# BIOLOGICAL ACTIVITY OF SEVERAL ESSENTIAL OILS AGAINST *TETRANYCHUS URTICAE* KOCH (ACARI: TETRANYCHIDAE)

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## INTRODUCTION

The two-spotted spider mite, *Tetranychus urticae* Koch is one of most serious sucking pests, which reduce plant ability to build carbohydrate resulting in reduction of total yield. *T. urticae* infests a very wide range of hosts. It was recorded by Abd El-Rahman (1996) on 60 economic plant species varied among fiber crops, vegetables, fruits, medical plants, ornamental plants and cereal crops. The industry of chemicals focused primarily on toxic chemicals over the past 50 years, neglecting the fact that plants have their own self defense system against external aggressions. Recent scientific advances in chemical ecology have highlighted a number of natural compounds. Momen *et al.*, (2001) found that the essential oils of *Mentha virdis* L. and *Mentha piperita* L. had repellent effect and reduced the total number of eggs laid by *T. urticae*.

The present study aimed to determine the efficacy of several essential oils of different plants namely; *Coriandrum sativum* L., *Petroselinum sativum* L., *Cuminum cyminum* Linn., *Origanum vulgare* L., *Mentha piperita* L., *Mentha spicata* L., *Ocimum basilicum* Linn., *Eucalyptus sp*, *Pelargonium radula* Cav., *Cymbopogon citratus* Stapf and *Citrus aurantium* L. against eggs, protonymphs and adults of the red spider mite *T. urticae* Koch. This study was also conducted to evaluate the effect of the tested essential oils on development, fecundity and egg hatchability of *T. urticae*.

## MATERIAL AND METHODS

The tested *T. urticae* was reared under laboratory conditions at 25 ± 0.5° C and 70% ± 5 R.H. according to Darwish (1991).

The plant origins of the tested essential oils are tabulated in Table (1), which includes six different families, scientific names and English names as well as the used part. The essential oils used in this study were obtained from Cato Aromatic Company. Series of aqueous concentrations of each essential oil were prepared with Triton X-100 as surfactant at the rate of 0.1 % to be used in biological activity tests.

**TABLE (I)**
The classification and plant origin of the tested essential oils.

| Family | Scientific name | English name | part used to get oil |
|---|---|---|---|
| Apiaceae | *Coriandrum sativum* L. | Coriander | Herb |
| | | | Seeds |
| | *Petroselinum sativum* L. | Parsley | Herb |
| | | | Seeds |
| | *Cuminum cyminum* Linn | Cumin | Seeds |
| Lamiaceae | *Origanum vulgare* L. | Marjoram | Herb |
| | *Mentha piperita* L. | Peppermint | Herb |
| | *Mentha spicata* L. | Spearmint | Herb |
| | *Ocimum basilicum* Linn. | Sweet basil | Herb |
| Myrtaceae | *Eucalyptus* sp | Eucalyptus | Leaves |
| Geraniaceae | *Pelargonium radula* Cav. | Geranium | Herb |
| Poaceae | *Cymbopogon citratus* Stapf | Lemon grass | Herb |
| Rutaceae | *Citrus aurantium* L. | Bitter orange | New leaves |

**Treatment of eggs, protonymphs and adults:**

The method of Barakat et al., (1985) was followed to study the efficacy of essential oils against the eggs of T. urticae. The one day old eggs were sprayed by a glass atomizer with different concentrations for each essential oil. Eggs were incubated at 25 ± 0.5 °C and 70% ± 5 R.H. for six days till hatching. The percentage of hatchability was determined and corrected by Abbott's formula (1925). The $LC_{50}$, $LC_{90}$ and slope values were calculated according to Finney (1971).

Newly emerged protonymphs or adult females were used to evaluate the acaricidal activity of the tested materials by using the direct spray technique of Abo-Shabana (1980). Twenty protonymphs or adult females were transferred to the lower surface of lima bean disc (1 inch in diameter) using fine brush. Four discs were used as four replicates for each treatment. Discs were placed upside-down on moist

cotton wool in petri dishes. The disc surfaces carrying the protonymphs or adult females were directly sprayed with the aqueous solution of the tested materials using a manual atomizer. Control treatment was sprayed with aqueous solution of Triton X-100 at a rate of 0.1%. Mortality was calculated 24 h. after spraying and corrected by Abbott's formula (1925). The $LC_{50}$, $LC_{90}$ and slope values were calculated according to Finney (1971).

**Treatment of the protonymphs with $LC_{50}$ values of tested essential oils:**

Newly emerged protonymphs were treated with $LC_{50}$ values of the tested essential oils by using the same procedure of Abo-Shabana (1980). After one day of application the survived protonymphs were placed individually each one on lima bean leaf disc. The discs were then placed in petri dishes on moist cotton wool. Leaf discs were changed when they wilt. Twenty replicates were used for each treatment. Treated protonymphs were incubated at 25 ± 0.5 °C and 70% ± 5 R.H. The periods of deutonymph, pre-oviposition, oviposition and post-oviposition were recorded. The mortality percentages, number of deposited eggs per female and egg hatchability were estimated. The Oviposition Deterrent Indices (ODI) were calculated using the equation of Lundgren (1975).

## RESULTS AND DISCUSSION

**Toxicity of several essential oils to the different stages of *T. urticae*:**

Seed oil of *Petroselinum sativum* L. was the most toxic essential oil among the tested oils with 141.08 times as toxic as that of *Eucalyptus sp.* oil at $LC_{50}$ level (Table 2). Considering $LC_{50}$ values, the rest of tested oils were arranged in a descending order as follows: *Coriandrum sativum* L. (herb), *Ocimum basilicum* Linn., *Pelargonium radula* Cav., *Cuminum cyminum* Linn., *Cymbopogon citratus* Stapf, *Coriandrum sativum* L. (seed), *Mentha spicata* L., *Petroselinum sativum* L. (herb) and *Mentha piperita* L. The toxicity lines of the tested oils of *Coriandrum sativum* L. (seed), *Petroselinum sativum* L. (herb) and *Petroselinum sativum* L. (seed) were steepest, with slope values 3.60, 3.44 and 3.15, respectively. On the contrary, the toxicity lines of the essential oils of *Pelargonium radula* Cav. and *Eucalyptus sp.* were flattest with slope values 1.64 and 1.02.

Seed oil of *Petroselinum sativum* L. was the most potent oil against mite protonymphs, while *Citrus aurantium* oil was the least potent one (Table 3). The tested essential oils can be classified into three categories according to their $LC_{50}$.

The first category includes nine oils which had $LC_{50}$ less than one percent. These oils were *Petroselinum sativum* L. (seed), *Ocimum basilicum* Linn., *Coriandrum sativum* L. (herb), *Pelargonium radula* Cav., *Cymbopogon citratus* Stapf, *Mentha piperita* L., *Cuminum cyminum* Linn., *Mentha spicata* L. and *Petroselinum sativum* L. (herb) with $LC_{50}$ values ranged from 0.26 to 0.55%.

**TABLE (II)**

Comparative toxicity of different essential oils to *T. urticae* eggs.

| Oils | Scientific name | $LC_{50}$ (%) | Toxicity index | Folds | $LC_{90}$ (%) | Slope |
|---|---|---|---|---|---|---|
| Parsley (seed) | *Petroselinum sativum* L. | 0.67 | 100 | 141.08 | 1.71 | 3.15 |
| Coriander (herb) | *Coriandrum sativum* L. | 1.57 | 42.68 | 60.20 | 5.32 | 2.42 |
| Sweet basil | *Ocimum basilicum* Linn. | 2.84 | 23.59 | 33.28 | 8.15 | 2.79 |
| Geranium | *Pelargonium radula* Cav. | 3.16 | 21.20 | 29.91 | 19.12 | 1.64 |
| Cumin | *Cuminum cyminum* Linn. | 3.65 | 18.36 | 25.90 | 10.51 | 2.79 |
| Lemon grass | *Cymbopogon citratus* Stapf | 3.93 | 17.05 | 24.05 | 10.58 | 2.98 |
| Coriander (seed) | *Coriandrum sativum* L. | 4.58 | 14.63 | 20.64 | 10.41 | 3.60 |
| Spearmint | *Mentha spicata* L. | 4.68 | 14.32 | 20.20 | 13.14 | 2.86 |
| Parsley (herb) | *Petroselinum sativum* L. | 5.65 | 11.86 | 16.73 | 13.33 | 3.44 |
| Peppermint | *Mentha piperita* L. | 6.68 | 10.03 | 14.15 | 23.88 | 2.32 |
| Eucalyptus | *Eucalyptus sp.* | 94.52 | 0.71 | 1.00 | 1706 | 1.02 |

**TABLE (III)**

Comparative toxicity of different essential oils to *T. urticae* protonymphs.

| Oils | Scientific name | $LC_{50}$ (%) | Toxicity index | Folds | $LC_{90}$ (%) | Slope |
|---|---|---|---|---|---|---|
| Parsley (seed) | *Petroselinum sativum* L. | 0.26 | 100 | 197.46 | 0.66 | 3.19 |
| Sweet basil | *Ocimum basilicum* Linn. | 0.30 | 86.67 | 171.13 | 0.90 | 2.71 |
| Coriander(herb) | *Coriandrum sativum* L. | 0.31 | 83.87 | 165.61 | 0.58 | 4.68 |
| Geranium | *Pelargonium radula* Cav. | 0.37 | 70.27 | 138.76 | 0.76 | 4.09 |
| Lemon grass | *Cymbopogon citratus* Stapf | 0.38 | 68.42 | 135.11 | 0.72 | 4.60 |
| Peppermint | *Mentha piperita* L. | 0.40 | 65.00 | 128.35 | 0.96 | 3.38 |
| Cumin | *Cuminum cyminum* Linn. | 0.51 | 50.98 | 100.67 | 1.35 | 3.05 |
| Spearmint | *Mentha spicata* L. | 0.51 | 50.98 | 100.67 | 1.10 | 3.84 |
| Parsley (herb) | *Petroselinum sativum* L. | 0.55 | 47.27 | 93.35 | 2.56 | 1.92 |
| Marjoram | *Origanum vulgare* L. | 1.03 | 25.24 | 49.85 | 2.98 | 2.77 |
| Coriander(seed) | *Coriandrum sativum* L. | 1.28 | 20.31 | 40.11 | 3.04 | 3.41 |
| Eucalyptus | *Eucalyptus* sp | 2.55 | 10.20 | 20.13 | 7.30 | 2.80 |
| Bitter orange | *Citrus aurantium* L. | 51.34 | 0.51 | 1.00 | 503.4 | 1.29 |

The second category includes three oils namely *Origanum vulgare* L., *Coriandrum sativum* L. (seed) and *Eucalyptus sp.* with $LC_{50}$ values 1.03, 1.28 and

2.55 %, respectively. The third category includes *Citrus aurantium* L. oil only which showed very low efficiency against mite protonymphs with $LC_{50}$ value 51.34 %. Based on the slope values of the toxicity lines, coriander (herb), lemon grass and geranium oils showed the steepest toxicity lines with slope values 4.68, 4.60 and 4.09, respectively. Parsley (herb) and bitter orange showed the flattest toxicity lines with slope values 1.92 and 1.29. The slope values of the other essential oils lie between 2.71 and 3.84.

Parsley seed oil was also the most toxic one against *T. urticae* adults at the $LC_{50}$ level, while bitter orange oil was the least toxic (Table 4). The tested essential oils could be classified into four categories according to $LC_{50}$ values. The first category contains three essential oils *P. sativum* L. (seed) with $LC_{50}$ 0.34 % followed by *O. basilicum* Linn. (0.52%) and *C. sativum* L. herb (0.77%). The second category includes seven oils namely *M. Piperita* L. (1.07%), *P. radula* Cav. (1.50%), *O. vulgare* L. (1.59%), *C. citrates* Stapf (1.73%), *C. cyminum* Linn. (1.75%), *P. sativum* L. herb (1.87%) and *M. spicata* L. (1.94%). The third category includes *C. sativum* L. (seed) and *Eucalyptus sp.* oils with $LC_{50}$ 2.09 and 2.67%. The fourth category present the very low efficiency, *C. aurantium* L. oil with $LC_{50}$ 65.58%. Comparing the slope values of the toxicity lines of tested essential oils indicated that spearmint had the steepest toxicity line (4.62), whereas bitter orange showed the flattest one (1.44). The slope values of the other toxicity lines ranged between (2.20 and 3.73).

**TABLE (IV)**

Comparative toxicity of different essential oils to *T. urticae* adults.

| Oils | Scientific name | $LC_{50}$ (%) | Toxicity index | Folds | $LC_{90}$ (%) | Slope |
|---|---|---|---|---|---|---|
| Parsley (seed) | *Petroselinum sativum* L. | 0.34 | 100 | 192.88 | 0.96 | 2.85 |
| Sweet basil | *Ocimum basilicum* Linn. | 0.52 | 65.39 | 126.12 | 1.42 | 2.95 |
| Coriander(herb) | *Coriandrum sativum* L. | 0.77 | 44.16 | 85.17 | 1.73 | 3.66 |
| Peppermint | *Mentha piperita* L. | 1.07 | 31.78 | 61.29 | 4.08 | 2.20 |
| Geranium | *Pelargonium radula* Cav. | 1.50 | 22.67 | 43.72 | 3.80 | 3.18 |
| Marjoram | *Origanum vulgare* L. | 1.59 | 21.38 | 41.25 | 4.83 | 2.65 |
| Lemon grass | *Cymbopogon citratus* Stapf | 1.73 | 19.65 | 37.91 | 3.82 | 3.73 |
| Cumin | *Cuminum cyminum* Linn. | 1.75 | 19.43 | 37.47 | 4.58 | 3.07 |
| Parsley (herb) | *Petroselinum sativum* L. | 1.87 | 18.18 | 35.07 | 7.10 | 2.22 |
| Spearmint | *Mentha spicata* L. | 1.94 | 17.53 | 33.80 | 3.67 | 4.62 |
| Coriander (seed) | *Coriandrum sativum* L. | 2.09 | 16.27 | 31.38 | 5.28 | 3.19 |
| Eucalyptus | *Eucalyptus* sp | 2.67 | 12.73 | 24.56 | 8.92 | 2.45 |
| Bitter orange | *Citrus aurantium* L. | 65.58 | 0.52 | 1.00 | 506.8 | 1.44 |

Seed oil of *P. sativum* L. was superior against protonymph and adult stages of *T. urticae* stages followed by *O. basilicum* Linn and *C. sativum* L. (herb) oils. This order was changed to *P. sativum* L. (seed) oil followed by oils of *C. sativum* L. (herb) and *O. basilicum* Linn in case of mite eggs. Oils of *P. radula* Cav. and *C. citratus* Stapf had advanced order against all investigated mite stages. *M. piperita* L. oil gave a good control to adults and protonymphs but it had low efficacy against mite eggs. The potency of *O. vulgare* L. oil was good against mite adults and low against protonymphs. *C. cyminum* Linn., *P. sativum* L. (herb) and *M. spicata* L. oils can be considered as an intermediate potent oils against all tested mite stages. *T. urticae* eggs were more tolerant to tested essential oils than the adults and protonymphs. Essential oils of *Eucalyptus sp.*, *C. sativum* L. (seed) and *C. aurantium* L. had very low potency against protonymph and adult stages.

These results agreed with those of Mansour *et al.*, (1986) who reported that the oils of *O. basilicum* Linn. and *M. piperita* L. were toxic against *T. cinnabarinus* mite and their $LC_{50}$ values were 1.42 and 1.28 %. El-Halawany and Sawires (1988) noticed that volatile oil of cumin possessed the most potent acaricidal activity against egg and adult stages of *T. urticae* followed by spearmint and then marjoram. Chungsamarnyart and Jiwajinda (1992) found that the volatile oil of *C. citratus* stapf exhibited high acaricidal activity against tropical cattle ticks *Boophilus microplus*. Tunl and Sahinkaya (1998) found that the essential oils of cumin (*C. cyminum* Linn.), oregano (*Origanum syriacum* var. *bevanii*) and eucalyptus (*Eucalyptus camaldulensis*) were toxic to *T. cinnabarinus*. Momen and Amer (1999) mentioned that sweet marjoram oil was relatively toxic to the predacious mites; *Typhlodromus athiasae* and slightly toxic to *Amblyseius barkeri*. Momen *et al.*, (2001) found that 2, 1, 0.5, 0.25 and 0.125 % concentrations of *Mentha virdis* L. oil resulted in 75, 40, 20, 15 and 10 % mortality of *T. urticae*.

**Effect of tested essential oils on development of *T. urticae* koch:**

Results presented in Table (5) show that treated *T. urticae* protonymphs with $LC_{50}$ of essential oils induced shorting or prolongation in the stage duration of nymphs or adults. Lemon grass and marjoram oils significantly shortened quiescent protonymph period to 0.56 and 0.67 day comparing with 1.06 days in control treatment. On the contrary, spearmint and peppermint oils significantly elongated quiescent protonymph period to 1.42 and 1.50 days. Peppermint, sweet basil, cumin and spearmint oils significantly prolonged deutonymph period to 1.80, 1.75, 1.73 and 1.50 days, respectively, comparing with 1.06 days in control treatment. Geranium oil significantly shortened quiescent deutonymph period from 1.07 days

in control treatment to 0.67 day. On the other hand, significant prolongation was observed in case of marjoram, parsley (herb) and peppermint oils.

There was no significant effect of the tested essential oils on pre-oviposition period of adult females except sweet basil oil, which significantly prolonged this period to 1.60 days comparing to 1.13 days in control treatment. All the tested essential oils significantly shortened oviposition period except parsley (seed) and eucalyptus oils. The treatments of sweet basil, coriander (herb), parsley (herb), geranium and marjoram significantly shortened post-oviposition period.

**TABLE (V)**

Efficiency of $LC_{50}$ of essential oils on duration of nymph and adult stages of *T. urticae*.

| Oils | Duration (days) of nymphs and adults | | | | | |
|---|---|---|---|---|---|---|
| | Quiescent protonymph | Deuto-nymph | Quiescent Deutonymph | Pre-Oviposition | Ovi-position | Post-oviposition |
| Cumin | 1.19 | 1.73* | 0.87 | 1.50 | 5.50* | 1.67 |
| Spearmint | 1.42* | 1.50* | 1.25 | 1.44 | 4.60* | 1.60 |
| Marjoram | 0.67* | 1.18 | 1.43* | 1.36 | 5.75* | 1.08* |
| Peppermint | 1.50* | 1.80* | 1.40* | 1.29 | 6.00* | 1.58 |
| Coriander (seed) | 0.78 | 1.33 | 1.33 | 1.12 | 6.00* | 1.50 |
| Parsley (herb) | 0.92 | 0.75 | 1.42* | 1.00 | 6.55* | 1.00* |
| Lemon grass | 0.56* | 1.19 | 1.38 | 1.25 | 4.53* | 1.33 |
| Geranium | 0.75 | 0.81 | 0.67* | 1.00 | 5.33* | 1.08* |
| Coriander (herb) | 0.76 | 1.06 | 0.94 | 1.40 | 6.54* | 0.92* |
| Sweet basil | 0.82 | 1.75* | 1.07 | 1.60* | 6.50* | 0.75* |
| Eucalyptus | 1.13 | 1.25 | 1.25 | 1.13 | 8.33 | 1.17 |
| Parsley (seed) | 0.90 | 1.05 | 1.06 | 1.43 | 7.23 | 1.38 |
| Control | 1.06 | 1.06 | 1.07 | 1.13 | 8.29 | 1.71 |
| LSD at 0.05 | 0.35 | 0.36 | 0.31 | 0.39 | 1.11 | 0.55 |

Treated nymphs with the $LC_{50}$ of the tested oils induced adverse effect on the fecundity of *T. urticae* females (Table 6). Data showed that in all treatments the deposited eggs were significantly decreased to various rates. Cumin and spearmint oils highly reduced the number of eggs per female from 39.71 in control treatment to 7.92 and 8.53. Marjoram, peppermint, coriander (seed) and parsley (herb) oils had intermediate activity and reduced eggs number per female to 13.92, 14.42, 17.69 and 19.82, respectively. Lemon grass, geranium, coriander (herb), sweet basil, eucalyptus and parsley (seed) oils were least effective in reducing the numbers of egg-laying.

Cumin and spearmint oils were more effective than the other tested essential oils. Their Oviposition Deterrent Indices (ODI) reached 66.74 and 64.64%. However, the effect of other essential oils on fecundity of *T. urticae* was pronounced and their ODI ranged between 17.59 and 48.09%. There was no significant effect of the tested oils on egg hatchability except of lemon grass oil treatment only, which significantly reduced the percentage of egg hatchability from 96.57 in the control treatment to 89.66.

These results agreed with the finding of Mansour *et al.*, (1986) who found that fecundity of *T. cinnabarinus* females was reduced after application with *O. basilicum* Linn. and *M. piperata* L. El-Halawany and Sawires (1988) reported that, rearing immatures of *T. urticae* on leaves treated with citronella oil resulted in increasing of generation period and reduction in the females fecundity by about 95%. Weaver *et al.*, (1994) mentioned that finely-powdered *Ocimum canum* dried leaves completely suppressed oviposition of *Zabrotes subfasciatus* at 2%. Momen *et al.*, (2001) reported that the oils of *Mentha virdis* L. and *Mentha piperita* L. had toxic and repellent effects on *T. urticae* under laboratory conditions. Also, both materials caused reduction in the total numbers of eggs laid per female.

**TABLE (VI)**

Fecundity and hatchability of eggs laid by *T. urticae* females developed from treated nymphs with $LC_{50}$ of tested essential oils.

| Oils | Scientific name | Eggs No/female | ODI (%) | Hatchability (%) |
|---|---|---|---|---|
| Cumin | *Cuminum cyminum* Linn. | 7.92* | 66.74 | 94.36 |
| Spearmint | *Mentha spicata* L. | 8.53* | 64.64 | 98.33 |
| Marjoram | *Origanum vulgare* L. | 13.92* | 48.09 | 93.34 |
| Peppermint | *Mentha piperita* L. | 14.42* | 46.72 | 97.41 |
| Coriander (seed) | *Coriandrum sativum* L. | 17.69* | 38.36 | 95.06 |
| Parsley (herb) | *Petroselinum sativum* L. | 19.82* | 33.41 | 95.89 |
| Lemon grass | *Cymbopogon citratus* Stapf | 22.07* | 28.55 | 89.66* |
| Geranium | *Pelargonium radula* Cav. | 24.33* | 24.02 | 97.69 |
| Coriander (herb) | *Coriandrum sativum* L. | 24.54* | 23.61 | 97.59 |
| Sweet basil | *Ocimum basilicum* Linn. | 24.58* | 23.53 | 94.12 |
| Eucalyptus | *Eucalyptus* sp | 25.50* | 21.79 | 95.65 |
| Parsley (seed) | *Petroselinum sativum* L. | 27.77* | 17.59 | 98.52 |
| Control | --- | 39.71 | 0.00 | 96.57 |
| LSD at 0.05 | --- | 5.99 | --- | 6.33 |

## SUMMARY

Seed oil of *Petroselinum sativum* L. (seed) oil was superior against all tested mite stages followed by *Ocimum basilicum* Linn. and *Coriandrum sativum* L.

(herb) oils in case of both protonymphs and adults. This order was changed to *Petroselinum sativum* L. (seed) oil followed by *Coriandrum sativum* L. (herb) and *Ocimum basilicum* Linn. Oils against mite eggs. *Cuminum cyminum* Linn., *Petroselinum sativum* L. (herb) and *Mentha spicata* L. oils showed an intermediate efficacy against all tested mite stages. Essential oils of *Eucalyptus sp.*, *Coriandrum sativum* L (seed) and *Citrus aurantium* L. exhibited very low potency against protonymph and adult stages. *T. urticae* eggs were more tolerant to tested essential oils than the adults and protonymphs. Most tested oils significantly shortened oviposition period and decreased egg laying. Oils of *Cuminum cyminum* Linn. and *Mentha spicata* L. were most potent than the other tested essential oils as a deterrent agent. Their Oviposition Deterrent Indices (ODI) reached 66.74% and 64.64%.

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