



Evaluation of certain olfactory compounds and natural oils as attractants or repellents for fruit flies in Egypt

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Abstract

Field experiments were conducted to determine attractability or repellency of certain compounds and natural oils for two species of fruit flies (*Ceratitis capitata* and *Bactrocera zonata*). Buminal and Ammonium compounds attracted the highest average number of both species that significantly varied with those investigated for trimedlure (in case of *C. capitata*) or methyl eugenol (in case of *B. zonata*). The average numbers of fruit flies (the two species of *C. capitata* and *B. zonata*) attracted to traps baited with garlic oil was nil. Irrespective of the used compounds, the average numbers of attracted individuals of the Med-fly gradually increased throughout the period of investigation (12 weeks). But, in case of the peach fruit fly a gradual increment was observed during the first 8 weeks. On the other hand, females of both the Mediterranean and peach fruit flies were more attracted to the tested compounds than males of the two species. Also, the highest the concentration, the highest was the average numbers of attracted individuals.

To determine the repellent action of certain natural oils for fruit flies under field conditions, cotton wicks baited with garlic oils (50 and 25%), Citronella oil at 25% and Camphor oil at 50% were hung within the canopy of Valencia orange trees during pre-mature fruiting period facing the neighbor-suitable previously infesting host. All used natural oils insignificantly attracted different average numbers of both the Mediterranean and peach fruit flies which significantly varied with those attracted to Buminal. Garlic oil at 50% attracted the lowest average number of both *C. capitata* and *B. zonata*. Generally, the average number of captured flies of the two species of fruit flies gradually increased by lapse of time. During fruit maturity period of Valencia orange, traps baited with Buminal at 10% were surrounded by 4 cotton wicks from tested every repellent (garlic oil at 50% and Citronella oil at 25%) to investigate the repellent action of these oils which may prevent fruit infestation. The two tested natural oils (Garlic at 50% and Citronella at 25%) showed high significantly a repellent action against the two species of fruit flies (*C. capitata* and *B. zonata*) where the average numbers of captured flies in traps surrounded by natural oils were much lower than that of control. Garlic oil at 50% was insignificantly much more effective as repellent compound for fruit flies than Citronella oil at 25%.

Keywords: natural oils, fruit flies, *C. capitata* and *B. zonata*, Citronella oil.

Introduction

Fruit flies (Diptera: Tephritidae) are among the most important quarantine pests worldwide which cause severe damage to horticultural crops reducing both quantity and quality of fruits. Family Tephritidae (= Trypetidae), the true fruit flies, includes about 4000 Species assigned to 500 genera. As such, it is amongst the largest of dipteran families (true flies), and, economically, one of the most important pestiferous groups (White and Harris, 1994). Among these, the peach fruit fly, *Bactrocera zonata* (Saund.) and the Mediterranean fruit fly, *Ceratitis capitata* (Wied.) that heavily attack many fruit hosts in Egypt and in other countries such as apricot, peach, pear, mango, guava, fig, citrus and others. In Egypt, fruit flies; which are polyphagous and multivoltine insect pest because of their broad host range, attacking over 250 different types of fruits and vegetables, and their importance to international quarantine; affect seriously the production and exportation of various fruit especially mango, grapes and citrus (Alzubaidy, 2000 and Shelly *et al.*, 2012).

Pheromones, kairomones and allomones are chemicals which released from insects or hosts for mating, aggregation and feed. Phytochemicals from host plants are well known to affect behavior and physiology for a wide range of insects. Tephritid fruit flies are trapped for a variety of reasons-surveillance, suppression, and ecological study among others, and chemical baits have played a central role in these efforts (Jacobson *et al.*, 1973; Sivinski & Calkins, 1986; Deng *et al.*, 2004; Witzgall *et al.*, 2010 and Laura *et al.*, 2015). Females of tephritid flies need certain amino acids as nutrition for developing their eggs and so they are attracted by the bait. Protein hydrolyzate preparations (food attractants) were previously used as baits in McPhail traps and they captured a large number of both males and females of PFF and MFF. Catches of MFF and PFF by olfactory stimulants (such as ammonium compounds) in attractant traps can be used to monitor their populations and for predicting the infestation level. In addition, Bait Application Technique (BAT) is a widely used technique for controlling fruit flies; deploys spots of protein bait mixed with insecticide that attract and kill adult fruit flies. Different protein hydrolaste compounds are used globally to monitor the population of fruit flies. Ammonia is an essential substance that used as food by females of fruit flies in order to develop eggs. Protein hydrolysates are used in many fruit growing areas of the world for fruit fly control and have undoubtedly led to reduced environmental

contamination by insecticides (Bateman & Morton, 1981; Mazor *et al.*, 1987; Vargas, *et al.*, 2002; Uchida *et al.*, 2006; Ravikumar & Viraktamath, 2007 and Mahmoud *et al.*, 2012).

Detection systems for fruit flies and other insects usually are based on strong olfactory attractants, which ideally are species-specific. The most widely used lure in trapping programs for medfly detection is trimedlure, a synthetic compound primarily attractive to male medflies. But, with respect to the peach fruit fly, a synthetic compound primarily attractive to males (methyl eugenol) is widely used. The lack of an effective female attractants has prompted several studies to examine the male sex pheromone and host odors as lures for attracting female flies. In recent years, there has been renewed interest in developing more efficient baits and traps for monitoring economically important fruit flies. Trapping systems for pestiferous fruit flies provide useful information about the presence, seasonal abundance, and spatial distribution of the adults in order to make predictions of host fruit infestation levels (Fletcher *et al.*, 1975; Mitchell *et al.*, 1985; Hee & Tan, 1998; Shelly and Pahio, 2002; Midgarden *et al.* 2004; Uchida *et al.*, 2006 and Mwatawala *et al.*, 2012).

Olfactory response of fruit flies and other insects to different-groups of chemicals was studied by several researches under field conditions. This work aims to evaluate certain proteinaceous materials and other chemical compounds as attractants and/or repellent for two species of fruit flies, *Bactrocera zonata* (Saund.) and *Ceratitis capitata* (Wied.) in citrus orchard in Egypt.

Materials and Methods

Location of Experimental Farm

The experiments were conducted in mixed citrus orchard (navel orange, mandarin and Valencia orange) of about 25 feddans (a feddan = 4200m²) in Menouf district, Menoufia governorate. Trees of about 30 years old that flood irrigated were cultivated at 5 × 5 meters in clay soil. Three Jackson traps baited with trimedlure (to monitor *Ceratitis capitata*) as well as another three traps baited with methyl eugenol (for monitoring *Bactrocera zonata*) were randomly distributed in the first week of September 2016 within the canopy of trees to detect and determine the population of the two species of fruit flies.

Chemicals Used

- Buminal, Di-ammonium phosphate, Ammonium acetate, Ammonium chloride, Ammonium carbonate, Ammonium hydrogen orthophosphate at concentration of 1, 5 and 10%
- Clove oil, Peach oil, Orange oil, Citronella oil, Paprika Extract, Ginger Oil, Watercress Oil, Lemon oil, Garlic oil and Camphor oil at 25, 50 and 100%.

Procedures

The abovementioned compounds were tested as attractants or repellents for the two species of fruit flies (*Ceratitis capitata* and *Bactrocera zonata*) using Makkar and El-Abbassi traps (Makkar *et al.*, 2015) in navel orange for 12 successive weeks from the last week of September. The traps of each treatment replicated three times and randomly distributed for every three trees (the distances between every two adjacent traps = 15 meters). Traps were weekly inspected, cleaned and the concentration of the tested compounds changed. All traps were alternatively hung every week within the canopy of trees at a height of about 1.5 to 2 meters above on soil surface.

To determine the repellent action of certain natural oils for fruit flies under field conditions, cotton wicks saturated or baited with garlic oils (50 and 25%), Citronella oil at 25% and Camphor oil at 50% were randomly hung within the canopy of Valencia orange trees during pre-mature fruiting period in zigzag line among two rows facing the neighbor-suitable previously infesting host. The concentration used for tested material were determine according to data obtained from laboratory test. The distance between every to successive traps in each row was 20 meter and the distance between this to rows 15 meters. After another 15 meter Makkar and El-Abbassi traps baited with Buminal at 10% were hung in a row to record the immigrated fruit flies which were sorted and identified.

All obtained data were statistically analyzed using a software program (SAS, 2002).

Results and Discussion

Attractability of Certain Substances for Fruit Flies

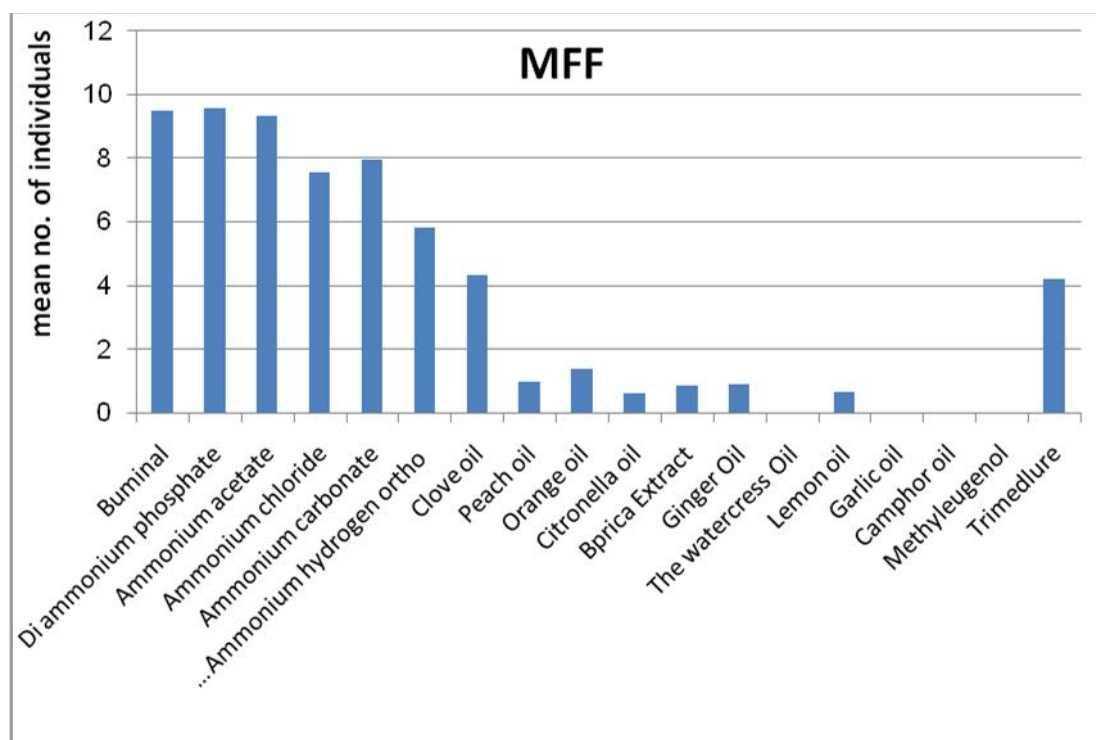
Data compiled in Table (1) and illustrated in Fig. (1) Indicate that the average number of attracted individuals of both the Mediterranean and peach fruit flies to traps baited with different substances.

Buminal and Ammonium compounds showed the highest attracted average number of both species. The average numbers of fruit flies (the two species of *C. capitata* and *B. zonata*) attracted to traps baited with garlic oil was nil. This means that garlic oil may be had a repellent action against fruit flies. **Bateman and Morton (1981)** studied the response of Queensland fruit fly to feed-based lure with particular emphasis on the importance of ammonia as an attractant or repellent. Certain solutions of ammonium bicarbonate were found to be highly effective attractants for the Queensland fruit fly. **Heath *et al.* (1995)** tested traps baited with a 2-component blend of ammonium acetate and putrescine against populations of the Mediterranean fruit fly *Ceratitis capitata* (Wiedemm) and the Mexican fruit fly *Anastrepha ludns* (Loew) in field trials conducted in Guatemala. The combination of ammonium acetate and putrescine was better than either ammonium acetate-only, putrescine-only, or unbaited traps. **Abd El-Kariem *et al.* (2009)** carried out experiments in guava orchard in Egypt using eight different plant oil extracts [olive, orange, peppermint, basil, clove (Egyptian & French), parsley and black cumin] which bioassayed as attractants for the tephritids, *B. zonata* and *C. capitata* males and females. *B. zonata* males and females as well as *C. capitata* females showed no response to all the tested oils. Also, the highest concentration used, the highest was average numbers of attracted individuals. **Bateman and Morton (1981)** found that the attractancies of the Queensland fruit fly strongly dependent on concentration and mean attractancies more than five times that of the commercial protein hydrolysate used as a standard were obtained. **Abd El-Kariem *et al.* (2009)** reported that *C. capitata* males exhibited a significant positive response to French and Egyptian clove oils; while it had no response to olive, basil, parsley and black cumin oils. **Moustafa *et al.* (2012)** reported that the clove oil (*Eugenia caryophyllata*, family Myrtaceae) at concentration of 50%, gave the highest attraction of *C. capitata* males, compared to trimedlure (as a reference attractant). The prepared (local) methyl eugenol (50,100% concentration) has approximately the same efficacy in attracting PFF males as well as imported methyl eugenol.

Table (1): Average number of two species of fruit flies attracted to different olfactory substances and natural oils under field conditions.

Substances	Average no. of adults of			
	MFF		PFF	
Buminal	9.5152	a	5.3737	ab
Di-ammonium phosphate	9.5808	a	5.8131	a
Ammonium acetate	9.3485	a	5.3333	abc
Ammonium chloride	7.5606	b	5.1263	bc
Ammonium carbonate	7.9495	b	4.8030	c
Ammonium hydrogen ortho phosphate	5.8485	c	3.4343	e
Clove oil	4.3586	d	0.5152	gh
Peach oil	0.9747	e	0.2071	hi
Orange oil	1.3788	e	0.0960	hi
Citronella oil	0.6414	efg	0.3636	ghi
Paprika Extract	0.8889	efg	0.8081	g
Ginger Oil	0.9192	efg	2.0253	f
The watercress Oil	0.0455	fg	0.5960	hg
Lemon oil	0.6768	efg	0.5101	ghi
Garlic oil	0.0000	i	0.0000	g
Camphor oil	0.0255	fi	0.0000	i
Methyl leugenol	0.0000	g	3.9500	d
Trimedlure	4.2167	d	0.0000	i
F value	202.47		180.95	
P value	0.0001		0.0001	

Means followed by the same letter (within each factor) are not significantly differed ($P > 0.05$).



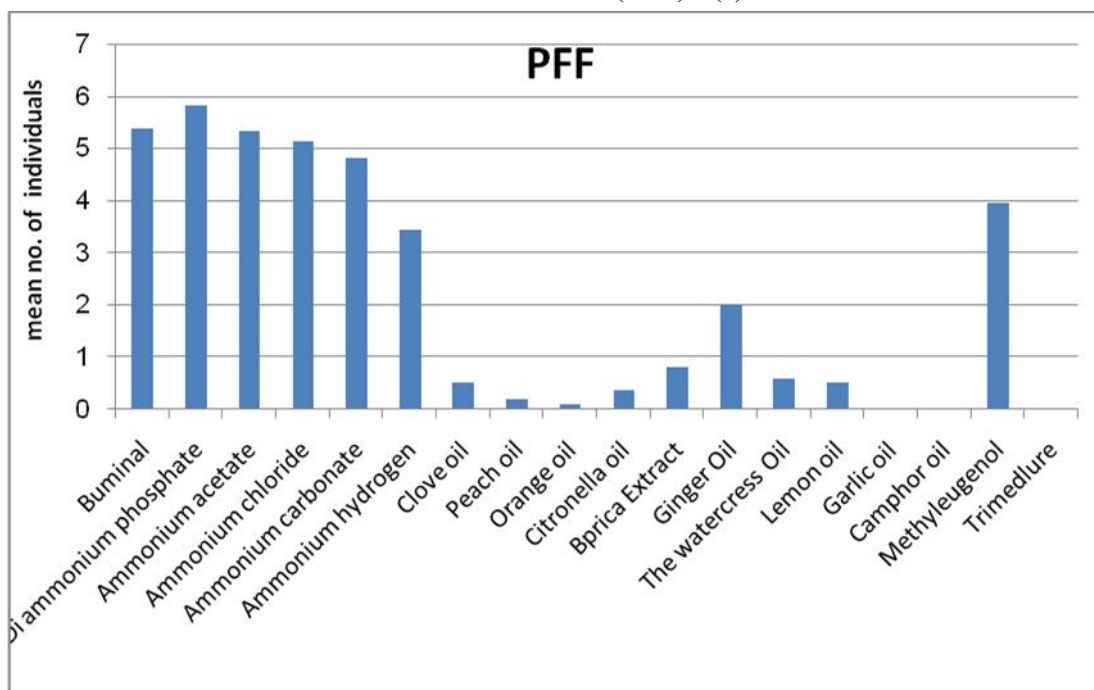


Fig. (1): Average number of attracted individuals of two species of fruit flies to different olfactory substances and natural oils under field conditions.

Repellency action of Natural Oils to Fruit Flies Throughout Premature Fruiting Period of Valencia Orange

Data shown in Table (2) and illustrated in Figs. (2) Revealed that all tested natural oils non significantly attracted different average numbers of both the

Mediterranean and peach fruit flies which significantly varied with those attracted to Buminal. Garlic oil at 50% attracted the lowest averagenumber of both *C. capitata* and *B. zonata*. Generally, the average number of captured flies of the two species of fruit flies gradually increased by lapse of time.

Table (2): Effect of certain natural oils as repellents for fruit flies in pre-mature fruiting period of Valencia orange.

Factor	Compound	Average no. of adults of			
		MFF		PFF	
Treatment	garlic oil 50%	0.1528	b	0.097	b
	garlic oil 25%	0.3125	b	0.125	b
	Citronella oil 25%	0.5139	b	0.278	b
	Camphor oil 50%	0.9063	b	0.313	b
	Buminal 10%	7.5139	a	2.917	a
	F value	170.85		69.62	
	P value	0.0001		0.0001	
Sex	Female	3.15	a	1.229	a
	Male	1.3357	b	0.564	b
	F value	58.18		21.65	
	P value	0.0001		0.0001	

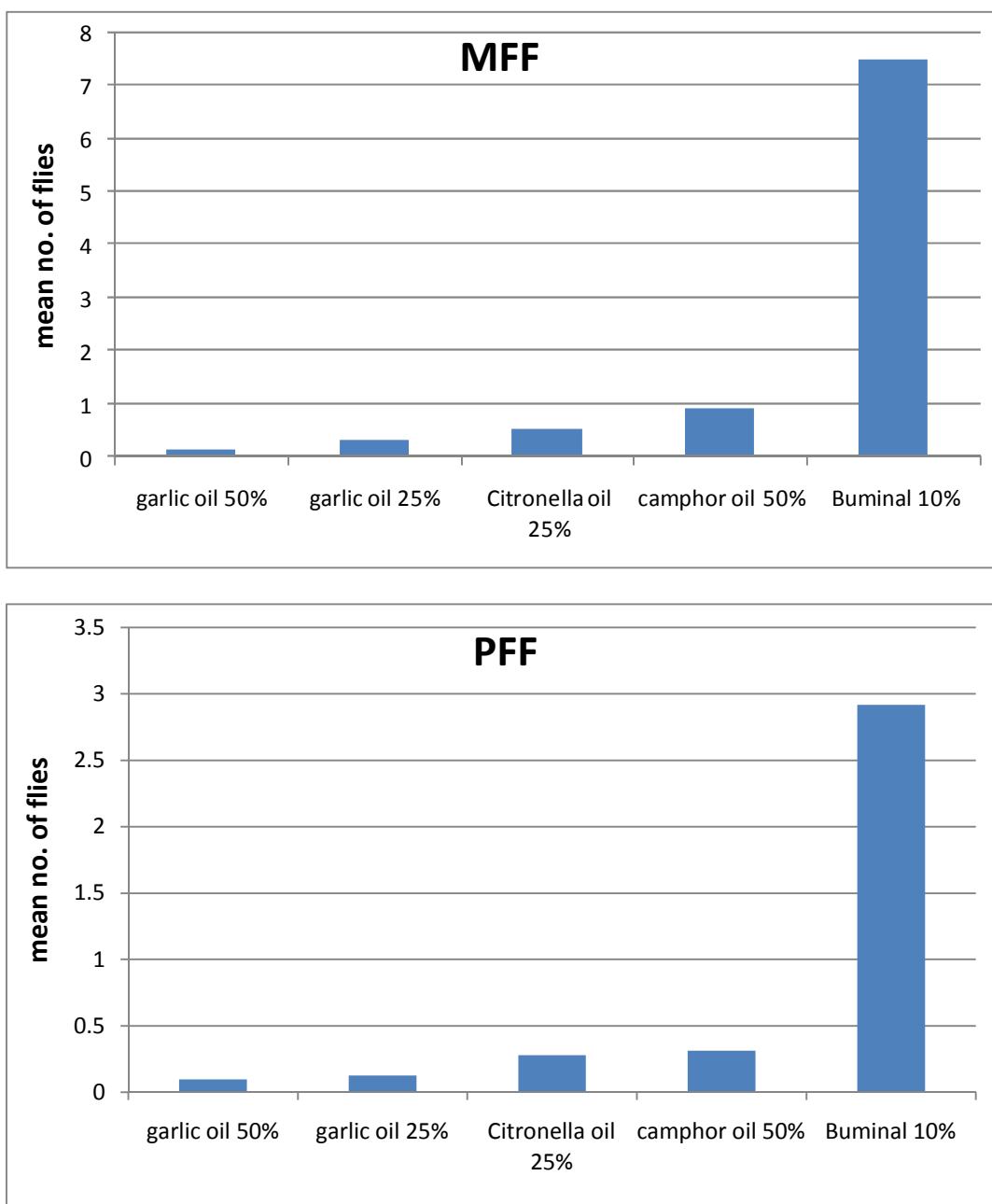


Fig. (2): Natural oils as repellents for fruit flies in pre-mature fruiting period of Valencia orange.

Efficiency of Natural Oils as Repellents for Fruit Flies during Maturity stage of Valencia Orange

Traps baited with Buminal at 10% were surrounded by 4 cotton wicks from every repellent (garlic oil at 50% and Citronella oil at 25%) to investigate the repellent action of these oils and their ability in preventing fruit infestation. The captured flies were weekly recorded for successive nine weeks which compared to those attracted to traps baited with Buminal as control. Data in Table (3) and Fig.(3) indicate that the two tested natural oils (Garlic at 50% and Citronella at 25%) showed high significantly repellent action against the

two species of fruit flies (*C. capitata* and *B. zonata*) where the average numbers of captured flies in traps of loaded with Buminal surrounded by natural oils were much lower than that of control (Traps not surrounded by cotton wick mounted with this natural oils). Garlic oil at 50% was insignificantly much more effective as repellent compound for fruit flies than Citronella oil at 25%. As shown in Table (3) and Fig. (3), the captured flies of the Med fly, in general, gradually increased with time during the first seven weeks, but in case of the peach fruit fly, sharply increment in attracted individuals took place throughout the first four weeks.

Table (3): Effect of certain natural oils as repellents for two species of fruit flies under field conditions during mature fruiting period of Valencia orange.

Factor	Level	Average no. of adults of			
		MFF		MFF	
Substance	garlic 50%	0.2639	b	0.194	b
	Citronella 25%	0.9722	b	0.597	b
	Buminal 10%	6.8889	a	3.806	a
F value		183.6		94.06	
P value		0.0001		0.0001	
Sex	Female	4.0833	a	2.259	a
	Male	1.3333	b	0.806	b
	F value	78.69		38.07	
P value		0.0001		0.0001	

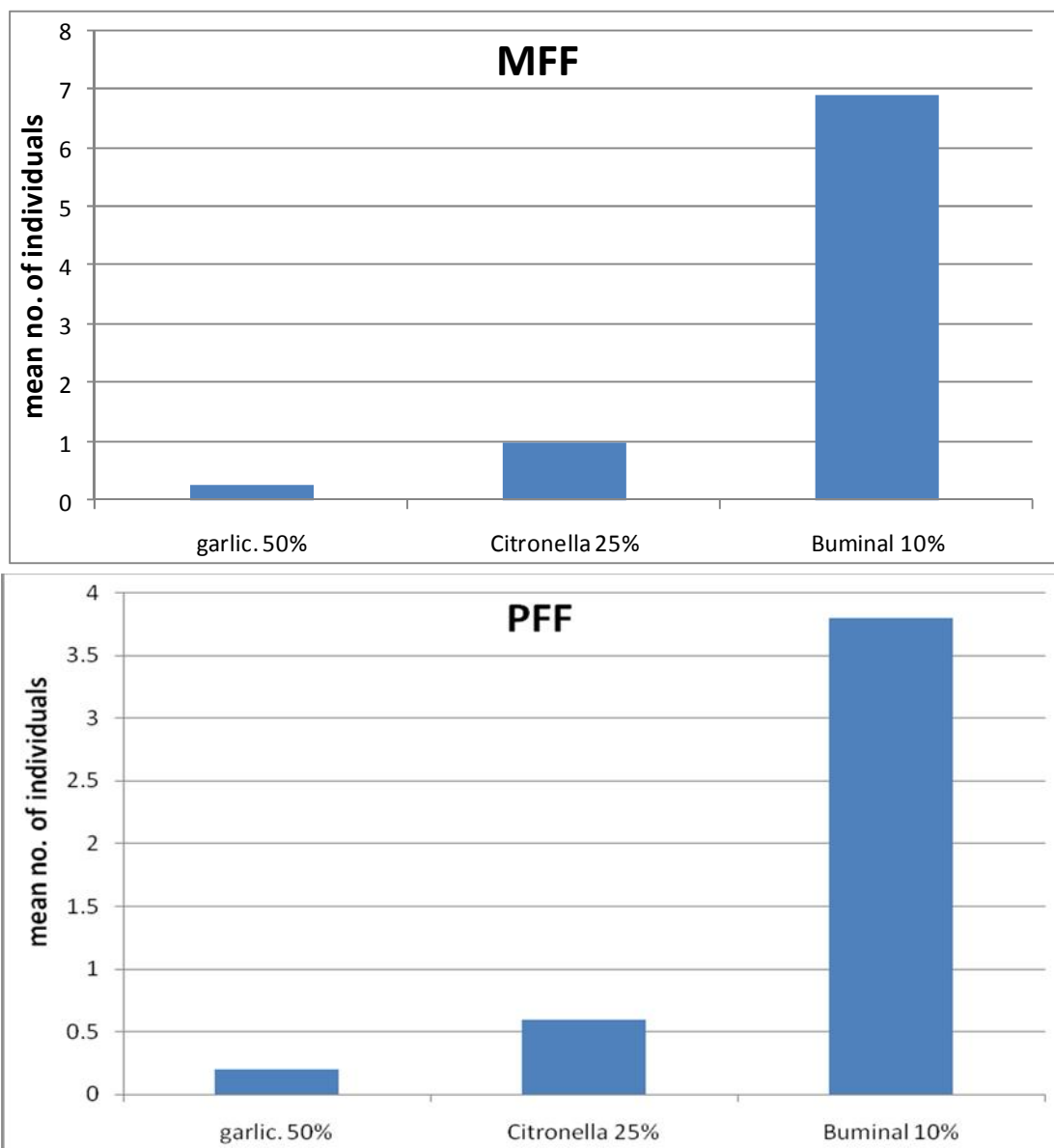


Fig. (3): Natural oils as repellents for two species of fruit flies under field conditions during mature fruiting period of Valencia orange.

Conclusion

Data obtained from this study revealed that some of tested materials like Buminal and certain ammonium compounds were more attractive for both sexes of med fly and peach fruit flies when compared with other tested materials. Moreover, they were more attractive to females than males. Meanwhile, some natural materials like clove and orange oils were also attractive to fruit flies under this investigation but were more attractive to males than females. Garlic oil and citronella showed a repellent effect represented on lower number of attracted flies inside traps mounted with the food attractant buminal when these traps were surrounded by cotton wicks saturated with these two materials. This effect lasted for a period of nine weeks. Therefore, it could be concluded that these two natural materials might be used for preventing infestation of orange fruits by fruit flies under our local field conditions and may be useful as an item in integrated pest management programs. However, more studies should be conducted on different hosts, locations, in one host orchard and/or mixed host orchards.

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