

TOXICITY AND REPELLENCY EFFECTS OF FIVE ESSENTIAL OILS AGAINST *TETRANYCHUS URTICAE* KOCH, AND THE PREDATORY MITE *AGISTEMUS EXSERTUS* GONZALEZ (ACARI: TETRANYCHIDAE, STIGMAEIDAE)

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ABSTRACT: *The present study was carried out to conduct a laboratory test of toxicity, and repellency or attractancy effects of five essential oils (garlic, thyme, menthol, jojoba and camphor) against Tetranychus urticae and Agistemus exsertus. Results indicated that garlic oil gave the highest percentages of mortality when used at 2% concentration (81.43%) as mean mortality after 7 days of spray on the two spotted spider mite, T. urticae followed by camphor, recorded 27.14, 42.86 and 65.00% mean mortality at 0.5, 1.0 and 2.0% concentrations, while jojoba oil recorded only 32.14% mean mortality ranged from 6.43 to 79.29% when concentrations from 0.5 to 10% used. The lowest effect was obtained when menthol oil was used, only 14.29% mean mortality obtained at 2.0% concentration while the highest mortality obtained at 10.0% concentration (77.86% after 7 days). As for the predatory mite, A. exsertus, data cleared that both garlic and camphor have high toxic effect when 5.0% and 10.0% concentrations used, recorded 66.43, 79.29% for garlic and 62.14, 77.14% for camphor. While thyme gave the lowest effect followed by jojoba with 10.0% concentration. The most safety oil on the predatory mite was menthol, without any effect at 0.5, 1.0, 2.0% concentration. Also, the study showed that menthol and camphor have high repellency effect after one and six hours, but the thyme oil have the lowest repellency effect where recorded the second class of repellency (21:40%) after one hour for T. urticae. The obtained results also indicated that the camphor oil have the highest repellency oil, 2.0% concentration for the predator mite A. exsertus. It could be concluded that both garlic and camphor are sufficient oils to control of T. urticae at 10.0% concentration and more toxic on A. exsertus, Also menthol have high repellency effect and good toxicity effect on T. urticae with safe use on A. exsertus also thyme have sufficient toxicity effect on T. urticae.*

Key words: *Toxicity, repellency, Essential oils, Tetranychus urticae, Agistemus exsertus.*

INTRODUCTION

Among the different species of mites of the family Tetranychidae, the two-spotted spider mite (*Tetranychus urticae*) is considered the most important. This cosmopolitan pest feeds on several plant species, including fruits, vegetables and ornamental plants worldwide (Johnson and Lyon, 1991). About 1,200 plant species of which more than 150 are economically important have been reported as the mite's host (Zhang *et al.*,

2003; Jeppson *et al.*, 1975). The main form of control for *T. urticae* is the use of synthetic pesticides, together with biological control involving the predatory mite *Agistemus exsertus* Gonzalez, which is a natural predator of *T. urticae* found on different crops worldwide. Predacious mites in the family Stigmaeidae are important natural enemies of several phytophagous mite pests on various crops (Hoyt, 1969; Gomaa, 1975; Santos, 1976). *A. exsertus*

was reported as the most abundant stigmatid species (85%) in a number of Egyptian cropping systems (Zaher, *et al.* 1971; Solimon, *et al.* 1976). This stigmatid mite has been reported as an egg predator of tetranychid mites (*T. urticae*) (EL-Badry, *et al.* 1969; Oomen 1982; Hafez *et al.* 1983; EL-Bagoury *et al.* 1989; Yue and Childers, 1994). However, the continual use of conventional acaricides has caused serious damage due to environmental contamination as well as the elimination of predacious mites and various pollinating insects, so to reduce these negative effects, alternative methods for the control of *T. urticae* are being tested, including the use of essential oils (Motazedian *et al.*, 2012). Essential oils are promising agents for the control of agricultural pests, as these substances act on the nervous system of the target insect, causing physiological and behavioral responses (Mossi *et al.*, 2013). Essential oils extracted from aromatic plants have been widely investigated because they are deemed as potentially becoming the alternative to replace synthetic pesticides and because of also being more convenient to use. Generally, essential oils are mostly non toxic to mammals, birds and fish (Isman, 2006). On the other hand, they act as broad spectrum pesticides, that may affect pests, their natural enemies and pollinators due to their several modes of action including repellency and antifeedant activity,

disruption of molting and cuticle, as well as retardation of growth and fecundity (Cosimi *et al.*, 2009; Sertkaya *et al.*, 2010).

The aim of the present study was to conduct a laboratory test of toxicity, repellency and attractancy effects of five essential oils (Garlic, Thyme, Menthol, Jojoba and Camphor) against *T. urticae* and *A. exsertus*.

MATERIALS AND METHODS

1. Mite sources:

1.1 *Tetranychus urticae* Koch:

Stock colony of *Tetranychus urticae* was originated from infested leaves of castor plants, *Ricinus communis*. The colony had been reared on bean plants, *Phaseolus vulgaris* cultivated in pots at 22±2°C, and 60 ± 5 RH % under natural daylight in the experimental greenhouse.

1.2 *Agistemus exsertus* Gonzalez:

The predatory stigmatid mite, *Agistemus exsertus* adult females were collected from leaves of broad bean plants, *Vicia faba* cultivated in acarology greenhouse, Faculty of Agriculture, Menoufia University.

2. Essential oils used:

Three aqueous concentrations (0.5, 1.0, 2.5 and 10 %), of each oil: Garlic, Thyme, Menthol, Jojoba and Camphor were conducted with four replicates for each. Tested materials were sprayed by a glass atomizer.

Table (1): English name, scientific name, Family name and Arabic name of five essential oils used.

English name	Scientific name	Family name	Arabic name
Garlic	<i>Allium sativum</i>	Alliaceae	الثوم
Thyme	<i>Thymus vulgaris</i>	Lamiaceae	الزعتر
Menthol	<i>Mentha piperita</i>	Lamiaceae	النعناع البلدى
Jojoba	<i>Simmondsia Chinensis</i>	Simmondsiaceae	الجوجوبا
Camphor	<i>Eucalyptus globulus</i>	Myrtaceae	الكافور

3. Toxicity effect of five oils against *Tetranychus urticae* and *Agistemus exsertus*:

Five essential oils of Garlic, Thyme, Menthol, Jojoba and Camphor were used at concentrations of 0.5, 1.0, 2.0, 5.0 and 10.0% for each oil treatment. Four leaf discs (2cm diameter) of fresh leaves of broad bean plants, *Vicia faba* were placed upside down on wet cotton pad in Petri dish (9 cm in diameter) which represents as four replicates for each concentration of tested oil. Ten adult females of *T. urticae* were transferred to each leaf disc before spraying essential oil solution. Tested oils were sprayed by a glass atomizer. The treated adult females were kept under laboratory conditions (25±2°C and 60±5% R.H.).

The same mentioned technique was used with the predatory mite *Agistemus exsertus*. Ten movable stages of *A. exsertus* were transferred to each disc, individuals of *T. urticae* were added as prey. Predatory mite was maintained under laboratory conditions (25 ± 2°C and 60 ± 5% R.H.). Mortality percentages were calculated for *T. urticae* and *A. exsertus* after 24 hrs of spraying for a week and estimated by Abbot's formula (1925).

4. Repellent and attractant activity experiments:

The repellency and attractancy tests were made according to the method described by Kogan & Goeden (1970). Leaf disks of green bean plants of 4.0 cm diameter were used to evaluate the repellent activity of the essential oils. Half of the disk was sprayed with essential oil of three concentrations 0.5, 1.0 and 2.0 %. After drying, the other half of the disk was sprayed with water, which served as control. Four leaf discs of fresh leaves of green bean were placed upside down on wet cotton pad in a Petri dish 9 cm diameter. Five adult females of mites were put on each disk, each treatment

was repeated four times. The repellent activity evaluation was made after 1 and 6 hrs, where mites present on each half of the leaf disk were counted. Mites found in the neutral area were considered as repellent or attracted, based on their proximity to the blank or to the treatment. The Repellent Index (RI) of the oils was calculated according to the equation:

$R_p = (C-T / C+T) \times 100$ proposed by Pascual – Villalobos and Robledo (1998), Where C = number of mites on control half, T= number of mites on treated half. RI varying from -100 (Total attractancy) to +100 total repellency), with 0 meaning no effect.

RESULTS AND DISCUSSION

1. The toxicity effect of essential oils:

Toxicity effect of five essential oils were experiments against both the phytophagous mite, *Tetranychus urticae* and the predatory mite, *Agistemus exsertus* under laboratory conditions.

1.1. Effect on *Tetranychus urticae*:

Data in Table 2 cleared that garlic oil gave the highest percentages of mortality when used at 2% concentration (81.43%) as mean mortality where 0.5 and 1% concentrations recorded 55.71 and 62.14% as mean mortality.

After 7 days of spray both 5 and 10% concentrations recorded 91.42 and 94.29% respectively, followed by camphor, recorded 27.14, 42.86 and 65.00% mean mortality at 0.5, 1.0 and 2.0% concentrations while the highest concentrations 5, 10% recorded 80.0, 82.86% only, as for jojoba oil, it recorded only 32.14% mean mortality ranged from 6.43 to 79.29% when concentrations from 0.5 to 10% used. The same results obtained when thyme used, it recorded 29.29% mean mortality at 2.0% concentration, while 0.5, 1.0, 5.0, 10.0% concentrations recorded 7.86, 13.57,

58.57 and 85.14% mean mortality. The lowest effect was obtained when menthol oil was used, only 14.29% mean mortality obtained at 2.0% concentration while the highest mortality obtained at 10.0% concentration (77.86% after 7 days).

1.2. Effect on *Agistemus exsertus*:

Data in Table 3 cleared that both garlic and camphor have high toxic effect when

5.0% and 10.0% concentration used, record 66.43, 79.29% for garlic and 62.14, 77.14% for camphor. While thyme gave 60.71% followed by jojoba (43.57%) as mean mortality with 10.0% concentration. The most safety oil on the predatory mite was menthol, without any effect at 0.5, 1.0, 2.0% concentration and only 14.29% mean mortality at 10.0% concentration.

Table 2: Toxicity effect of five essential oils on the phytophagous mite, *Tetranychus urticae*.

Oil conc.	Mortality Percentage (%M)							% Mean
	1d	2d	3d	4d	5d	6d	7d	
	Menthol							
0.5%	0	5	5	5	5	5	5	4.29
1.0%	0	5	15	15	15	15	15	11.43
2.0%	0	5	15	20	20	20	20	14.29
5.0%	5	10	25	30	35	35	35	25.71
10.0%	35	70	70	85	95	95	95	77.86
	Garlic							
0.5%	5	35	50	60	70	80	90	55.71
1.0%	5	45	60	65	70	90	100	62.14
2.0%	20	75	85	90	100	100	100	81.43
5.0%	52	85	100	100	100	100	100	91.42
10.0%	70	90	100	100	100	100	100	94.29
	Camphor							
0.5%	5	10	20	30	35	45	45	27.14
1.0%	15	30	35	45	50	60	65	42.86
2.0%	25	40	55	65	75	95	100	65.00
5.0%	55	55	65	85	100	100	100	80.00
10.0%	55	65	70	90	100	100	100	82.86
	Jojoba							
0.5%	0	0	5	10	10	10	10	6.43
1.0%	0	5	10	15	20	20	20	12.86
2.0%	15	25	35	35	35	35	35	32.14
5.0%	25	45	45	50	50	50	55	45.71
10.0%	40	65	80	85	95	95	95	79.29
	Thyme							
0.5%	0	0	5	10	10	15	15	7.86
1.0%	0	5	10	15	20	20	25	13.57
2.0%	10	25	25	30	35	40	40	29.29
5.0%	25	50	50	65	70	75	75	58.57
10.0%	45	65	85	95	95	95	95	85.14

Toxicity and repellency effects of five essential oils against

Table 3: Toxicity effect of five essential oils on the predatory mite, *Agistemus exsertus*.

Oil conc.	Mortality Percentage (%M)							% Mean
	1d	2d	3d	4d	5d	6d	7d	
	Menthol							
0.5%	0	0	0	0	0	0	0	0
1.0%	0	0	0	0	0	0	0	0
2.0%	0	0	0	0	0	0	0	0
5.0%	0	0	5	10	10	10	10	6.43
10.0%	10	10	10	10	20	20	20	14.29
	Garlic							
0.5%	0	0	5	10	15	15	15	8.57
1.0%	0	5	10	15	20	25	25	14.29
2.0%	0	15	25	25	35	40	40	25.71
5.0%	60	60	60	60	75	75	75	66.43
10.0%	70	70	75	85	85	85	85	79.29
	Camphor							
0.5%	0	5	5	5	10	10	15	7.14
1.0%	5	10	15	15	25	25	25	17.14
2.0%	10	15	25	30	35	35	40	27.14
5.0%	50	50	65	65	65	70	70	62.14
10.0%	60	60	20	70	90	95	95	77.14
	Jojoba							
0.5%	0	0	0	0	0	0	0	0
1.0%	0	0	5	5	5	5	5	3.57
2.0%	15	15	15	15	25	25	30	20.00
5.0%	20	20	20	30	30	30	30	25.71
10.0%	25	25	25	40	60	60	65	43.57
	Thyme							
0.5%	0	0	0	0	0	0	0	0
1.0%	0	0	5	5	5	5	5	3.57
2.0%	5	5	10	10	10	10	15	9.29
5.0%	25	25	30	35	45	45	45	35.71
10.0%	30	40	55	70	70	80	80	60.71

2. The repellency and attractancy effect:

Laboratory experiment was conducted to evaluate the repellency or attractancy effect of five essential oils with 0.5, 1.0, and 2.0% concentration

2.1. On *Tetranychus urticae*:

Data in Table 4 showed that menthol and camphor have high repellency effect after one and six hours, menthol gave

100% repellency at 1.0% and 2.0% concentration after one hour and 90, 100% after six hours. Also camphor recorded 100% repellency for the same concentrations after one and six hours followed by jojoba, where repellency percentage was 75% and 95% after one and six hours at 2.0% concentration, while garlic have good repellency after one hour 55, 60, 75% but it decreased to 40, 30, 20% after six hours when 0.5, 1.0

and 2.0% concentration used. Thyme have the lowest repellency effect recorded the second class of repellency (21:40%) after one hour and the first class of repellency after six hours at 1.0 and 2.0% concentrations while 0.5% gave little attractancy (-5%).

2.2. On *Agistemus exsertus*:

Data in Table 5 showed that the camphor oil gave the highest repellency oil 0.5, 2.0% concentration gave 50, 60% repellency after one and six hours followed by menthol where repellency were 30 and 25% after one and six hours for 2.0% concentration. Jojoba haven't

any effect for 0.5% concentration after one hour and attractive effect after six hours (-5%) while both 1% have first class of repellency 10.0% after one and six hours, 2.0% concentration haven't any effect after six hours. Garlic have slight repellency effect after one hour while after six hours gave slight attractive -5, -10% for 0.5 and 1.0% concentrations while 2.0% haven't repellency or attractancy effect. Thyme as general have attractancy effect from the first class for the three concentrations after six hours.

Table 4: the repellency and attractancy effect of some oils on *Tetranychus urticae*.

Plant oils	One hour				Six hours			
	T	C	RP%	Class	T	C	RP%	Class
Menthol								
0.5%	1	39	95	Vr	4	36	80	IVr
1.0%	0	40	100	Vr	2	38	90	Vr
2.0%	0	40	100	Vr	0	40	100	Vr
Garlic								
0.5%	9	31	55	IIIr	12	28	40	IIr
1.0%	8	32	60	IIIr	14	26	30	IIr
2.0%	5	35	75	IVr	16	24	20	Ir
Camphor								
0.5%	2	38	90	Vr	2	38	90	Vr
1.0%	0	40	100	Vr	0	40	100	Vr
2.0%	0	40	100	Vr	0	40	100	Vr
Jojoba								
0.5%	10	30	50	IIIr	7	33	65	IIIr
1.0%	8	32	60	IIIr	5	35	75	IVr
2.0%	5	35	75	IVr	1	39	95	Vr
Thyme								
0.5%	15	25	25	IIr	21	19	-5	Ia
1.0%	12	28	40	IIr	18	22	10	Ir
2.0%	12	28	40	IIr	18	22	10	0

Toxicity and repellency effects of five essential oils against

Table 5: the repellency and attractancy effect of some oils on *Agistemus exsertus*.

Plant oils	One hour				Six hours			
	T	C	RP%	Class	T	C	RP%	Class
	Menthol							
0.5%	16	24	20	lr	18	22	10	lr
1.0%	14	26	30	llr	15	25	15	llr
2.0%	14	26	30	llr	17	23	25	lr
	Garlic							
0.5%	15	25	25	llr	21	19	-5	la
1.0%	18	22	10	lr	22	18	-10	la
2.0%	14	26	30	llr	20	20	0	0
	Camphor							
0.5%	10	30	50	lr	8	32	60	llr
1.0%	12	28	40	llr	10	30	50	llr
2.0%	17	23	15	lllr	14	26	30	lllr
	Jojoba							
0.5%	20	20	0	0	21	19	-5	la
1.0%	18	22	10	lr	18	22	10	lr
2.0%	19	21	5	lr	20	20	0	0
	Thyme							
0.5%	21	19	-5	la	22	18	-10	la
1.0%	20	20	0	0	21	19	-5	la
2.0%	21	19	5	lr	22	18	-10	la

Discussion of results revealed that both garlic and camphor are sufficient oils to control of *Tetranychus urticae* at 10.0% concentration and camphor appear as good repellency oil with less repellency effect and toxicity on *Agistemus exsertus*. Also menthol have high repellency effect on *T. urticae* and good toxicity effect on *T. urticae* with safe use on *A. exsertus* and thyme have sufficient toxicity effect on *T. urticae*. The obtained results are in harmony with those conducted by Sertkaya, *et al.*, 2010; Abd El-Moneim, 2012; Motazedian, *et al.*, 2012; who studied the toxicity and repellency effects of three essential oils against *Tetranychus urticae*.

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التأثير السام والطارد لخمس من الزيوت الأساسية ضد كلا من أكاروس العنكبوت الأحمر والمفترس الأكاروسى *Agistemus exsertus*

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معهد بحوث وقاية النباتات - الدقى - الجيزة - مصر

الملخص العربى

اجريت دراسته بمعمل ابحاث كلية الزراعة جامعة المنوفية بهدف دراسته التأثير السام والتأثير الجاذب والطارد لخمس زيوت نباتية هي: (الثوم - الزعتر - النعناع - الجوجوبا - الكافور) ضد كلا من اكاروس العنكبوت الاحمر *Tetranychus urticae* والمفترس الاكاروسى *Agistemus exsertus*. اوضحت النتائج ان اعلى نسبة موت عند رش الثوم بتركيز ٢% على اكاروس العنكبوت الاحمر حيث أدت نسبة موت ٤٣.٨١% بعد ٧ ايام من المعاملة يليه الكافور بنسبه موت ١٤.٢٧% , ٨٦.٤٢% , ٦٥% عند تركيزات 0.5% و ١.٠% و ٢.٠% بينما أعطى زيت الجوجوبا متوسط نسبة موت ٣٢.١٤% وتراوحت نسبة الموت من ٦.٤٣% الى ٧٩.٢٩% عند تركيز ٠.٥% الى ١٠% وكان اقل الزيوت المستخدمه تأثيرا هو زيت النعناع حيث اعطى متوسط نسبة موت ١٤.٢٩% عند تركيز ٢% بينما اعطى تركيز ١٠% متوسط نسبة موت ٧٧.٨٦% بعد ٧ ايام من المعاملة. أما بالنسبة للمفترس الاكاروسى *Agistemus exsertus* اوضحت النتائج ان كلا من الثوم والكافور كان لها تأثير سام قوى عند استخدامهم بتركيز ٠.٥% و ١٠% حيث سجل زيت الثوم متوسط نسبة موت ٦٦.٤٣% , ٧٩.٢٩% بعد ٧ ايام من المعاملة فى حين سجل زيت الكافور متوسط نسبة موت ٦٢.١٤% , ٧٧.١٤% عند تركيز ٠.٥% , ١٠% بينما كان الزعتر ذو تأثير اقل يليه زيت الجوجوبا بتركيز ١٠% وكان اكثر الزيوت امانا واقلها تأثير على المفترس الاكاروسى هو زيت النعناع حيث لم يظهر اى تأثير عند استخدامه بتركيز ٠.٥% , ١% , ٢%

كما اظهرت الدرسته ان كلا من زيت النعناع والكافور كان له تأثير طارد وقوى بعد ساعه و ٦ ساعات من المعامله وكان زيت الزعتر اقل تأثير طارد حيث سجل متوسط نسبة طرد ٢١.٤% بعد ساعه من معاملته على اكاروس العنكبوت الاحمر .

كما اوضحت النتائج ان زيت الكافور كان ذو تأثير طارد قوى عند معاملة المفترس الاكاروسى بتركيز ٢% من النتائج يتضح ان كلا من زيت الثوم والكافور ذوى تأثير واضح فى مكافحه اكاروسى العنكبوت الاحمر عند تركيزات ١٠% وله تأثير سام وقوى على المفترس الاكاروسى ايضا النعناع له تأثير طارد بشدة على اكاروس العنكبوت الاحمر وتأثير سام على اكاروس العنكبوت الاحمر وكان امن الاستخدام على المفترس الاكاروسى *Agistemus exsertus* كذلك أظهر زيت الزعتر تأثير سام واضح على *Tetranychus urticae*.

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