of PFF males attracted to traps when ME coated with different polymers at Mansoura and Menouf districts.

At Mansoura district

The data obtained indicated that the ME coated by PVA 0.5% was the highest one for attracting *B. zonata* males in comparison with other tested treatments thought the six weeks of experiment, except the last two weeks (4th and 5th weeks) where Chitasan 0.5% was insignificantly the highest attracting (Table 4). After 6 weeks of experimentation, the general mean CTD values of males attracted were 5.23, 3.70, 6.80, 7.13 and 4.50 male / flies / trap for the ME that coated by polymers, Na Alginate 0.5%, St Acylate 8%, Chitasan 0.5% and PVA. 0.5% and standard treatment (control), respectively.

TABLE 4. Mean number of PFF male captured in traps loaded with ME coated with different polymers in citrus orchards at Mansoura district.

Weeks of inspection	Polymer				The standard treatment (Control)	L.S.D.at 5%
	Na alginate 0.5%	St Acylate 8%	Chitasan 0.5%	PVA. 0.5%		
1st	12.20 **a**	9.80 **a**	11.40 **a**	19.20 **a**	8.60 **a**	7.69
2nd	7.60 **a**	4.00 **a**	9.20 **a**	10.60 **a**	6.40 **a**	6.69
3rd	6.00 **ab**	3.80 **b**	10.00 **a**	7.20 **ab**	6.00 **ab**	4.67
4th	3.20 **b**	2.40 **b**	6.80 **a**	2.80 **b**	4.60 **ab**	2.55
5th	1.80 **a**	1.60 **a**	2.40 **a**	1.80 **a**	1.00 **a**	2.85
6th	0.60 **a**	0.60 **a**	1.00 **a**	1.20 **a**	0.40 **a**	1.04
Mean	5.23 **ab**	3.70 **b**	6.80 **a**	7.13 **a**	4.50 **ab**	3.09

Means in the same raw followed by the same letters were not significantly at 0.05 level.

TABLE 5. Mean number of PFF male captured in traps loaded with ME coated with different polymers in guava orchards at Menouf district.

Weeks of inspection	Polymer				The standard treatment (Control)	L.S.D.at 5%
	Na alginate 0.5%	St Acylate 8%	Chitasan 0.5%	PVA. 0.5%		
1st	19.2 **a**	19.8 **a**	28.0 **a**	37.4 **a**	27.6 **a**	19.88
2nd	17.2 **ab**	10.4 **b**	28.2 **a**	15.2 **ab**	22.2 **ab**	13.50
3rd	26.4 **a**	6.2 **a**	13.2 **a**	15.4 **a**	11.4 **a**	21.39
4th	3.8 **a**	3.8 **a**	4.8 **a**	4.8 **a**	3.0 **a**	3.37
5th	0.8 **a**	0.8 **a**	0.6 **a**	1.4 **a**	0.6 **a**	1.75
6th	6.4 **a**	1.0 **b**	2.8 **ab**	4.6 **ab**	4.0 **ab**	3.89
7th	0.6 **a**	0.8 **a**	0.8 **a**	1.2 **a**	1.0 **a**	1.08
8th	1.6 **a**	1.6 **a**	0.8 **a**	2.6 **a**	1.4 **a**	1.65
Mean	9.5 **a**	5.5 **a**	9.9 **a**	10.3 **a**	8.75 **a**	5.91

Means in the same raw followed by the same letters were not significantly at 0.05 level.

At Menouf district

The ME that coated by the polymer PVA 0.5% was the superior for attracting *B. zonata* males when compared with other tested polymers, (Table 5). The insignificant differences among tested treatments were observed during almost the period of inspection except the 2nd and 6th weeks. The general mean of CTD value of males attracted to traps over 8 weeks were 9.5, 5.5, 9.9, 10.3 and 8.75 males / trap /day for the ME that coated by polymers, Na Alginate 0.5%, St Acylate 8%, Chitasan 0.5% and PVA. 0.5% and the standard treatment (control), respectively.

The mean relative attractancy % of ME that coated by various polymers at the two districts shows that the PVA 0.5% recorded 24.85 and 25.63 % of the total captured males at Mansoura and Menouf districts, respectively, following by Chitasan 0.5% and Na alginate 0.5%. While, St Acylate 8% was the lowest one recording 14.02 and 14.29 % of the captured total flies at Mansoura and Menouf districts, respectively (Fig. 2).

From the obtained results, it was found that at lower population of either MFF or PFF coating cotton wick dispensers loaded the males sex attractant will not possibility effect monitoring both flies. Generally, it could be concluded that PVA. 0.5% polymer might be used successfully for treated traps loaded with ME for monitoring PFF insect or in integrated pest control programs.

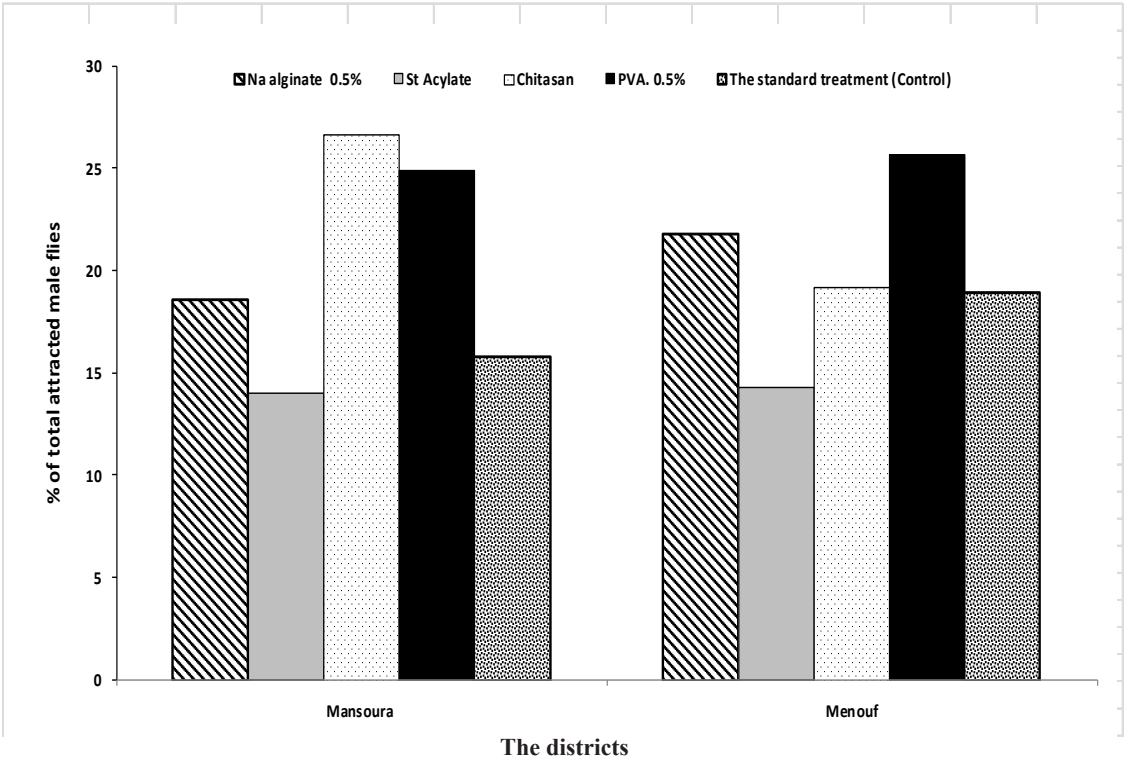


Fig. 2. The mean relative attractancy % of PFF males to different ME coated by different polymers at two districts.

Discussion

The aims of polymers as organic ingredients of nano-formulations are consisting in; increasing the apparent solubility of poorly soluble active ingredient; and releasing the active ingredient in a slow/targeted manner and/or protecting the active ingredient against premature degradation [6]. The obtained results revealed that all the tested polymers that coated TML and ME varied in their effect and longevity, such variation may be due to difference of the polymer. Such differences may be due to the polymer biodegradability characteristics, also, several natural biopolymers, especially the class of polysaccharides, have some inherent disadvantages, such as poor mechanical strength, uncontrolled water uptake, and microbial contamination [7].

Concerning TML trail, St Acylate recorded insignificantly highest numbers of attracted flies comparing with standard treatment that containing TML only, in same time, the TML that coated by St Acylate 8% were effective more than 6 weeks. This obtained results disagree with that revealed TML had high volatility from the cotton and it was found to be effective for only 2–4 weeks [14]. Solutions were developed to extend the effective life of TML and ME diluting by paraffin oil (to 75% or sometimes to 50% of its original concentration) might be used successfully [15,16]. A nanogelled ME " A nanogel" was prepared from ME using a low-molecular mass gelator. A nanogel was very stable at open ambient conditions and slowed down the evaporation of ME significantly [17].

It could be concluded the attracting efficiency of the paraphermone, TML and ME for attracting both of *C. capitata* and *B. zonata* males are improved when coating by using some polymers like St Acylate 8% and PVA 0.5%. Such results require more of studies to minimize the used quantities without affecting the attraction efficiency.

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تأثير تغطية الترايمدلور والميثيل ايوجينول ببعض البوليمرات على كفاءة الجذب لذكور ذبابة فاكهة البحر المتوسط وذبابة ثمار الخوخ تحت الظروف الحقلية

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تسبب ذبابتا فاكهة البحر المتوسط وذبابة ثمار الخوخ أضراراً اقتصادية جسيمة لثمار الفاكهة المصرية وهدفت هذه الدراسة الى التعرف على استجابة ذكور ذباب ثمارفاكهة البحر الأبيض المتوسط وثمار الخوخ إلى التريميدور أو أوالميثيل أوجينول المغلفة بأنواع مختلفة من البوليمرات. وقد تم معاملة فتائل القطن المشبعة بالترايمدلور والميثيل أوجينول بتغطيتها بالبوليمرات التالية الكيتوزان ٠,٥ ٪ وألجينات الصوديوم ٠,٥٪ والأستايرين أكريلات ٨,٠٪ وبولي فينيل الكحول (عديد كحول الفينيل) ٠,٥٪. وأجريت الدراسة باستخدام مصائد جاكسون في بساتين مختلفة في محافظتي الدقهلية والمنوفية ، وقد أظهرت النتائج تحسن نتائج الجذب لكل من الترايمدلور والميثيل ايوجينول بصورة معنوية ببعض البوليمرات. وسجلت فتائل القطن المشبعة بالترايمدلور والمغطاة بالأستايرين أكريلات ٨,٠٪ أعلى جذب لذكور ذبابة فاكهة البحر المتوسط بينما كانت فتائل القطن المشبعة بالميثيل ايوجينول والمغطاة ببولي فينيل الكحول (عديد كحول الفينيل) ٠,٥٪ أعلى جذب لذكور ذبابة ثمار الخوخ . وتقترح الدراسة توجيه المزيد من الاهتمام نحو تغطية الجاذبات المعنية بانواع مختلفة من البوليمرات لتحسين كفاءة الجذب لها.