International Journal of Agricultural Technology 2017 Vol. 13(3): 433-446
Available online http://www.ijat-aatsea.com
ISSN 1686-9141

Efficiency of *Pelargonium Graveolens* and *Gaultheria Procumbens* Essential Oils and Their Formulations on *Tetranychus Urticae* (Acari: Tetranychidae) and Two Predatory Phytoseiid Mites.

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Fatma S. A. Mohamed; Sanaa A. A. Amer; Elham. A. Sammour; Zakeya E. A. arwish; Hoda, E. Hussein and Marwa E. El-Desouky (2017). Efficiency of Pelargonium graveolens and Gaultheria procumbens essential oils and their formulations on Tetranychus urticae (Acari: Tetranychidae) and two predatory phytoseiid mites. International Journal of Agricultural Technology 13(3): 433-446.

Pelargonium graveolens L'Her and *Gaultheria procumbens* L. essential oils were extracted, identified and formulated as gerano and winticide, respectively. The acaricidal effects of tested material were investigated against the phytophagous mite, *Tetranychus urticae* Koch,the predatory mites, *Phytoseiulus persimilis* Athias- Henriot and *Typhlodromus negevi* Swirski & Amitai. *G. procumbens* oil was more toxic to *T. urticae* eggs than *P. graveolens* oil and the reverse effect was on females by contact spray; LC_{50} values of *G. procumbens* and *P. graveolens* oils were 0.09×10^4ppm &1.08×10^4ppm for eggs and 1.24×10^4ppm & 0.45×10^4ppm for females, respectively. Just *P. graveolens* oil caused mortality to *T. urticae* stages by fumigant spray and LC_{50} values were 0.48×10^4ppm & 0.55×10^4ppm for eggs and females, respectively. Gerano and winticide had strong contact toxic effect than oils on eggs and females of *T. urticae*. LC_{50} values reported to eggs by gerano and wintecide were (0.001×10^4ppm& 0.0006×10^4ppm) and for females (0.009×10^4ppm &0.017×10^4ppm), respectively. Both tested oils and their formulations were significantly repelled *T. urticae* females and decreased oviposition with the same pattern. Both phytoseiid mites less affected by material than *T. urticae. T. negevi* females were more sensitive to *P. graveolens* oil and gerano (LC_{50}:0.44×10^4ppm & 0.23×10^4ppm) than *P. persimilis* (LC_{50}: 0.77×10^4ppm &0.29×10^4ppm), respectively. The reverse effect was resulted by *G. procumbens* oil and winticide; LC_{50} values reported to *T. negevi* females were 0.42×10^4ppm &0.16×10^4 ppm while, *P. persimilis* were 0.35×10^4ppm &0.14×10^4ppm. Gerano and winticide were non-persisted and the residual effect faded by time passed.

Keywords: Essential oils, Toxicity, Repellency, Geranium, Wintergreen, *Tetranychus urticae*, Phytoseiid mites.

Introduction

Tetranychus urticae Koch (Acari: Tetranychidae) is a phytophagous mite and one of the most notorious pests worldwide, it causes a significant loss to big portion of many agricultural crops such as vegetables, fruits

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(Ismail *et al*., 2007), also it is responsible for attrition of wide range of chemical pesticides (Dekeyser, 2005), which considered the major method in pest control, and resulted in chemical persistence, *T. urticae* resistance and resurgence, also decreased the population of its natural enemies and other side effects on other surrounded ecosystem (Cohen, 2006 and Kim *et al*., 2007).

In last few decades, essential oils have been given big attention in pest control; they characterized by volatile nature and various complex components, act as repellent, toxic, antifeedant and oviposition deterrence (Bakkali, *et al*., 2008). This manifold mode of action played a significant role in plant protection from pest attack with limited or no side effects on the natural enemies and on other ecosystem and (Bale *et al*., 2008). So, essential oils could be used as safe alternatives and this Compatible with integrated pest management indigence.

In this regard, we explored here the toxic effect of Geranium, *Pelargonium graveolens* L'Her. and winter green, *Gaultheria procumbens* L. essential oils (Family: Geraniaceae & Ericaceae) against eggs and females of *T. urticae* by contact and fumigation and the side effects were examined on two predatory mites, *Phytoseiulus persimilis* Athias- Henriot and *Typhlodromus negevi* Swirski and Amitai (Acari: phytoseiidae). Also, the formulations of these essential oils were tested on all mites reported here. Identifying volatile oil components was included and Persistence of formulations was evaluated.

Materials and methods

Plant material and preparation of essential oils

The aerial parts of *P. graveolens* and *G. procumbens* plants were air dried and grinded to a coarse powder then processed by hydro-distillation apparatus (Clevenger–type) for 3-hrs to obtain the essential oil. The collected oil was dehydrated over anhydrous sodium sulfate and kept in brown tubes in the freezer till use

The obtained essential oil was analyzed by a Thermo GC ULTRA trace gas chromatography connected to ISQ Single Quadruple mass spectrometry. Ionization voltage: 70 eV in electronic ionization mode. Capillary column of TG-5MS non polar 5% Phenyl Methyl siloxane (30m x 0.25mm ID x 0.25um). The carrier gas Helium, flow rate 1mL/min. The injected sample was 1µl in split mode. oven temperature program started with 40°C (3 min), then increased to 280°C with rate of 5°C/min and finally at 280 ºC for 5 min. The components identification depended on comparison of their retention indices and mass spectra with counterparts of published data (Adams, 2001).

Preparation of P. graveolens and G. procumbens essential oil formulations

The tested oils, *P. graveolens* and *G. procumbens* were naturally prepared as emulsifiable concentrate (EC) by mixing the oil with appropriate amounts of different types of emulsifiers and natural solvent (mineral and vegetable oils) and named (Gerano and wintecide), respectively.

Source and rearing of mites

The pest mite, *T. urticae* was collected from infested leaves of castor bean, *Ricinus communis* L. (F: Euphorbiaceae) and then was reared in the laboratory for many generations on lima bean, *phaseolus vulgaries* L. (F: Fabaceae).

The exotic predatory mite *P. persimilis,* which was established in the most of Egyptian agricultural plants, and the endogenous species *T. negevi,* which has been found on tomato**,** *Solanum lycopersicum* L. and eggplant, *Solanum melongena* L. plants (F: Solanaceae) were transferred to N.R.C. laboratory and reared on culture of *T. urticae.* Races of mites were kept under 26±2 ^{o}C and 65±5% R.H.

Contact toxicity effect of P. graveolens and G. procumbens essential oils and their formulations on eggs and females of T. urticae

Eggs (0-24h age) and mated females of the same age were transferred to lima bean leaf discs (3cm in diameter) on wet cotton pads in Petri-dishes. They were sprayed directly by glass atomizer contained aqueous concentrations of tested materials, which dissolved in distilled water with a drop of Triton-X 100, in which each one had five replicates (20female/replicate, 50 egg/ replicate). A control was included utilizing water only. Mortality of females was recorded after 48h from spraying and in eggs followed till 6 day from spraying either.

Fumigant toxicity effect of P. graveolens and G. procumbens essential oils on eggs and females of T. urticae

Eggs (0-24h age) and mated females of the same age were conveyed to lima bean leaf discs (3cm in diameter) placed upside-down on wetted cotton wool in Petri-dish. Different concentrations of tested material were dissolved in acetone and were sprayed at filter paper (4cm in diameter) fixed in the inner side of Petri dish cover. The tested concentrations comprised five replicates (20female/replicate and 50 egg/ replicate). Petri dishes closed tightly by parafilm to prevent volatile oils loss. A control was

included by utilizing acetone only. Mortality of females was recorded after 48h and after 6 days in eggs by removing parafilm after 48h from treatment.

Contact toxicity effect of P. graveolens and G. procumbens essential oils and their formulations on eggs and females of P. persimilis and T. negevi females

The side effects of tested materials on predators were evaluated with the same pattern of toxicity effects on the pest mite which mentioned previously but, tangle foot was put on the edge of the leaf discs to prevent predators getting-away, fifteen female/ replicate, thirty egg/ replicate from both two predatory mites were used and eggs mortality was calculated after 72h from treatment.

Ldp line software was used to calculate probit analysis according to (Finney, 1971) and mortality percentages of eggs and females were corrected according to Schneider-Orelli's formula (Püntener, 1981).

Repellent effect of P. graveolens and G. procumbens essential oils and their formulations on T. urticae females

Symmetrical halves along the midrib of lima bean leaf discs (5cm in diameter) were placed on the lower surface in Petri dishes with moist cotton wool. One half of the disc was painted by the tested material and the other half served as a control. The tested concentrations consisted of five replicates (20 females/ replicate) and placed on the middle line of the leaf. Distribution of tested females on both halves was recorded after 2, 4, 6, 24 and 48h and the number of deposited eggs after 48h was counted.

The persistence of Gerano and wintecide under semi field conditions

Cucumber seeds, *Cucumis sativus* L. (F: Cucurbitaceae) of two pure lines (5-57-22-17 KAHA and 25-2-1-90 KAHA) from Improvement of the Main Vegetables and Hybrids Production Project (Ayman, 2008) were planted in pots under environmental condition and after appearance of three true leaves; they were sprayed by LC_{90} concentration values of *T. urticae* multiplied by 5 of both formulations. Leaves from treated plants were taken to the laboratory after 1, 2, 3, 6, 9 days post-treatment and the mortality of females was recorded after 48h and 96h from these days post- treatment. In every test day, five treated leaves represented five replicates and each replicate had twenty adult females.

Statistical analysis:

(Lwande *et al*., 1985) and (Pascual-villalobos & Robledo, 1999) were taken as a reference in calculating Oviposition deterrence and repellency index, respectively.

The other statistical data in the research were analyzed by one-way ANOVA and T test using SPSS 14.00 program. Test of Duncan multiple range was used to compare means.

Results and Discussion

***GC-MS analysis of P. graveolens and G. procumbens essential oils*:**

Tables (1, 2) presented the percent area and retention time (R_t) of detected components of *P. graveolens* and *G. procumbens* oils, respectively. *P. graveolens* oil was mainly characterized by Geraniol and beta-Citronellol which were the major compounds (12.44% and 11.95%), respectively. *G. procumbens* oil was mainly characterized by Pyrene hexadecahydro, L-(-)-Menthol and p-Menthone which were the major compounds (41.36%, 25.62 and 14.01%), respectively.

Table (1): GC-MS analysis of *P. graveolens* essential oil

No.	Compound	R_t(min.)	(peak area)%
1	alpha-Pinene	7.236	0.89
2	2H-Pyrene, 2-ethenyltetrahydro-2,6,6-trimethyl-	8.709	0.14
3	Vetiverol	9.523	0.25
4	Benzene, methyl(1-methylethyl)-	10.624	0.25
5	dl-Limonene	10.794	0.59
6	cis-Ocimene	11.316	0.14
7	Linalool oxide	12.503	0.36
8	L-linalool	13.957	3.08
9	trans-Rose oxide	14.104	3.37
10	cis-Rose oxide	14.596	1.62
11	p-Menthone	15.468	1.18
12	L-Menthone	15.990	6.05
13	beta-Citronellol	19.562	11.95
14	Geraniol	20.227	12.44
15	6-Octen-1-ol, 3,7-dimethyl-, formate	20.380	7.16
16	Geraniol formate	21.064	2.94
17	alpha-Cubebene	22.294	1.05
18	Citronellyl propionate	22.601	1.14
19	alpha-copaene	23.084	1.60
20	beta-Bourbonene	23.381	3.23
21	Lavandulyl acetate	23.540	1.10
22	Caryophyllene	24.440	3.94
23	Germacrene-D	24.682	0.71
24	Isoledene	25.158	1.27

Table (1). (Con.)

25	Aromadendrene	25.624	0.74
26	trans-beta-Farnesene	26.314	4.69
27	Ledene	26.736	1.37
28	alpha-Muurolene	26.893	0.93
29	gamma-Cadinene	27.267	1.24
30	beta-Cadinene	27.636	3.04
31	Citronellyl acetate	27.865	2.53
32	Murolan-3,9(11)-diene-10-peroxy	28.110	1.26
33	Caryophyllene oxide	28.304	0.26
34	11-Norbourbonan-1-one	28.538	0.28
35	Propanoic acid, 2-methyl-,3,7-dimethyl-2,6-octadienyl ester	28.813	2.62
36	Spathulenol	29.148	1.64
37	Phenyl ethyl tiglate	29.423	2.47
38	10-epi-gamma-eudesmol	30.436	5.89
39	Geranyl isovalerate	30.970	0.80
40	Geranyl tiglate	32.654	2.79
41	Geranyl hexanoate	33.958	0.48
42	Geranyl acetate	36.421	0.53

R_t: retention time

Table (2): GC-MS analysis of *G. procumbens* oil

No.	Compound	R_t(min.)	(peak area)%
1	alpha-Pinene	7.217	2.04
2	beta-Pinene	8.733	1.99
3	dl-Limonene	10.790	4.02
4	p-Menthone	15.347	14.01
5	L-Menthone	15.699	7.30
6	d-Isomenthol	15.812	3.67
7	L-(-)-Menthol	16.100	25.62
8	Pyrene, hexadecahydro	31.185	41.36

R_t: retention time

Contact and fumigant toxicity effects of P. graveolens and G. procumbens essential oils on T. urticae eggs:

Table (3) showed that both tested oil had toxic effects against eggs of *T. urticae*. *G. procumbens* oil was the most effective by contact method followed by *P. graveolens* oil and LC_{50} values were (0.09×10^4ppm and 1.08×10^4ppm), respectively. In case of fumigant, *P. graveolens* oil was effective (LC50: 0.48×104ppm) while *G. procumbens* oil had no effect.

Table (3): Contact and fumigant toxicity effects of *P. graveolens* and *G. procumbens* oils and their formulations Gerano and wintecide on females and eggs of *T. urticae*

Material	stage	method	LC_{50} (ppm) Lower -upper limits	LC_{90} (ppm) Lower – upper limits	slope±S.E.	x^2
***P. graveolens* oil**	Females	Contact	0.45×10^4 0.42×10^4-0.49×10^4	0.75×10^4 0.67×10^4-0.86×10^4	5.8±0.5	1.37
		Fumigant	0.55×10^4 0.51×10^4-0.61×10^4	1.03×10^4 0.91×10^4-1.2×10^4	4.79±0.4	1.33
	Eggs	Contact	1.08×10^4 0.93×10^4-1.30×10^4	4.65×10^4 3.33×10^4-7.72×10^4	2.02±0.22	0.03
		Fumigant	0.48×10^4 0.44×10^4-0.52×10^4	0.93×10^4 0.82×10^4-1.09×10^4	4.4±0.38	0.09
***G. procumbens* oil**	Females	Contact	1.24×10^4 1.12×10^4-1.38×10^4	2.7×10^4 2.3×10^4-3.49×10^4	3.74±0.38	0.64
		Fumigant	-	-	-	-
	Eggs	Contact	0.09×10^4 0.03×10^4-0.15×10^4	0.78×10^4 0.58×10^4-1.19×10^4	1.34±0.27	0.88
		Fumigant	-	-	-	-
Gerano	Females	Contact	0.009×10^4 0.007×10^4-0.01×10^4	0.03×10^4 0.026×10^4-0.041×10^4	2.3±0.25	0.44
	Eggs	Contact	0.001×10^4 0.0007×10^4-0.0014×10^4	0.005×10^4 0.004×10^4-0.007×10^4	1.89±0.26	0.37
wintecide	Females	Contact	0.017×10^4 0.015×10^4-0.019×10^4	0.05×10^4 0.04×10^4-0.07×10^4	2.59±0.23	0.94
	Eggs	Contact	0.0006×10^4 0.0005×10^4-0.0007×10^4	0.002×10^4 0.0018×10^4-0.0025×10^4	2.48±0.26	0.05

- No effect

Contact and fumigant toxicity effects of P. graveolens and G. procumbens essential oils on T. urticae females:

P. graveolens oil was the most potent against *T. urticae* females by both contact and fumigant methods (LC_{50}: 0.45×10^4ppm & 0.55×10^4ppm), respectively. On the other hand, *G. procumbens* oil had less effect by contact method (LC_{50}: 1.24×10^4ppm) and had no effect by fumigant method (table, 3).

This toxic action of *P. graveolens* oil resemble other researches in their effects; it caused mortality to females of *Bemisia tabaci* Gennadius biotype B (F: Aleyrodidae) (Baldin, *et al*., 2014) also, (Jeon, *et al*., 2008) found that the oil components were highly effective against *Dermatophagoides farinae* and *D. pteronyssinus* (F: Pyroglyphidae). The contact toxicity effect of *P. graveolens* oil was better than fumigant effect on *Sitophilus zeamais* (Motsch.) (F: Curculionidae) (Kabera, *et al*., 2011). On contrary of our results, *G. procumbens* oil was potent by fumigant against *Sitophilus oryzae* L. (F: Curculionidae) (Yazdgerdian, *et al*., 2015) and *Camptomyia corticalis* (Loew) (F: Cecidomyiidae) (Kim, *et al*., 2012)

Contact toxicity effect of Gerano and wintecide on eggs and females of T. urticae

The two formulated components more toxic and effective than the oils against the pest mite, *T. urticae* as shown in (table, 3). The eggs were more sensitive than the females to both formulated compounds but, wintecide was stronger in its effect on eggs than gerano and the reverse in females. LC_{50} values reported to eggs by gerano and wintecide were (0.001×10^4ppm & 0.0006×10^4ppm) and for females (0.009×10^4ppm &0.017×10^4ppm), respectively. (Cilek, *et al*., 2011) assessment some formulated essential oils against *Aedes albopictus* and *Culex quinquefasciatus* and showed a good mortality. Also in agreement with our results, the formulations from *Azadirachta indica* A. Juss. (F: Meliaceae) had toxic effect on *Diatraea saccharalis* F. (F: Crambidae) and *T. urticae* (Dimetry, *et al*., 2008 & da Silva *et al*., 2013).

Toxicity effect of P. graveolens and G. procumbens essential oils and their formulaions Gerano and wintecide on T. negevi and P persimilis females

Females of *T. negevi* were more sensitive to *P. graveolens* oil than females of *P. persimilis* (LC_{50} =0.44×10^4ppm &0.77×10^4ppm), respectively and the reverse effect was done when treated by *G. procumbens* oil (LC_{50} = 0.42×10^4ppm& 0.35×10^4ppm), respectively (table, 4).

The same trend of effect resulted also when females of both predators treated by Gerano and wintecide; Females of *P. persimilis* were sensitive to formulated winticide than *T. negevi* females (LC_{50} = 0.14×10^4 ppm & 0.16×10^4ppm), respectively and the reverse effect was shown by formulated gerano (LC_{50} = 0.29×10^4ppm & 0.23×10^4ppm), respectively.

But in general, *G. procumbens* oil and winticide were the most toxic than *P. graveolens* oil and gerano on both predators. Here, management of *T. urticae* with predators was suggested to be compatible with the use of the tested formulations and this similar to the action of *Rosmarinus officinalis* L. oil and *R. officinalis* oil-based pesticides (EcoTrol) on *T. urticae* with *P.*

persimilis (Miresmailli and Isman, 2006) and *Artemisia judaica* L. ethanolic extract (El-Sharabasy, 2010). *A. maritime* and *Thymus vulgaris* oils and their formulations, which were studied by Fahim (2016), were found to be more effective against *T. urticae* and less effective against its predator, *Neoseiulus barkeri*.

Table (4): contact Toxicity effects of *P. graveolens* and *G. procumbens* oils and their formulations Gerano and wintecide on predatory phytoseiid mites, *P. persimilis* and *T. negevi* females

material	*P. persimilis*				*T. negevi*			
	LC_{50} (ppm) Lower - upper limits	LC_{90} (ppm) Lower - upper limits	slope±S.E.	x^2	LC_{50} (ppm) Lower - upper limits	LC_{90} (ppm) Lower - upper limits	slope±S.E.	x^2
***P.graveolens* oil**	0.77×10^4 0.63×10^4 - 0.9×10^4	3.12×10^4 2.6×10^4 - 4.1×10^4	2.11±0.21	0.12	0.44×10^4 0.31×10^4 - 0.56×10^4	2.02×10^4 1.63×10^4 - 2.78×10^4	1.95±0.26	0.15
***G. procumbens* oil**	0.35×10^4 0.26×10^4 - 0.43×10^4	1.78×10^4 1.36×10^4 - 2.72×10^4	1.8±0.24	0.09	0.42×10^4 0.34×10^4 - 0.49×10^4	1.98×10^4 1.52×10^4 - 2.9×10^4	1.89±0.22	0.95
Gerano	0.29×10^4 0.25×10^4 - 0.33×10^4	0.98×10^4 0.77×10^4 - 1.39×10^4	2.4±0.25	0.7	0.23×10^4 0.19×10^4 - 0.27×10^4	0.93×10^4 0.71×10^4 - 1.37×10^4	2.1±0.24	0.6
wintecide	0.14×10^4 0.12×10^4 - 0.16×10^4	0.39×10^4 0.32×10^4 - 0.51×10^4	2.9±0.36	0.75	0.16×10^4 0.14×10^4 - 0.19×10^4	0.56×10^4 0.46×10^4 - 0.74×10^4	2.39±0.25	0.2

Distribution, repellency index, Oviposition deterrence and mortality of T. urticae females on treated leaves with different concentrations of P.graveolens and G. procumbens oils

Table (5) illustrated that both tested oils had the same effect and were highly significantly repelled *T. urticae* females at the first three concentrations (RI >92%), but (RI) at the last concentration was higher by *P. graveolens* oil than *G. procumbens* oil (>66% & >56%), respectively. By comparing the tested exposure times at every tested concentration of both oils, there were no significant differences among them except the last concentration of *P. graveolens* oil; the percentage of mites distribution increased after 24h. There was no mortality recorded in females of *T. urticae* by *P. graveolens* oil while *G. procumbens* oil caused mortality ≤ 5% after 48h. Deterring females of *T. urticae* from depositing eggs confirmed the repellent effect of tested oils at all used concentrations in comparison with control. *P. graveolens* and *G. procumbens* oils had similar pattern (D>98%) for first three concentrations table (5).

Distribution, repellency index, Oviposition deterrence and mortality of T. urticae females on treated leaves with different concentrations of formulated Gerano and wintecide compounds

Table (6) explained that Mite's distribution increased by passing time and by decreasing the concentrations. Both formulations had similar repellent effect at every tested concentrations; (RI >82%) except the last one (RI = 80±4.47% & 64±4 %) by Gerano and wintecide, respectively. Gerano deterred *T. urticae* females from oviposition (≥ 91%) and data resulted by winticide was the same pattern, except with the last concentrations, deterrence decreased to78.27%. The strong repellent action which resulted here by the tested oils and their formulations on *T. urticae* agree with the action of *Syzygium aromaticum*, *Mentha spicata* and *Cuminum cyminum* oils (Kheradmand *et al.,* 2015) as well as *T. urticae* oviposition reduction which potently obtained by *Majorana hortensis* L. Moench and *R. officinalis*. (Momen *et al*., 2001)

Persistence of Gerano and wintecide under semi-field conditions

It was obvious in table (7) that Gerano gave 65 % & 99% mortality on 5-57-22-17 KAHA and 25-2-1-90 KAHA *C. sativus* lines, respectively at first day post- treatment, while winticide gave 80% with two *C. sativus* lines. Mortality of *T. urticae* females by gerano and winticide were gradually faded by time post-treatment. Likely, *R. officinalis* oil and EcoTrol were non-persistent (Miresmailli and Isman, 2006)

Table (5): Distribution, repellency index, Oviposition deterrence and mortality of *T. urticae* females on treated leaves with different concentrations of *P. graveolens* and *G. procumbens* oils

(ppm) Conc.	**(%) distribution of mites on treated leaves after** (Mean ±S.E.)					**F** value ($df_{4,20}$)	**(%)RI** after 48h (Mean ±S.E.)	**(%) M** after 48h	**No. of deposited eggs/♀ after 48h** (Mean ±S.E.)		**(%) D**
	2h	4h	6h	24h	48h				T	C	
	***P. graveolens* oil**										
1×10^4	0±0A	0±0A	0±0B	0±0B	0±0B	-	100±0A	0	0±0B	9.9±1.01A	100±0A
0.5×10^4	1±1Aa	1±1Aa	1±1Ba	2±1.22Ba	2±1.22Ba	0.25ns	96±2.45A	0	0.03±0.02B	9.01±0.46A	99.66±0.22A
0.25×10^4	2±2Aa	5±2.24Aa	4±2.45ABa	2±2Ba	4±2.45Ba	0.36ns	92±4.89A	0	0.1±0.03B	7.65±0.45A	98.63±0.51A
0.125×10^4	5±2.24Ab	5±2.24Ab	7±1.22Ab	15±1.58Aa	17±2.55Aa	8.09**	66±5.09B	0	0.88±0.29A	9.52±0.92A	90.39±3.49B
F value ($df_{3,16}$)	1.87ns	2.52ns	4.71*	23.79**	16.83**		16.83**		8.08**	1.69^{ns}	6.65**
	***G. procumbens* oil**										
1×10^4	1±1B	1±1B	0±0B	1±1B	1±1B	0.25ns	98±2A	5	0.02±0.02B	8.7±0.5A	99.79±0.21A
0.5×10^4	1±1B	3±1.22B	2±1.22B	2±1.22B	2±1.22B	0.36ns	96±2.45A	4	0.05±0.04B	7.79±0.91A	99.51±0.36A
0.25×10^4	2±1.22B	2±2B	3±2B	4±2.91B	4±1.87B	0.23ns	92±3.74A	3	0.1±0.05B	8.62±0.47A	98.89±0.53A
0.125×10^4	10±2.24A	15±1.58A	10±2.24A	16±1.87A	22±2A	6.2**	56±4B	5	1.9±0.17A	9.1±0.78A	78.31±2.90B
F value ($df_{3,16}$)	8.94**	19.07**	7.21**	13.31**	39.3**		39.3**		96.79**	0.64^{ns}	50.16**

Capital letters denote a significant difference within the same column and small letters indicate a significant difference within the same raw.
*=*P* value ≤ 0.05 (significant), **=*P* value ≤ 0.01(highly significant), ns= not significant, -=cannot be computed because the standard deviations of both groups are 0, RI= Repellency index, T= treatment, C= control, D= deterrence

Table (6): Distribution, repellency index, Oviposition deterrence and mortality of *T. urticae* females on treated leaves with different concentrations of formulated Gerano and wintecide compounds

(ppm) Conc.	**(%) distribution of mites on treated leaves after** (Mean ±S.E.)					**F** value ($df_{4,20}$)	**(%)RI** after 48h (Mean ±S.E.)	**(%) M** after 48h	**No. of deposited eggs/♀ after 48h** (Mean ±S.E.)		**(%) D**
	2h	4h	6h	24h	48h				T	C	
Gerano compound											
0.01×10^4	0±0Bb	0±0Bb	2±1.22Bb	1±1Bb	6±1.87Aa	5.17**	88±3.74A	0	0.08±0.025B	5.08±0.40B	98.33±0.57A
0.005×10^4	3±1.22ABa	2±1.22ABa	2±1.22Ba	2±1.22Ba	6±1.87Aa	1.58ns	88±3.74A	1	0.13±0.06B	6.19±0.32AB	97.76±1.16A
0.0025×10^4	4±2.45ABa	4±1Aa	3±1.22Ba	5±1.58Ba	7±1.22Aa	0.92ns	86±2.44A	1	0.21±0.06B	5.75±0.59B	96.25±0.98A
0.00125×10^4	7±3Aab	4±1.87Ab	8±2Aab	12±2.55Aa	10±2.24Aab	1.64ns	80±4.47A	0	0.65±0.17A	7.27±0.39A	91.12±2.18B
F value ($df_{3,16}$)	2.02ns	2.44ns	3.88*	1.06ns			1.06ns		7.51**	4.39*	5.83**
Winticide compound											
0.01×10^4	2±1.22Ca	3±2Ba	3±2Ba	3±2Ba	5±1.58Ba	0.38ns	90±3.16A	2	0.17±0.05B	5.16±0.23A	96.71±0.92A
0.005×10^4	7±1.22BCa	3±2Ba	3±2Ba	7±2Ba	6±1.87Ba	1.24 ns	90±3.16A	3	0.26±0.02B	5.36±0.27A	95.14±0.33A
0.0025×10^4	8±2.55Ba	8±2.55Ba	9±2.92ABa	8±2Ba	9±1.87Ba	0.05 ns	82±3.74A	5	0.42±0.04B	5.79±0.09A	92.75±0.74A
0.00125×10^4	19±1.87Aa	14±1Aa	14±4Aa	16±1.87Aa	18±2Aa	0.93 ns	64±4B	5	1.23±0.17A	5.72±0.34A	78.27±3.09B
F value ($df_{3,16}$)	15.79**	7.05**	3.48*	7.66**	10.37**		12.03**		27.78**	1.45ns	25.76**

Capital letters denote a significant difference within the same column and small letters indicate a significant difference within the same raw.
*=*P* value ≤ 0.05 (significant), **=*P* value ≤ 0.01(highly significant), ns= not significant, RI= Repellency index, T= treatment, C= control, D= deterrence

Table (7): Persistence of Gerano and wintecide under semi-field conditions

Tested times after treatment (day)	% cumulative mortality of *T. urticae* females on *C. sativus* leaves							
	Gerano				wintecide			
	5-57-22-17 KAHA		25-2-1-90 KAHA		5-57-22-17 KAHA		25-2-1-90 KAHA	
	48h	96h	48h	96h	48h	96h	48h	96h
1	13	65	14	99	10	80	10	80
2	10	23	11	61	10	30	10	33
3	5	20	10	50	2	2	3	3
6	0	3	6	32	0	0	0	0
9	0	1	3	9	0	0	0	0

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(Received 2 March 2017, accepted 30 April 2017)