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Evaluation the Effectiveness of Two Various Compounds Against Green Peach Aphid, *Myzus persicae* Sulzer and Their Indirect Impacts on the Green Lacewing, *Chrysoperla carnea* (Stephens)

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Abstract: Series laboratory experiments were conducted to examine the efficacy of different concentrations of the essential lemon oil and the novel systemic insecticide closer against the green peach aphid, *Myzus persicae* Sulzer and investigate their indirect impacts on the predator, *Chrysoperla carnea* (Stephens). Findings indicated that both lemon oil and closer were highly effective in managing *M. persicae* whereas lemon oil seemed to be less sharp on *C. carena* compared with closer. The mortality rates varied for the different concentrations used where it was high by the higher concentrations than the lower one particularly in the youth instars, where the first and second in star larvae of the predator proved to be more susceptible than its third in star which showed to be most tolerance.

Key words: *Myzus persicae* · *Chrysoperla carnea* · Lemon oil · Closer

INTRODUCTION

The green peach aphid, *M. persicae* is one of the main serious pests worldwide which causes an economic damage to vegetables and fruits [1]. It have an extremely wide host range in over 40 different plant families, due to its short generation and massive fecundity it can amount a very high population densities, thus it is able to cause critical damage directly by sucking the host plant which leads to many problems like wilting, deformation, premature leaf senescence and retarded growth rate of the plant and indirectly by its capable to transmit several viral diseases to planted vegetables[2, 3]. *M. persicae* is an important vector of over 100 plant viruses and the ability of both nymphs and adults to transmit the virus is equal [4, 5]. Moreover, honeydew and sooty mould causes more damage to the plant beside contamination of harvestable plant which causes considerable losses [6].

Increase the use of chemical insecticides in control over many years encouraged insect phytotoxicity, resistance and unbalance in the normal biotic ecosystem [7]. *M. persicae* resistance to many synthetic insecticides is widely reported and its mechanisms are reviewed [8]. It is also causing many other problems such as environmental pollution and toxic threats to human beings as well as its harmful effect on the non-target organisms like the natural enemies of the insect including the polyphagous, *C. carnea* [9, 10]. The green lacewing, *C. carnea* act as one of the most important predators that has been effectively used to control various insect pests due to the ability of its larvae to feed on a wide prey range including aphidswhere commonly found in agricultural systems and widely used for aphid biocontrol [11, 12].

Thus, finding new plant protection alternatives being effective in control insect pests and safer on non- target organisms and environment has become necessary. Plant extracts and essential oils are generally among the substances which considered safe for the environment and health where it isolated from plants [13]. Weinzierl and Henn [14] reported a new interest in using natural products to control pests with reduce chemical insecticides dangers, including botanical oils [15]. Lemon oil is a natural compound derived from lemon fruits, *Citrus limon* L. (Sapindales: Rutaceae) which has toxic effect against insect pests [16]. Therefore, it could represent important tool in pest management including aphids, but the assessment of their risk on the natural enemies and the other non-target organisms is still very necessary. Sulfoximines also are a new class of insecticides targeting sap-feeding insects [17, 18]. The present study was conducted to examine the efficacy of different concentrations of the essential lemon oil and

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the systemic insecticide sulfoxaflor (closer®) which classified as a sulfoximine on *M. persicae* and investigate their indirect impacts on the predator, *C. carnea* under laboratory conditions.

MATERIALS AND METHODS

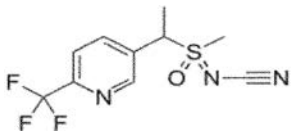
Rearing of the Insects: To begin the experiment, green peach aphids, *M. percicae* were collected from infested tomato plants at the unsprayed experimental farm of Faculty of Agriculture, Mansoura University and transported to the laboratory in paper bags. Tomato leaves carrying *M. persicae* were transferred and kept in jars covered with muslin and aphids were supplied with fresh tomato leaves which were provided for it daily where it maintained for approximately two generations before the beginning of the experiment.

To secure sufficient numbers of the 1st, 2nd and 3rd instars of *C. carnea* to carry out all experiments, neonate predator larvae were obtained from the Bio-Control Laboratory of the Plant Protection Research Institute, Dokki, Egypt and continuous laboratory cultures were established. *M. percicae* were offered to predator during its development except the adult. Colonies were kept at 27±2°C and 65±5% RH.

Compounds Used: Essential lemon oil (volatile) was extracted from the lemon fruit peels by steam distillation apparatus found in Plant Protection Institute, Mansoura, Egypt. The oil was separated dried over anhydrous sodium sulfate and stored in dark glass bottles at 4°C in refrigerator until used. The active ingredient of lemon oil is limonene and the chemical formula is $C_{10}H_{16}$.

Limonene structure [19]

The insecticide Sulfoxaflor, also marketed as Isoclast (Closer 24%, SC), which is a member of a class of chemicals called sulfoximines and its chemical formula is $C_{10}H_{10}F_3N_3O_S$.



Sulfoxaflor structure

On basis of the examined plant oil weight and the volume of the distilled water (w/v) in the presence of tween 80 (0.1%) as emulsifier, convenient stock concentrations of lemon oil were prepared periodically and stored under refrigeration in closed glass bottles. Four diluted concentrations for lemon oil was used to draw the LC-P lines, beside concentrations of the insecticide which were prepared by the use of distilled water only while the untreated was prepared by distilled water with tween 80 (0.1%).

Experiments Application: To evaluate the efficacy of lemon oil and closer on *M. persicae* four concentrations of each of them were used by the directly sprayed from a distance of 20 cm. on the target insect pest where 250, 500, 750 and 1000 ppm were used for lemon oil and 26.25, 52.5, 105 and 210 ppm for the insecticide. Four replicates were observed for every treatment. Twenty individuals of green aphids were placed on tomato leaves in Petri dishes (9 cm in diameter) and treated with concentrations mentioned for each treatment to estimate the mortality line and the same in the untreated which was sprayed only by distilled water and tween. The mortality percentage was calculated and corrected according to Abbott [20]. LC_{50} values were determined using probit analysis statistical method of Finney [21] and LC_{50} index was determined by the following equation according to Sun [22].

$$\text{Toxicity inder for } LC_{50} = \frac{LS_{50} \text{ of the most effective compound}}{LC_{50} \text{ of the other tested compound}} \times 100$$

On the other side, three separated experiments were conducted to investigate the indirect effect of lemon oil and closer on the predator, *C. carnea* through provided *M. persicae* treated by direct spraying with various concentrations of the current compounds to its first, second and third instars as food where 250, 500 and 1000 ppm were used for lemon oil and 52.5, 105 and 210 ppm for the insecticide.

After six hours starved, first instar larvae of *C. carnae* were introduced individually into Petri dishes which containing treated aphids. Each treatment was replicated ten times. To avoid cannibalism, only one larva of the predator was placed separately in each replicate and the same in the untreated. Predator larvae were supplied with treated aphids for only two days and numbers of dead larvae were recorded after 48 hours then the remaining live larvae were provided with untreated *M. persicae* and after completion of larval development, pupae were kept to adult emergence. The predator mortality rate was assessed during stages of its development until the emergence of adults.

In the same way, the experiment was repeated using the second and the third instars of *C. carnea* and both duration and mortality were recorded in all treatments during predator development. Statistically analyzed of data were done using Co Stat Computer Software, according to CoHort [23].

RESULTS AND DISCUSSION

Efficiency of Essential Lemon Oil and Closer on *M. persicae*: Data presented in Table (1) showed that both lemon oil and closer were highly effective in managing *M. persicae* with LC_{50} and LC_{90} where LC_{50} was 65.05 and 0.714 ppm for lemon oil and closer, respectively while LC_{90} was 507.92 ppm for lemon oil and 30.316 ppm for closer (Figure 1). After o ne day, mortality rates of *M. persicae* were 30%, 40%, 42.5% and 50% at 250, 500, 750 and 1000 ppm, respectively by lemon oil. Whereas, it recorded 68.75 %, 71.25%, 82.5% and 86.25% at 26.25, 52.5, 105 and 210 ppm, respectively by closer. Sulfoxaflor is a systemic insecticide, acts as a neurotoxin to affected insects and kills through contact or ingestion. It is extremely effective against many sap-feeding insects, including, aphids in all major vegetables and crops[24]. Barrania *et al.* [25] reported that sulfoxaflor exhibited fast action activity against *A. gossypii*. In addition, Convertini *et al.*[26]reported the successfully used of sulfoxaflor against *A. gossypii* on horticultural crops. Five days post treatment, corrected total mortality of *M. persicae* ranged from 80% to 96.25% for 250 and 1000 ppm of lemon oil, respectively. While in closer, it ranged between 88.75% for 26.25 ppm to 97.5% for 210 ppm then reached to 100% in both of them. Tang *et al.* [27] showed that sulfoxaflor possessed high toxicity against *M. persicae*, with an LC_{50} of 0.059 mg/liter through Leaf-dip bioassays. However, although lemon essential oil was natural material, it was highly toxic also to *M. persicae* [28]. This findings were in agreement with Al-Antary *et al.* [17] who proved that lemon oil was very effective in controlling the green peach aphid, *M. persicae* when using four solvents acetone, ethanol, n-hexane and chloroform where Al-Antary *et al*. [29] noted that essential oil has a great ability to penetrate through the cuticle of aphids and they have also been shown to act as a contact neurotoxin against several insects including the green peach aphid, by damaging their olfactory senses [30, 31]. Prates *et al.* [32] showed that essential oils reveal contact toxicity through the insect cuticle. Coats *et al.* [33] discussed the toxicity and neurotoxic effects of monoterpenoids (including d-limonene) and Ibrahim *et al.* [34] reviewed the suitability of limonene for control of insect pests wherefore several reports suggest using limonene for its control.

Indirect Impacts of Essential Lemon Oil and Closer on *C. carnea*: Tables (2, 3 and 4) showed the effectiveness of different concentrations of lemon oil and closer on *C. carnea* after feeding its 1st, 2nd and 3rd instars on treated *M. persicae* under laboratory conditions. Results indicated that after 48 h, the highest mortality rate of the 1st instar larvae of *C. carnea* was 20% (0.2±0.13) after feeding it on *M. persicae* treated by concentrations 500 and 1000 ppm of lemon oil while it was 50% (0.5±0.16), 80% (0.8±0.13) and 90% (0.9±0.1), respectively after its feeding on aphids treated by 52.5, 105 and 210 ppm of closer. In the d ays following the past of the first 48 h, the loss rate in the larval stage ranged from 30% to 60% at the use of 250 and 1000 ppm of lemon oil, respectively. Where, although lemon oil had less effect on the predator in comparison with closer, higher concentrations of both them caused higher loss. At the use of the lowest concentration of oil, 50% of the larvae were able to complete their development and reached successfully to the adult. Nasreen *et al.* [35] revealed that higher concentrations of some examined insecticides through leaf dip bioassay method was proved to have detrimental effects against neonate of *C. carnea* as compared to lower concentration, beside those including imidacloprid which found to be harmful to the predator at all concentrations after exposure for 24 and 48 h under laboratory conditions. First instar larvae of *Episyrphus balteatus* DeGeer proved to be highly susceptible, when feeding 24 h on aphids sprayed with neem kernel water extract [36].Mortality rate differed significantly at the treatments used with its different concentrations after 48h and from the 1st instar larvae to adults as well as durations during its different developmental stages (Tables 2 and 5).

When the 2nd instar larvae of *C. carnea* was fed on treated *M. persicae* by closer, the mortality rate 40% (0.4 ± 0.16), 60% (0.6 ± 0.16) and 80% (0.8 ± 0.13) were achieved by the use of 52.5, 105 and 210 ppm respectively, 48h post treated. 70%, 60% and 40% of larvae were able to reach to the adult at 250, 500 and 1000 ppm respectively, when using oil which seemed to be less impact on the predator in compared to closer. Gatineau *et al.* [37], observed that synthetic and bio pesticides effect on mortality and biology of *C. carnea*. It was also observed that 2nd instar larvae of the predator were more tolerant than its 1st instar and this is in agreement with Ahmad *et al.* [36] who reported that 2nd instar larvae of

Table 1: Efficiency of essential lemon oil and closer against *M. persicae* under laboratory conditions

Treatments	Conc. (ppm.)	Mortality rate after one day %	Corrected total mortality after five days %	LC_{50}	LC_{90}	Slope± S.D.	Toxicity index LC_{50}
Lemon oil	250	30	80	65.05	507.92	1.44± 0.36	1.1
	500	40	90				
	750	42.5	93.75				
	1000	50	96.25				
Closer	26.25	68.75	88.75	0.714	30.316	0.787± 0.313	100
	52.5	71.25	93.75				
	105	82.5	95				
	210	86.25	97.5				

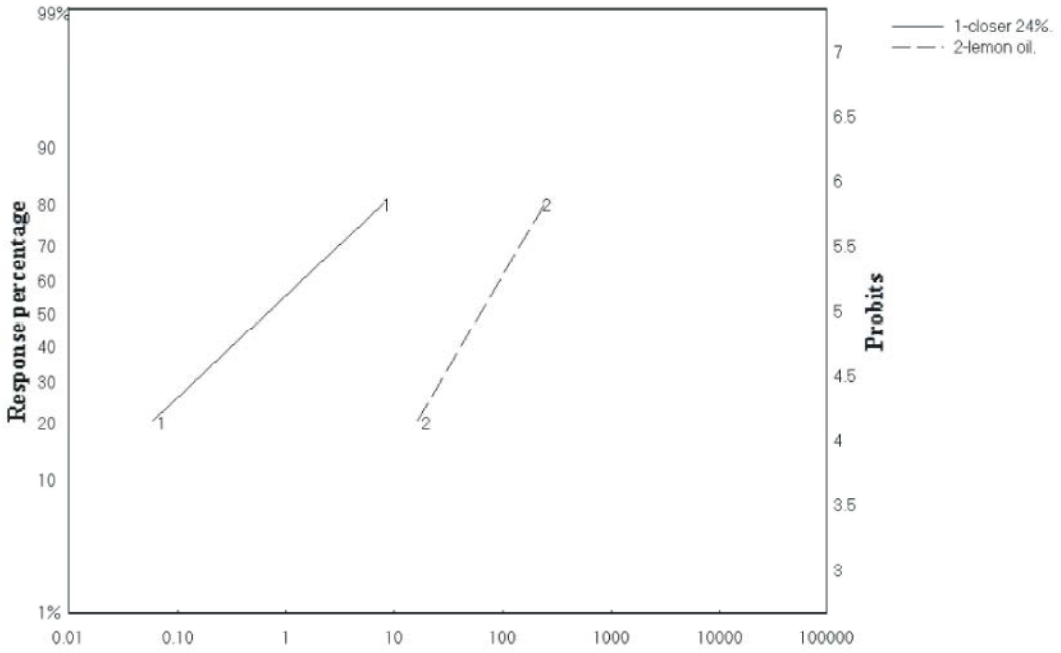


Fig. 1: LC-P line for lemon oil and closer 24% against *M. persicae*

Coccinella septempunctata L. were less susceptible when feeding on neem-sprayed aphids than 1st instars which showed a very high mortality when feeding on aphids sprayed with different neem preparations. After the first 48 h, no significant difference was found on mortality rate at the use of 250 ppm of the oil with the untreated and also on the duration of the 2nd instar larvae of the predator for the same concentration, while there was a highly significant difference in the rate of mortality at the other treatments used with its different concentrations after 48 h and, from the 2nd instar larvae to adults as well as durations during its different developmental stages between each of them and also the untreated (Tables 3 and 6).

Despite the failure of 10% (0.1±0.1) of the 3rd instars larvae of the predator to pupate after fed on treated aphids by lemon oil at 500 ppm and 20% (0.2 ± 0.13) at 1000 ppm, but 100%, 80% and 60% of larvae were able to completed its development and adult emergence when 250, 500 and 1000 ppm used, respectively. In the case of closer also, larvae succeeded to pupate and reached to adult stage for 60% (0.6 ± 0.16) by the use of 52.5 ppm and 40% (0.4 ± 0.16) by the use of 105 ppm. Nasreen *et al.*[35]observed that once *C. carnea* larvae tolerated the insecticide exposure, they could pupate and adults emerge successfully. Barrania *et al.*[25]conducted field experiments on cucumber to studied the efficiency of some insecticides including sulfoxaflor, they mentioned its slightly toxic on *C. carnea*, with the consideration of difference in effects between the field and the laboratory which are frequently more [38-39]. No significant difference was found on the mortality rate of the 3rd instars larvae of the predator after the first 48h at the three concentrations used of the oil with the untreated but it differed significantly at the three concentrations used of closer, also highly significant difference was found in the

Table 2: Efficacy of different concentrations of essential lemon oil and closer on the development of *C. carnea* after feeding its 1st instar larvae on treated *M. persicae* under laboratory conditions

		Rates and Means mortality ± SEM					
		After 48 h				Until the rest of the test	
Treatments		1st	1st	2nd	3rd	P.	A.
Lemon oil	250ppm	0.1± 0.1 d (10%)	0.2±0.13 ab (20%)	0.1±0.1 a (10%)	0 a (0%)	0.1±0.1 a (10%)	0 (0%)
	500ppm	0.2±0.13 cd (20%)	0.3±0.15 ab (30%)	0.1±0.1 a (10%)	0.1±0.1 a (10%)	0 a (0%)	0 (0%)
	1000ppm	0.2±0.13 cd (20%)	0.4±0.16 a (40%)	0.2±0.13 a (20%)	0 a (0%)	0 a (0%)	0 (0%)
Closer	52.5ppm	0.5±0.16 bc (50%)	0.2±0.13 ab (20%)	0.1±0.1 a (10%)	0.1±0.1 a (10%)	0 a (0%)	0 (0%)
	105ppm	0.8±0.13 ab (80%)	0.2±0.13 ab (20%)	0 a (0%)	0 a (0%)	0 a (0%)	0 (0%)
	210ppm	0.9±0.1 a (90%)	0.1±0.1 ab (10%)	0 a (0%)	0 a (0%)	0 a (0%)	0 (0%)
Untreated		0 d (0%)	0 b (0%)	0 a (0%)	0 a (0%)	0 a (0%)	0 (0%)
LSD		0.339	0.359	0.233	0.151	0.106	--
F		8.637	1.029	0.837	0.833	1.0	--
P		***	ns	ns	ns	ns	--
		Rates and Means survival ± SEM					
		After 48 h				Until the rest of the test	
Treatments		1st	1st	2nd	3rd	P.	A.
Lemon oil	250ppm	0.9±0.1 a (90%)	0.7±0.15 ab (70%)	0.6±0.16 b (60%)	0.6±0.16 b (60%)	0.5±0.16 b (50%)	0.5±0.16 b (50%)
	500ppm	0.8±0.13 ab (80%)	0.5±0.16 bc (50%)	0.4±0.16 bc (40%)	0.3±0.15 c (30%)	0.3±0.15 c (30%)	0.3±0.15 bc (30%)
	1000ppm	0.8±0.13 ab (80%)	0.4±0.16 bc (40%)	0.2±0.13 cd (20%)	0.2±0.13 cd (20%)	0.2±0.13 bc (20%)	0.2±0.13 c (20%)
Closer	52.5ppm	0.5±0.16 bc (50%)	0.3±0.15 cd (30%)	0.3±0.15 cd (30%)	0.1±0.1 cd (10%)	0.1±0.1 c (10%)	0.1±0.1 c (10%)
	105ppm	0.2±0.13 cd (20%)	0 d (0%)	0 d (0%)	0 d (0%)	0 c (0%)	0 c (0%)
	210ppm	0.1±0.1 d (10%)	0 d (0%)	0 d (0%)	0 d (0%)	0 c (0%)	0 c (0%)
Untreated		1 a (100%)	1 a (100%)	1 a (100%)	1 a (100%)	1 a (100%)	1 a (100%)
LSD		0.339	0.339	0.328	0.297	0.300	0.300
F		8.637	9.098	9.352	12.128	11.239	11.239
P		***	***	***	***	***	***
		Rates and Means failed individuals ± SEM					
Treatments		1st	2nd	3rd	The larval stage	P.	From the 1st instar to adult
Lemon oil	250ppm	0.3±0.15 cd (30%)	0.1±0.1 a (10%)	0 a (0%)	0.4±0.16 b (40%)	0.1±0.1 a (10%)	0.5±0.16 b (50%)
	500ppm	0.5±0.16 bc (50%)	0.1±0.1 a (10%)	0.1±0.1 a (10%)	0.7±0.15 a (70%)	0 a (0%)	0.7±0.15 ab (70%)
	1000ppm	0.6±0.16 bc (60%)	0.2±0.13 a (20%)	0 a (0%)	0.8±0.13 a (80%)	0 a (0%)	0.8±0.13 ab (80%)
Closer	52.5ppm	0.7±0.15 ab (70%)	0.1±0.1 a (10%)	0.1±0.1 a (10%)	0.9±0.1 a (90%)	0 a (0%)	0.9±0.1 a (90%)
	105ppm	1 a (100%)	0 a (0%)	0 a (0%)	0 c (0%)	0 a (0%)	1 a (100%)
	210ppm	1 a (100%)	0 a (0%)	0 a (0%)	0 c (0%)	0 a (0%)	1 a (100%)
Untreated		0 d (0%)	0 a (0%)	0 a (0%)	0 c (0%)	0 a (0%)	0 c (0%)
LSD		0.339	0.233	0.151	0.297	0.106	0.300
F		9.098	0.837	0.833	14.7	1.0	11.239
P		***	ns	ns	***	ns	***

[a]Means followed by the same letter in a column are not significantly different at LSD 5%

Table 3: Efficacy of different concentrations of essential lemon oil and closer on the development of *C. carnea* after feeding its 2nd instar larvae on treated *M. persicae* under laboratory conditions

		Rates and Means mortality ± SEM				
		After 48 h			Until the rest of the test	
Treatments		2nd	2nd	3rd	P.	A.
Lemon oil	250ppm	0 d (0%)	0.1±0.1 a (10%)	0.1±0.1 a (10%)	0.1±0.1 a (10%)	0 (0%)
	500ppm	0.1±0.1 cd (10%)	0.1±0.1 a (10%)	0.2±0.13 a (20%)	0 a (0%)	0 (0%)
	1000ppm	0.2±0.13 cd (20%)	0.3±0.15 a (30%)	0.1±0.1 a (10%)	0 a (0%)	0 (0%)
Closer	52.5ppm	0.4±0.16 bc (40%)	0.2±0.13 a (20%)	0.1±0.1 a (10%)	0 a (0%)	0 (0%)
	105ppm	0.6±0.16 ab (60%)	0.2±0.13 a (20%)	0.1±0.1 a (10%)	0 a (0%)	0 (0%)
	210ppm	0.8±0.13 a (80%)	0.2±0.13 a (20%)	0 a (0%)	0 a (0%)	0 (0%)
Untreated		0 d (0%)	0 a (0%)	0 a (0%)	0 a (0%)	0 (0%)
LSD		0.335	0.332	0.256	0.106	--
F		6.842	0.689	0.576	1	--
P		***	ns	ns	ns	--
		Rates and Means survival ± SEM				
		After 48 h			Until the rest of the test	
Treatments		2nd	2nd	3rd	P.	A.
Lemon oil	250ppm	1 a (100%)	0.9±0.1 a (90%)	0.8±0.13 ab (80%)	0.7±0.15 ab (70%)	0.7±0.15 ab (70%)
	500ppm	0.9±0.1 ab (90%)	0.8±0.13 ab (80%)	0.6±0.16 bc (60%)	0.6±0.16 bc (60%)	0.6±0.16 bc (60%)
	1000ppm	0.8±0.13 ab (80%)	0.5±0.16 bc (50%)	0.4±0.16 cd (40%)	0.4±0.16 bcd (40%)	0.4±0.16 bcd (40%)
Closer	52.5ppm	0.6±0.16 bc (60%)	0.4±0.16 c (40%)	0.3±0.15 cd (30%)	0.3±0.15 cde (30%)	0.3±0.15 cde (30%)
	105ppm	0.4±0.16 cd (40%)	0.2±0.13 cd (20%)	0.1±0.1 de (10%)	0.1±0.1 de (10%)	0.1±0.1 de (10%)
	210ppm	0.2±0.13 d (20%)	0 d (0%)	0 e (0%)	0 e (0%)	0 e (0%)
Untreated		1 a (100%)	1 a (100%)	1 a (100%)	1 a (100%)	1 a (100%)
LSD		0.335	0.337	0.345	0.354	0.354
F		6.842	9.766	8.904	7.818	7.818
P		***	***	***	***	***
Treatments		Rates and Means failed individuals ± SEM				
		2nd	3rd	2nd +3rd	P.	From the 2nd instar to adult
Lemon oil	250ppm	0.1±0.1 d (10%)	0.1±0.1 a (10%)	0.2±0.13 cd (20%)	0.1±0.1 a (10%)	0.3±0.15 de (30%)
	500ppm	0.2±0.13 cd (20%)	0.2±0.13 a (20%)	0.4±0.16 bc (40%)	0 a (0%)	0.4±0.16 cd (40%)
	1000ppm	0.5±0.16 bc (50%)	0.1±0.1 a (10%)	0.6±0.16 ab (60%)	0 a (0%)	0.6±0.16 bcd (60%)
Closer	52.5ppm	0.6±0.16 b (60%)	0.1±0.1 a (10%)	0.7±0.15 ab (70%)	0 a (0%)	0.7±0.15 abc (70%)
	105ppm	0.8±0.13 ab (80%)	0.1±0.1 a (10%)	0.9±0.1 a (90%)	0 a (0%)	0.9±0.1 ab (90%)
	210ppm	1a (100%)	0 a (0%)	0 d (0%)	0 a (0%)	1 a (100%)
Untreated		0 d (0%)	0 a (0%)	0 d (0%)	0 a (0%)	0 e (0%)
LSD		0.337	0.256	0.345	0.106	0.354
F		9.766	0.576	8.265	1	7.818
P		***	ns	***	ns	***

[a]Means followed by the same letter in a column are not significantly different at LSD 5%

Table 4. Efficacy of different concentrations of essential lemon oil and closer on the development of *C. carnea* after feeding its 3rd instar larvae on treated *M. persicae* under laboratory conditions

		Rates and Means mortality ± SEM			
		After 48 h		Until the rest of the test	
Treatments		3rd	3rd	P.	A.
Lemon oil	250ppm	0 c (0%)	0 b (0%)	0 a (0%)	0 (0%)
	500ppm	0 c (0%)	0.1±0.1 ab (10%)	0.1±0.1 a (10%)	0 (0%)
	1000ppm	0.1±0.1 c (10%)	0.2±0.13 ab (20%)	0.1±0.1 a (10%)	0 (0%)
Closer	52.5ppm	0.2±0.1 bc (20%)	0.1±0.1 ab (10%)	0.1±0.1 a (10%)	0 (0%)
	105ppm	0.5±0.16 ab (50%)	0.1±0.1 ab (10%)	0 a (0%)	0 (0%)
	210ppm	0.7±0.15 a (70%)	0.3±0.15 a (30%)	0 a (0%)	0 (0%)
Untreated		0 c (0%)	0 b (0%)	0 a (0%)	0 (0%)
LSD		0.300	0.284	0.185	--
F		6.929	1.125	0.666	--
P		***	***	ns	--
		Rates and Means survival ± SEM			
		After 48 h	Until the rest of the test		
Treatments		3rd	3rd	P.	A.
Lemon oil	250ppm	1 a (100%)	1 a (100%)	1 a (100%)	1 a (100%)
	500ppm	1 a (100%)	0.9±0.1 a (90%)	0.8±0.13 ab (80%)	0.8±0.13 ab (80%)
	1000ppm	0.9±0.1 a (90%)	0.7±0.15 ab (70%)	0.6±0.16 bc (60%)	0.6±0.16 bc (60%)
Closer	52.5ppm	0.8±0.13 ab (80%)	0.7±0.15 ab (70%)	0.6±0.16 bc (60%)	0.6±0.16 bc (60%)
	105ppm	0.5±0.16 bc (50%)	0.4±0.16 b (40%)	0.4±0.16 c (40%)	0.4±0.16 c (40%)
	210ppm	0.3±0.15 c (30%)	0 c (0%)	0 d (0%)	0 d (0%)
Untreated		1 a (100%)	1 a (100%)	1 a (100%)	1 a (100%)
LSD		0.300	0.308	0.334	0.334
F		6.929	11.12	9.0	9.0
P		***	***	***	***
		Rates and Means failed individuals ± SEM			
Treatments		3rd	P.	From the 3rd instar to adult	
Lemon oil	250ppm	0 c (0%)	0 a (0%)	0 d (0%)	
	500ppm	0.1±0.1 c (10%)	0.1±0.1 a (10%)	0.2±0.13 cd (20%)	
	1000ppm	0.3±0.15 bc (30%)	0.1±0.1 a (10%)	0.4±0.16 bc (40%)	
Closer	52.5ppm	0.3±0.15 bc (30%)	0.1±0.1 a (10%)	0.4±0.16 bc (40%)	
	105ppm	0.6±0.16 b (60%)	0 a (0%)	0.6±0.16 b (60%)	
	210ppm	1 a (100%)	0 a (0%)	1 a (100%)	
Untreated		0 c (0%)	0 a (0%)	0 d (0%)	
LSD		0.308	0.185	0.334	
F		11.12	0.676	9.00	
P		***	ns	***	

[a] Means followed by the same letter in a column are not significantly different at LSD 5%

Table 5: Mean durations of *C. carnea* during their development after feeding its 1st instar larvae on *M. persicae* treated with different concentrations of essential lemon oil and closer under laboratory conditions

		Mean durations of the developmental stage in (days) ± SEM					
Treatments		The 1st instar	The 2nd instar	The 3rd instar	The larval stage	The pupal stage	From the 1st instar to adult
Lemon oil	250ppm	1.6 ±0.37 ab	1.9 ± 0.53 b	4.6 ± 1.26 b	7.9 ± 2.16 b	3.7 ± 1.24 b	10.3 ± 3.44 b
	500ppm	1.1 ±0.38 bc	1.3 ± 0.54 bc	2.2 ± 1.12 c	3.8 ± 1.73 c	2.1 ± 1.07 bc	5.9 ± 2.67 c
	1000ppm	0.8 ±0.33 c	0.6 ± 0.4 cd	1.5 ± 1.002 c	2.5 ± 1.67 c	1.4 ± 0.93 c	3.9 ± 2.6 c
Closer	52.5ppm	0.5 ±0.27 cd	0.6 ± 0.4 cd	0.9 ± 0.9 c	1.4 ± 1.4 c	0.7 ± 0.7 c	2.1 ± 2.1 c
	105ppm	0 d	0 d	0 c	0 c	0 c	0 c
	210ppm	0 d	0 d	0 c	0 c	0 c	0 c
Untreated		2.2 ± 0.13 a	3.2 ± 0.13 a	8.4 ± 0.2 a	13.8 ± 0.2 a	7.3 ± 0.2 a	21.1 ± 0.2 a
LSD		0.738	1.015	2.317	3.767	2.158	5.884
F		9.788	10.330	13.718	14.460	11.663	13.239
P		***	***	***	***	***	***

[a] Means followed by the same letter in a column of different treatments are not significantly different at LSD 5%

Table 6: Mean durations of *C. carnea* during their development after feeding its 2nd instar larvae on *M. persicae* treated with different concentrations of essential lemon oil and closer under laboratory conditions

		Mean durationsof the developmental stage in (days) ± SEM				
Treatments		The 2nd instar	The 3rd instar	The 2nd + 3rd instars	The pupal stage	From the 2nd instar to adult
Lemon oil	250ppm	2.7 ±0.33 a	6.3 ± 1.08 ab	8.8 ± 1.48 ab	5.3 ± 1.17 ab	13.1 ± 2.87 ab
	500ppm	2.4 ±0.43 ab	4.6 ± 1.26 bc	6.5 ± 1.77 bc	4.4 ± 1.2 bc	10.9 ± 2.97 bc
	1000ppm	1.4 ±0.48 bc	3.1 ± 1.27 cd	4.3 ± 1.76 cd	2.9 ± 1.19 bcd	7.2 ± 2.93 bcd
Closer	52.5ppm	1.1 ±0.46 c	2.3 ± 1.17 cde	3.2 ± 1.63 cde	2.2 ± 1.12 cde	5.4 ± 2.75 cde
	105ppm	0.6 ±0.4 cd	0.8 ± 0.8 de	1.1 ± 1.1 de	0.7 ± 0.7 de	1.8 ± 1.8 de
	210ppm	0 d	0 e	0 e	0 e	0 e
Untreated		3.1 ±0.1a	8 ± 0.21 a	11.1 ± 0.18 a	7.7 ± 0.21 a	18.8 ± 0.25 a
LSD		1.013	2.704	3.750	2.624	6.455
F		10.290	9.167	9.258	8.425	8.327
P		***	***	***	***	***

[a] Means followed by the same letter in a column of different treatments are not significantly different at LSD 5%

Table 7: Mean durations of *C. carnea* during their development after feeding its 3rd instar larvae on *M. persicae* treated with different concentrations of essential lemon oil and closer under laboratory conditions

		Mean durations of the developmental stage in (days) ± SEM		
Treatments		The 3rd instar	The pupal stage	From the 3rd instar to adult
Lemon oil	250ppm	7.8 ± 0.13 a	7.4 ± 0.2 a	15.2 ± 0.13 a
	500ppm	6.6 ± 0.76 ab	6.1 ± 1.04 ab	12.1 ± 2.02 ab
	1000ppm	4.8 ± 1.07 bc	4.5 ± 1.23 bc	8.8 ± 2.4 bc
Closer	52.5ppm	5.2 ± 1.14 b	4.7 ± 1.29 bc	9.2 ± 2.51 bc
	105ppm	2.9 ± 1.19 c	3.2 ± 1.31 c	6.1 ± 2.5 c
	210ppm	0 d	0 d	0 d
Untreated		8.2 ± 0.25 a	7.6 ± 0.2 a	15.8 ± 0.25 a
LSD		2.273	2.635	5.005
F		12.901	8.046	9.439
P		***	***	***

[a] Means followed by the same letter in a column of different treatments are not significantly different at LSD 5%

duration of its developmental stages at the both treatments used with its different concentrations with the untreated except the oil at the used of 250 ppm where no significant differences were found (Tables 4 and 7).

CONCLUSION

In conclusion, the previous findings clearly indicated diversity in the mortality rates among different concentrations where, although closer was more impact than lemon oil on *C. carnea* larvae which was fed on treated aphids, it was noticed that the high concentrations of the oil were most impact on the predator compared with the low concentrations, particularly in the youth instars of larvae predator which appeared more sensitive than the older one when fed on treated aphids, where the 1st instar larvae of the predator proved to be very susceptible than its 3rd instars which showed to be most tolerance. Consequently, it seems that degree of susceptibility differ by the several larval stage of the predator. As for *M. persicae*, findings showed that both lemon oil and closer achieved satisfied results in its managed.

Finally, lemon oil seemed to be less sharp on *C. carena* compared with closer which appeared not safe enough towards the predator. The use of sulfoxaflor in IPM strategies should be considered when either of biological control agents is released, because of the toxic behavior observed under laboratory conditions; moreover it is toxic to impollinator insects [40]. Particularly, since their presence in the field is dependent upon the lack of disruption due to different insecticides [41]. But in general it still not assured that oil extracts are completely harmless to predators, where Khan *et al.* [42] observed relatively high mortality of second instar larvae of *C. carnea* which reached to 100% by the use of high concentration (1.0%) from neem oil compared to low concentrations used. Therefore, based on the current results the different

impacts among concentrations used on the various instars of the predator larvae must be concerned before recommend it for IPM program. Nevertheless, it must be mentioned also that the impacts obtained in laboratory are often more severe than in the field which may be less in view of many different considerations [38-39]. So, the side effects on predators still needs to more future experimentation and investigation, for more review about the possibility harmony between using of plant oils and releasing of *C. carnea* against the target insect.

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