

Original Research

# Efficacy of Some Plant Essential Oils Against two Spotted Spider Mite *Tetranychus urticae* under Laboratory Conditions

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## Abstract

*Tetranychus urticae* is a critical pest affecting the quality and quantity of the yield under cover and in open ground. Its pesticide resistance and short life cycle leads to rapidly spreading. The present study evaluated the efficacy of essential oils (EOs) of caraway, lemon, mint and peppermint against adult and egg stages of two spotted spider mite *T. urticae*, compared to that of the recommended acaricide, abamectin. Abamectin is a recommended acaricide by the Agricultural Pesticide Committee. Our results proved that, the efficacy of the EOs was lower than the acaricide, abamectin showed the highest effect on the egg deposition (46.66 % reduction), and egg hatchability (47.91%), comparable to the control treatment (the leaves discs without treatments). However, peppermint oil had the least effect on the egg deposition (25% reduction), and egg hatchability (53.3%). Caraway, lemon and mint oils showed moderate impact on the egg hatchability and deposition. Toxicity of different compounds to eggs of *T. urticae* showed that Abamectin was the most effective however peppermint oil recorded the lowest effect. There for essential oils can be used in integrated best management programs to control *T. urticae*.

**Keywords:** abamectin, essential oils, spotted spider mite, *Tetranychus urticae*

## Introduction

There are many environmental stress factors that affect the growth and yield of several crops. These factors such as drought [1-9], salinity [10-18], pathogens [19-22], weeds [23-27] and pests [28-30] may cause significant losses in all plant stages. The two-spotted spider mite is a polyphagous universal pest causes great damage to crops of economic interest in protected cultivation systems over world and irrigated [31-33]. The negative effect of this pest on agriculture is regarded to its short biological cycle, ability to cause injuries and high fertility rate [34]. It primarily feeds nigh the midrib and the veins of plant, causing about 50 to 100 percent yield loss [35]. The population of mites and the losses that they cause can be reduced by the use of chemicals, but it is not sustainable for agriculture as, the wide spread use of acaricides cause ecological problems such as destroying non-target useful organisms, harmful for human health because their residues on food, and developing resistance to chemicals by pests [36]. Avermectins including abamectin and ivermectin which have been historically used such as antiparasitic drugs for applications of animal health [37]. Abamectin has been developed as a wide-spectrum insecticide/acaricide with vigor on Hemiptera, Coleoptera, Diptera, Lepidoptera, and several species, including two spotted spider mite (TSSM) [38]. Researchers have started to use plant extracts and essential oils as alternatives to synthetic chemicals pest management strategies to get both environmentally- and human-friendly and to avoid the resistance [39]. The essential oils have promising activities against many pests such as, the essential oils, oxidation water solubility and volatility which playing an important role in the essential oil's efficacy application and persistent, these problems must be resolved before using it for the pest control. Many studies have improved that essential oils have insecticidal/acaricidal efficiency against spider mites, inclusiving *T. urticae* [40]. Several essential oils of aromatic plants belonging to Zingiberaceae, Lamiaceae and Asteraceae families and have biological activities against mites including repellence, feeding and oviposition deterrence and toxicity [41]. Many studies have proved that acaricidal activity of many EOs as garlic, bergamot, basil, black pepper, citronellay eucalyptus, lavender, lemon, hot pepper, ginger, clove and rosemary [42,43]. *Mentha piperita* is a famous genus belongs to Lamiaceae family, and is well known in medicinal and aromatic value. That genus implicates about 30 species which well grow in the temperate regions of Australia, Eurasia and South Africa [44]. The Lamiaceae family consist of many genera and species, most of them have economical value because its use as a medicinal plant. A great number of its genera are rated to be a source of active substances particularly essential oils such as genus *Mentha* which contains *Mentha viridis* [45]. Caraway oil showed strong antigerminative effects against weed seeds planting in laboratory experiments [46]. Relating mints

(*Mentha* spp.) which avail as CPs, aromatic essential oils (including VOCs) of *M. longifolia*, *M. pulegium* and *M. piperita* have been shown to display toxicity against *T. urticae* [41]. The objective of this study was to evaluate the efficiency of Eos such as caraway, lemon, mint and peppermint comparing to synthetic acaricide, abamectin in reducing pest damage associated with toxicity of tested compounds to adult females of *T. urticae* and egg deposition as well as egg hatching. It was assumed that the effects of EOs would be sufficient to recommend their application in the control program against *T. urticae*.

## Materials and Methods

### Preparation of Culture

The culture of the two-spotted spider mite, *Tetranychus urticae* Koch (Acarina: Tetranychidae) was bred according to Dittrich [47] in 2022-2023. Three to Six seeds of castor beans (*Ricinus communis*) (L.) were planted (40 cm in diameter) and the growing seedlings (30 days after sowing) were infested by culture of red spider mites without pesticides. The colonies of *T. urticae* were taken from infested castor bean plants from Kafr EL-Sheikh governorate and bred under laboratory conditions. Mites were transmitted from old to young plants every two days. The culture was kept at 25±5°C under 16 hours photoperiod 65±5 R.H. The control treatment was the leaves discs without abamectin or essential oils treatments.

### Compounds Used

Abamectin (Superkin® 1.8 EC) purchased from Actra for chemical industry, Nubarya city, Alexandria. It is an acaricide with contact and stomach action, recommended by the Agricultural Pesticide Committee, Ministry of Agriculture and Land Reclamation, Egypt. While, caraway, lemon, mint and peppermint oil were obtained from local market in oil form.

### Toxicity of Tested Compounds to Adult Females of *T. urticae*

Leaf disc dip method [48] was used to assess the toxic impact of tested compounds formulation which diluted to definite concentrations for chemical compound (abamectin) 31.25, 62.5, 125, 250 and 500 ppm and concentrations for oils were 6250, 12500, 25000, 50000 and 100000 ppm. Four discs of castor bean leaves were treated with each concentration for five seconds and left to dry. Ten adult females of *T. urticae* were transmitted to each leaf disc. Petri dishes contains pad moist cotton wool up on its moist filter paper which carried the disc of females. Every treatment was replicated four times and kept under laboratory conditions of 25±5°C and 65±5 R.H. Mortality was accounted after 24 and

48h post treatment. The method of Abbott's formula [49] was used to correction the control mortality, the corrected mortality (%) was accounted for each treatment by measuring the mortality in the treatment and in the control as follow:

$$\text{Corrected mortality (\%)} = \frac{\text{Test mortality (\%)} - \text{Control mortality (\%)}}{100 - \text{Control mortality}} \times 100$$

The method of Finney [50] showed data which plotted on log dosage-probit papers in addition to statistically analyzed. Toxicity index of tested compounds was planned according to Sun [51].

$$\text{Toxicity index \%} = \frac{\text{LC50 of the most effective compound}}{\text{LC50 of tested compound}} \times 100$$

Where  $LC_{50}$  is the lethal concentration for 25% of the population

#### Toxicity of Tested Compounds to Eggs of *T. urticae*

10 adult females *T. urticae* were transmitted to each leaf disc to provide eggs overnight for the next days of the experiment, and removed in the morning. The eggs age was not longer than 24 hours at the being of the experiment to avoid egg hatching during the experimental period. Eggs number on each disc was counted. Every disc contains eggs were occupied in its definite concentration for five seconds. Every treatment was replicated Four times and kept in the laboratory ( $25 \pm 5^\circ\text{C}$  and  $65 \pm 5$  R.H.). Untreated discs were occupied in distilled water. The data were taken when the emergent eggs have reached to the protonymphal

stage in the control. Abbott's formula [49] was used to calculate egg mortality and correction for control mortality.

#### Effect of Compound's Residues on *T. urticae* Egg Deposition and Egg Hatching

The residual effect of tested chemical was assayed at the lethal concentration for 25% of the population ( $LC_{25}$ ) according the method of Keratum and Hosny [52]. Ten adult female mites of *T. urticae* with known age were placed on each leaf disc after treatment and let to laid. After 48 hours, the number of eggs laid were counted and the hatched eggs were counted two days after egg deposition. Each treatment was replicated four times and kept in the laboratory ( $25 \pm 5^\circ\text{C}$  and  $65 \pm 5$  R.H.).

#### Statistical Analysis

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) and Tukey's test was used for post hoc comparison using SPSS version 23.

#### Results

Based on  $LC_{50}$  values in Table 1, the toxicity index values showed that abamectin gave the best results and was the most effective compound, followed by caraway, lemon, mint and peppermint oils on adult females of *T. urticae* after 24 h post treatment with  $LC_{50}$  values of 146.7, 64688.4, 72798.9 and 448611.0 ppm, respectively. The results in Table 1 also showed that abamectin was the most effective and toxic compound, followed by caraway, lemon, mint and peppermint oils to adult

Table 1. Toxicity of different compounds to adult females of two-spotted spider mite *T. urticae* after 24 h and 2 days.

Compounds	$LC_{50}$	Confidence limits		Toxicity index	Slop value
		Lower	Upper		
After 24 h					
Abamectin	146.7	99.5	202.6	100	1.49
Caraway	64688.4	52592	79566.7	0.226	2.11
Lemon	72798.9	48890.3	180224	0.20	2.85
Mint	448611.0	373842	538333	0.032	0.97
Peppermint	-	-	-	-	-
After 2 days					
Abamectin	90.9	53.2	125	100	1.59
Caraway	30086.5	21086	48484	0.302	1.8
Lemon	66708	54311.7	86594.2	0.136	2.31
Mint	81640.5	65248.0	120099.3	0.111	2.15
Peppermint	283945.7	130146.8	583816	0.032	1.23

Table 2. Toxicity of different compounds to eggs of *T. urticae* Compounds LC<sub>50</sub>.

Compounds	LC <sub>50</sub> ppm	Confidence limits		Toxicity index	Slop value
		Lower	upper		
Abamectin	335.71	277.66	430.90	100	1.77
Caraway	43531.24	43201.12	57721.37	0.771	1.21
Lemon	57631.34	47759.37	73034.44	0.582	1.67
Mint	116265.57	73412.65	368767.18	0.288	1.79
Peppermint	166804.54	83064.06	203147.96	0.201	1.25

Table 3. Effect of compound's residues on *T. urticae* egg deposition and egg hatching.

Compounds	Number of eggs deposition	Reduction %	Hatching on third day post treatment	Hatching on fourth day post treatment	Mean	Hatchability %
Control	60±7.90 a		30±3.74 a	16±1.47 b	23	61.66
Abamectin	32±2.86b	46.66	31.5±3.42 a	31±3.53a	31.25	47.91
Caraway	35±4.54b	41.66	31±2.79a	29±2.12 ab	30	50
Lemon	39.25±2.68 b	34.58	32.5±2.95a	27±3.02 ab	29.75	50.41
Mint	42.5±3.12 ab	29.16	33± 2.67 a	25±1.47 ab	29	51.66
Peppermint	45±1.78 ab	25	34±2.12 a	22±4.70 ab	28	53.3

females of *T. urticae* after 2 days post treatment with LC<sub>50</sub> values of 90.9, 30086.5, 66708, 81640.5 and 283945.7 ppm, respectively. From Table 1 abamectin is the strongest compound induced mortality to adult females of *T. urticae* and peppermint oil has the least effect at all exposure periods.

Our results in Table 2 displayed that the most effective compound on eggs of *T. urticae* was recorded with abamectin followed by caraway, citrus lemon, mint and peppermint oils with LC<sub>50</sub> values of 335.71, 43531.24, 57631.34, 116265.57 and 166804.54 ppm, respectively.

Data revealed that on the second day of deposition, abamectin showed the highest effect on the egg deposition with reduction percentage (46.66%), followed by caraway oil (41.66% reduction), while lemon and mint oils caused a moderate reduction (34.58, 29.16%), respectively. Peppermint oil was the least effect (25% reduction). Treatment with peppermint oil showed the minimum effect on egg hatchability (53.3%) at third- and fourth-day post deposition comparable to the control treatment (61.66%) followed by mint (51.66%), lemon (50.41), and caraway (50%). Abamectin showed the highest effect on the egg hatchability (47.91%) (Table 3).

## Discussion

Botanical extracts of many plant species offer the prospect for use in control of many pests as they are

considered safe and eco-friendly insect pest control measure. This study determines the toxic impact of some essential oils and acaricide abamectin against *T. urticae*. Our results displayed that abamectin was the most effective and toxic compound against eggs and adults of *T. urticae*, however, essential oil of caraway was the most effective one. In fact, the toxicity index of any toxic compound was suggested mainly to pool different information about this compound against different mite species and mite stages by comparing their LC<sub>50</sub> values [51]. The final value concluded from this calculation is the efficiency of the compound tested in integrated pest management. The toxic effect of essential oils may be due to that these essential oils contain some active compounds such as ketones, aldehydes, terpenes and phenols which play a significant role as antioxidant, antimicrobial and acaricidal.

The present results were in accordance with those of Hussein et al. [53] and Sohrabi and Kohanmoo [54] showed that plant essential oils have been used against various species of mites. Marcic [55] indicated that the families of Asteraceae, Apiaceae, Myrtaceae, Lamiaceae, Rutaceae) are great source of natural products of pesticide activity. Keratum et al. [56] reported that abamectin has a special position in integrated mite management it has most toxic effect on eggs and adults of *T. urticae*. Salem et al. [57] indicated that after 24 h post treatment, the effect of abamectin 1.8 EC in the concentrations (20, 50, 100, 150, 200, 400, 600, 800 and 1000) mg/l gave mortality rates in the range (11 to 85%) against *T. urticae* adult mites.

Ismail et al. [58] found that abamectin was the most toxic compound against the egg stage. Ismail et al. [59] indicated that abamectin nanoemulsion was more toxic compound against adult females of *T. urticae* than abamectin emulsion at concentrations of (0.001, 0.01, 0.1, 1, and 10) µg/ml. By using 1/5<sup>th</sup> LC<sub>50</sub> values of abamectin emulsion reducing egg deposition (72%) after 5 days post treatment using the leaf disc technique. Tawfik and Elgohary [60] indicated that abamectin was the highest speed of action followed by emamectin benzoate, acequinocyl, chlorfenapyr and hexythiazox with LT50; 1.77, 2.85, 3.16, 3.94 and 4.55 days. Within 1.77days treatment with abamectin, half of *T. urticae* adults were killed, while after five days all *T. urticae* adults were killed. Abd-Allah et al. [61] indicated that total mortality for mint oil after seven days treatment with concentrations 1000, 5000, 10000 and 20000 ppm was 20, 40, 53 and 70%, respectively under laboratory conditions 25±2°C and 60±5% RH. Wasfy et al. [62] indicated that LC<sub>50</sub> values were 4155.979 and 13437.825 ppm for Basil and caraway oils at concentration 100, 1000, 10000, 10000 ppm respectively against *T. urticae*. Eswara and Dolma [63] indicated that at 10, 20, 50 and 100 mg/L air, *M. piperita* mortality was (33.33, 53.33, 93.33 and 100 %) after 20 h post treatment, LC50 was 15.86 mg L<sup>-1</sup> air on two spotted spider mite (*T. urticae*). Kheradmand et al. [64] showed that the peppermint oil contain thymol, menthol diterpene esters, triterpenes, piperitenone and steroids which were identified as the potent lethal constituents against two spotted spider mite. Appel et al. [65] showed that peppermint oil use as potential fire ant repellent, insecticide and in integrated pest management. Choi et al. [66] indicated that the oil of caraway seeds, citronella, lemon eucalyptus, pennyroyal, and peppermint had high toxic Mortality >90% at 14×10<sup>-3</sup> µl/ml after 24 h against adults of *T. urticae*. Han et al. [67] indicated that many essential oils are effective against females and eggs of *T. urticae* lacking direct contact but by fumigant, resulted mode of division of the oil was greatly caused by action in the vapor phase via the respiratory system. Amizadeh et al. [68] showed that the biological activities of plant essential oils are regarded to the monoterpenes and phenols in their contents. Isman, [69] proved that essential oils contain different biochemical including acids, alcohols, ketones, aldehydes, esters, terpenes, phenols and sesquiter penes. Essential oils are used as, antiviral, acaricidal, antimicrobial, antifeedant, antioxidant, contact antifungal, and repellent. Jeschke, [70] showed the action mechanisms of many acaricides and reported that the primary targets in mites are enzymes, receptors, or channel sites.

### Conclusions

Essential oils such as caraway, citrus lemon, mint and peppermint oils showed moderate toxicity on

adult females and egg stages of *T. urticae*, less than abamectin. The results showed, however, that EOs were sufficiently effective to recommend them as at least partial replacements for acaricides. Using essential oils is a great method to control *T. urticae* and safe to humans and the environment.

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### Conflict of Interests

The authors declare no conflict of interest.

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