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Impact of plant extract and essential oil of clove, *Syzegium aromaticum*, on life table parameters of the two-spotted spider mite; *Tetranychus urticae* koch (Acari: Tetranychidae).

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The effect of clove extract and essential oil of *Syzegium aromaticum* were investigated on life-table parameters of *Tetranychus urticae* (Acari:Tetranychidae) in the laboratory condition (25±2°C and 60%R.H.). Bioassay was conducted to assess the effect of plant extract effective concentrations that were caused between 10-90% mortality. Also, to assess the effect of different concentration of clove essential oil on the two spotted spider mite. Mortality, fecundity and longevity of females that survived from treatments were determined. Results show that, significant difference between clove extract *S. aromaticum* and its essential oil, on the life table parameters of the two-spotted spider mites. Essential oil is more effective than the extract. Clove essential oil had considerable effect on fecundity of *T. urticae* and showed a significant reduction on this parameter. Clove essential oil caused reduction in longevity (r_m) more than the extract, and caused increased in the development time to 11 day more than the extract 9.41 days. These result suggest that clove essential oil could be incorporated in integrated pest management (IPM) programs of *Tetranychus urticae*.

Keywords: *Syzegium aromaticum*, Clove, *Tetranychus urticae*, Life table parameters.

INTRODUCTION

The two- spotted spider mite is one of the most important pests of many crops worldwide. It attacks more than 1.000 economically important plant species of agricultural and ornamental plants (Gallo et al., 2002; Baptiste et al., 2003; Fasulo and Denmark, 2004).

Plant extracts have more attention in controlling many of the serious pests especially in tropical and subtropical countries. Also they are biodegradable and very low in mammalian toxicity and potentially compatible with natural enemies (Ebenso, 2004). Many studies have been carried out about plant extracts in the last decades (Erdogan et al., 2010). Neem extract, cumin, spearmint, rosemary, marjoram, thyme and citronella oils; caraway, anise, black pepper, fennel extracts; were tested against the red spider mite (Barakat et al., 1985).

Acaricidal activities of various essential oils have been assessed to *T. urticae* (Lee et al., 1997; Chiasson et al., 2001 and Refeat et al., 2002). Choi et al., (2004) has evaluated 53 plant essential oils against *T. urticae*. Before any control measure against a pest have to be taken, the thorough knowledge about biology of the pest

is necessary.

The net reproductive rat (R_0) are important indicators of tetranychid population dynamics (Krips et al., 1998; Pietrosiuk *et al*., 2003)**.** Comparisons of R_0 and r_m often provide considerable insight beyond that available from independent analysis of individual life history parameters (Zhang et al., 2007).

In this study, LC_{50} of *Syzegium aromaticum* plant extract and its essential oil were investigted against *T. urticae* and the effect of this natural pesticide has been studied on life table parameters of two spotted spider mite on *Acalypha marginata*. Aim of this study to show the effect of plant extract and essential oil of clove on life table parameters on *T. urticae* in laboratory.

MATERIALS AND METHODS

Tested mites

A population of *T. urticae* was taken from the laboratory of Acarology, Plant Protection Research Institute, Agriculture Research Center, Giza, Egypt. The mites were reared on the upper surface of leave of bean, *Phaseolus vulgaris*, and left to reproduce under laboratory condition (25±2°C and 60±5% R.H.).

Tested materials

Flower buds of clove, *Syzygium aromaticum*, are obtained from Dept. of Ornamental Horticulture, Faculty of Agriculture, Cairo University. A weight of 250 g of clove was ground in electric grinder into fine powder, then soaked in 350 ml hexane or 500 ml acetone, left for 2hrs, filtered to dryness under vacuum using a rotary evaporated in water bath at 50°C. The crude extract was then weighted and adjusted to 10 ml volume with acetone, kept in a refrigerator until used (Su and Horva, 2007).

Commercial of clove essential oil was obtained from El-Hawag Company. Series of aqueous concentrations of clove essential oil was prepared with Triton-100 as emulsifier agent at rate of 0.1%

Bioassay

Clove extract bioassay was conducted to determine the effective concentrations that were caused between 10-90% mortality. Ten adults of *T. urticae* were placed onto discs (2 cm diameter) of copper leaf, *Acalypha marginata*, that was placed separately upside-down on moist cotton Pads in Petri-dishes. Then sprayed with four concentrations (0.05, 0.0375, 0.018 and 0.009 mg/ml) of *S. aromaticum* hexane extract, dissolved in acetone as a solvent, and the control is with acetone only. After spraying, the adults were kept at room temperature. Adult mortalities were determined under a stereomicroscope after 24h.

Clove essential oil, four concentrations; 2%, 1%, 0.05% and 0.025%, of the tested essential oil of S*. aromaticum*, dissolved in water and one drop of triton x-100, were used. The control is composed of water and one drop of triton x-100. Ten adults were placed on the copperleaf, *Acalypha marginata*, and sprayed with the essential oil. After spraying the adults were kept at room temperature. Adult mortalities were determined under a stereomicroscope after 24h.

Four replicates were used for each concentration and control in both clove extract and essential oil applications. Mites were considered to be dead if their bodies or appendages did not move when prodded with fine brush. The LC_{50} value was corrected by Abbott's formula (Abbott, 1925).

Life table parameters.

Adults were maintained in the same leaf discs throughout the whole bioassay. Daily records for pre-oviposition and oviposition periods and fecundity were made. Life table parameters were taken until the death of the last individual. In order to obtain a non-detectable error doubt to the bioassay, sixteen rearing units were sprayed for each of control, clove extract and clove essential oil experiments (Rejman and Jesiort, 1977).

Life tables of *T. urticae* were constructed from the life history and fecundity data. The actual death occurred in the egg and immature stages were taken into account when the female survival rate at room temperature was determined. The total eggs laid by each individual were counted daily and each female transferred to the new leaf disc. This continued until death of all individuals. Life tables were constructed using the survival data of age–specific survival rates (Lx) and average number of female offspring produced per female in each age class (Mx), for each age interval (x). The net reproductive rate (R_0), the mean generation time (T), the intrinsic rate of increase (r_m), and the finite rate of increase (λ) were calculated.

Statistical analysis

Life table parameters were calculated, according to Birch (1948) using the basic computer program of Abou-Setta et al., (1986).

RESULTS

In this study, the lethal effect of clove, *Syzegicum aromticum*, essential oil is more effect than plant hexane extract. LC_{50} and LC_{90} on *T. urticae* were determined after 24h (Table 1).

Effect of plant extract of *Syzegium aromaticum* (clove)on life table parameters on two- spotted spider mite *Tetranychus urticae* Koch.

Table (2) shows results the effect of clove extract, *S. aromaticum* on life table parameters of *T. urticae*, there are significant reduction in each of r_m, R_0 and λ. The *S. aromaticum* extract caused a reduction in longevity, survival from 0.24 in control to 0.19 female/ female/day .The net reproductive rate R_0 decreased from 22.47 in control to 13.71 female/generation, but increase the mean generation time (T) from 12.7 in control to 13.7 in treated females. Fecundity and thereby causes a reduction in λ.

The λ value obtained with mites treated by *S. aromaticum* extract, was lower than that for mites untreated, which indicates that the population would develop much lower in treated mites. Similar to our results, Martinez and Nim (2002), who reported *T. urticae* treated by azadirachtin showed a negative value of r_m, resulting in a declining population.

Also, S´aenz-de-Cabazon *et al*. (2008) found that triflumuron caused a reduction in both of the percentage of eggs, that developed to adult stage, and the fecundity. The net reproductive rate (R_0), the intrinsic rate of increase (r_m) and the finite rate of increase (λ) of treated females were lower than those non treated, resulting in a reduction of population growth.

The course the age–specific survival rate (Lx) and age-specific fecundity (Mx) of *T. urticae* for control and treatments with clove extract are showed in Figure (1). At the control, peak of oviposition was quicker than that of clove extract. The results indicated significant differences among the fertility life table parameters of *T. urticae* caused by clove and control.

Effect of clove essential oil, Syzegium aromaticum, on life table parameters on two-spotted spider mite *Tetranychus urticae* Koch:-

Table (3) show the effect of essential oil of *S. aromaticum* on life table parameters show significant reduction in R_0, the net reproductive rate decreased from 10.56 in control to 9.10 in the treated discs. Also, the mean generation time (T), decreased from 14.7 in control to 14.12 in discs treated with essential oil of *S. aromaticum.* The longevity (r_m) decreased when used clove essential oil from 0.15 in control to 0.1. Similar to our results, is the study of Modarres-Najafabadi *et al*. (2014). They have been reported that, *T. urticae* treated by thymal essential oil can be considered as an acaricide against the two spotted spider mite, causing reduction in fecundity and longevity in the laboratory at concentration that cause no phytotoxicty to the host plants.

The course of age–specific survival rate (Lx) and age-specific fecundity (Mx) of *T. urticae* from control and treatment with clove essential oil are show in Figure (2). The results indicated significant differences among the fertility life table parameters of *T. urticae* caused by treatment with essential oil and the control.

Also there are significant difference between the clove, *S. aromaticum*, extract and its essential oil, on life table parameters of the two–spotted spider mites. The results obtained with the application of essential oil are more efficient than that of the extract. Essential oil had considerable effect on fecundity of *T. urticae* and showed a significant reduction in life table parameter. Also, clove essential oil caused reduction in longevity (r_m) to be 0.11, but in case clove extract longevity was 0.19, the change in longevity may affect fecundity and led to change in the population dynamism (Croft, 1990). Also clove essential oil caused increase in the developmental time (11 days) than that of clove extract (9.41 days), while in the control (water and triton) is 10.8 days and the other control (acetone) 8.5 day.

Sex ratio was similar at control of the two experiments, 0.73, (three females/one male), similar observation was reported by van de Vrie (1985) who mentioned that the normal sex ratio for the Tetranychidae is 1 male/3 females.

Also, Abo-Shnaf (2017) found that, sex ratio was similar at all tested temperatures as three females per one male, with the highest proportion of females occurring at 30°C. But clove extract cause increase in sex ratio to 0.78 while its essential is oil more effective to increase sex ratio to 0.83. These results suggest that clove, *Syzegium aromaticum*, essential oil could be incorporated in integrated pest management (IPM) programs of *Tetranychus urticae*.

Table (1): Estimation of LC_{50} and LC_{90} of *T. urticae*, treated with extract and essential oil of *Syzegicum aromticum.*

Tested Materials	Adults			Eggs		
	LC_{50}	LC_{90}	Slope	LC_{50}	LC_{90}	Slope
Hexane extract mg/ml	0.0068	0.03	1.76	0.01	0.4	0.79
Essential oil %	0.8	2.1	3.0	2.1	10.0	1.92

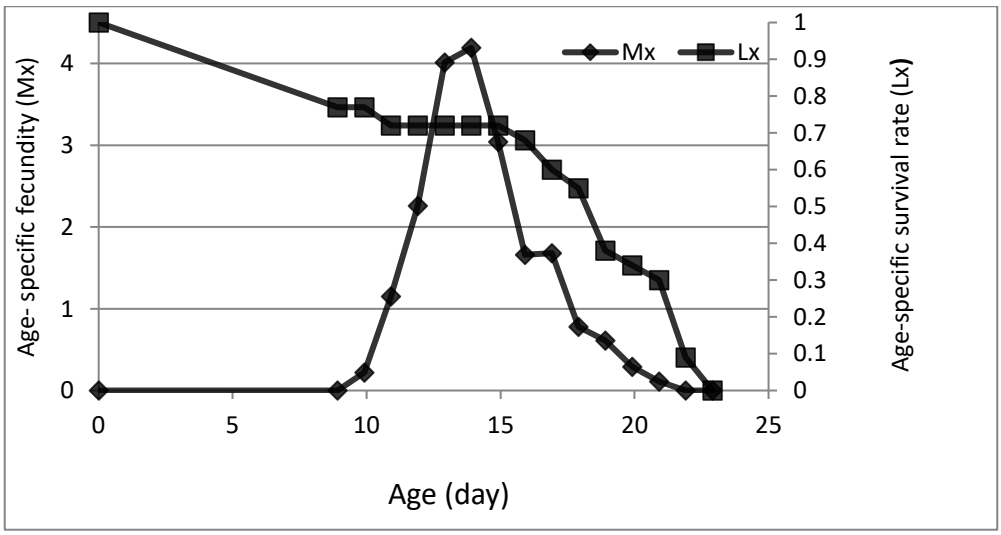
Table (2) Life-table parameters of T.urticae with clove extract extract and acetone as control.

Parameter	Control	Clove extract
The developmental time	8.5	9.41
Sex ratio (female/total)	0.73	0.78
The net reproductive rate (R_0)	22.47	13.71
Mean generation time (T)	12.7	13.7
The intrinsic rate of increase (r_m)	0.24	0.19
The finite rate of increase (exp. Rm) **λ**	1.27	1.21
The fraction of eggs reaching maturity	0.767	0.767

Table (3) Life-table parameters of T.urticae with clove essential oil and the control.

Parameter	Control	Essential Oil
The developmental time	10.8	11.0
Sex ratio (female/total)	0.73	0.83
The net reproductive rate (R_0)	10.56	9.10
Mean generation time (T)	14.7	14.12
The intrinsic rate of increase (r_m)	0.146	0.106
The finite rate of increase (exp. Rm) **λ**	1.15	1.17
The fraction of eggs reaching maturity	0.91	0.85

a- Clove extract



b- Control of clove extract

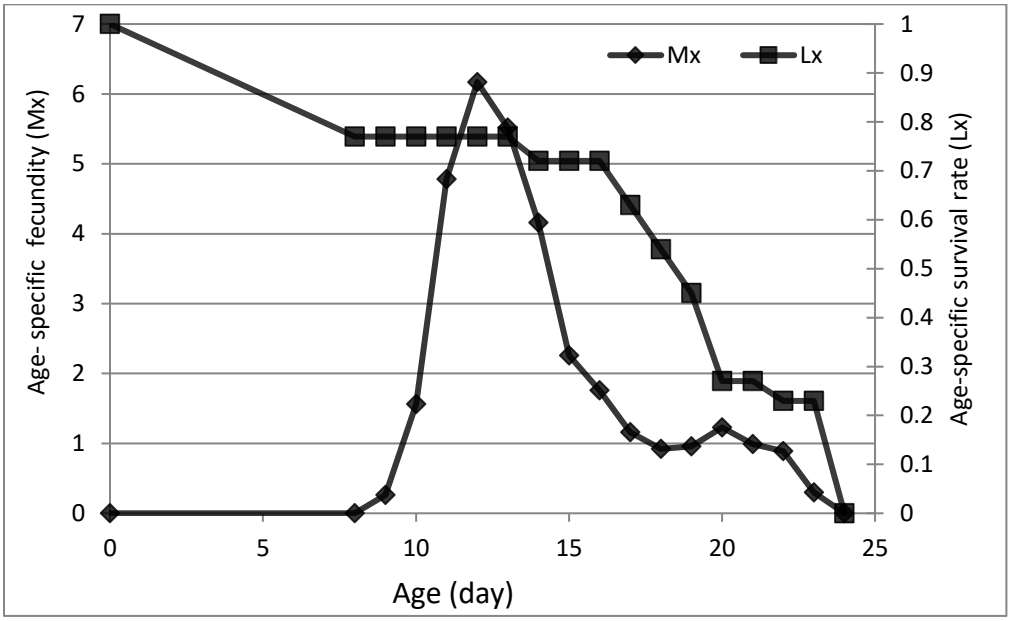
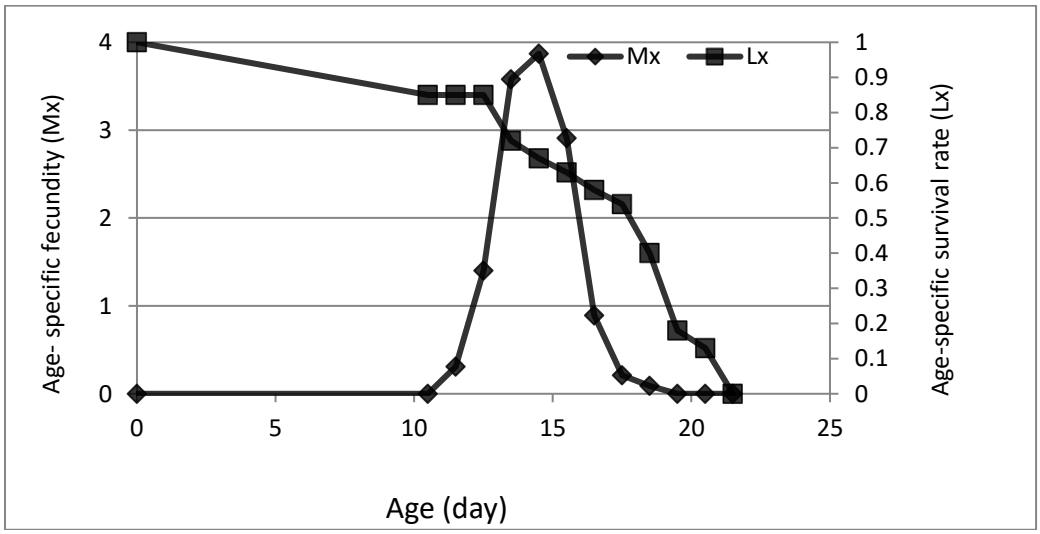


Figure. (1) Effect of clove extract on age-specific survival rate (L_x) and age-specific fecundity (M_x) of *T. urticae* .

Essential oil



a- Essential oil control

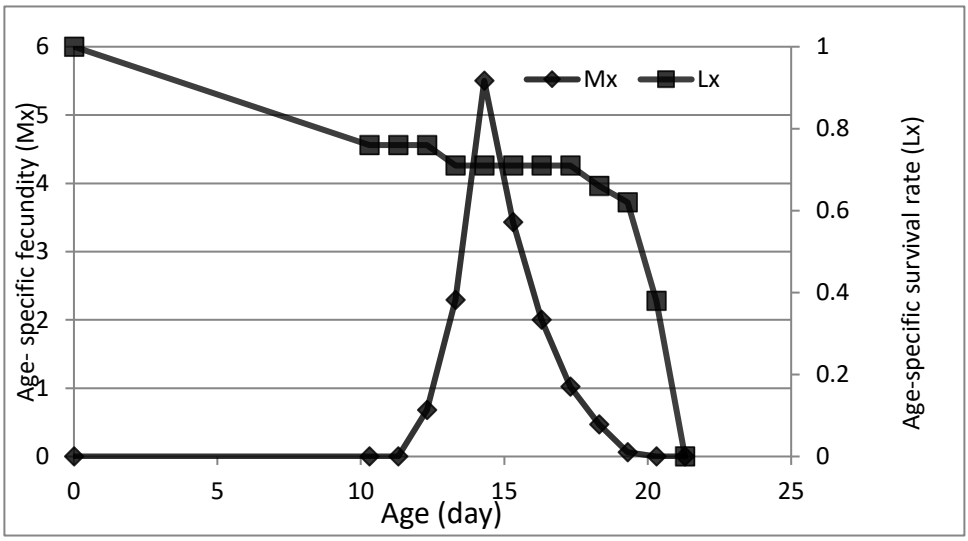


Figure.(2) Effect of clove essential oil on age-specific survival rate (L_x) and age-specific fecundity (M_x) of *T. urticae* .

CONCLUSION

Application of each of hexane extract and essential oil of clove, *Syzegium aromaticum*, on the life table parameters of the two-spotted spider mites, *Tetranychus urticae*, is significant, essential oil is more effective than the extract.

Clove essential oil had considerable effect on fecundity of *T. urticae* and showed a significant reduction on this parameter, and caused reduction in longevity (r_m) more than the extract, and increased in the development time to 11 day more than the extract 9.41 days.

These results suggest that clove essential oil could be incorporated in integrated pest management (IPM) programs of *Tetranychus urticae*.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

All authors contributed equally in all parts of this study

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