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Article

How organic medicinal plants affect life table parameters of *Tetranychus urticae* (Acari: Tetranychidae)?

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ABSTRACT
In this study, life table parameters of the two-spotted spider mite (TSSM) on four organic plants belonging to, Brassicaceae: Siberian (Russian) kale, *Brassica napus* L. var. *pabularia* L., Lacianto (Tuscan/Italian) kale, *Brassica oleracea* var. *palmifolia*, and Lamiaceae: Spearmint, *Mentha spicata* L. and Saudi Mint, *Mentha longifolia* L. were evaluated. The study also aimed to investigate plant nutritional content and morphological characters to explain how plant sources affect the life parameters of TSSM. Plants were cultivated in two organic locations: Giza Governorate (30° 09' 07.0" N, 30° 51' 00.2" E), and Fyoum Governorate (29° 34' 40.9" N, 30° 55' 38.3" E). Experiments were under laboratory conditions at 28 ± 2 °C and 75–80% RH. TSSM had the shortest life cycle, longevity, life span, the highest values of intrinsic rate of increase (r_m), net reproductive rate (R_0), finite rate of increase (λ), gross reproductive rate (*GRR*), shortest mean generation time (*T*) and doubling time (*DT*) on Siberian kale (Brassicaceae). Plant leaves were scanned by SEM to determine how plant texture could affect the TSSM's biology. Plant nutritional contents resulted in highly significant differences among the dry material of four tested plants for Nitrogen (N), Phosphor (P), Potassium (K), Sodium (Na) and Calcium (Ca). It is concluded that organic plant source, definitely affect life table parameters and behavior of TSSM. Plant-herbivore relation, were significant due to plant nutritional contents and morphological characters.

KEY WORDS: *Brassica napus* var. *pabularia*; *B. oleracea* var. *palmifolia*; Brassicaceae; Lamiaceae; *Mentha longifolia*; *M. spicata*; organic agriculture; plant nutritional contents.

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INTRODUCTION

Food and food components not only are satisfying hunger and providing nutrients, but also significantly influence human health and well-being (Siro *et al.* 2008; Šamec *et al.* 2019). Organic

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farming as an environmental friendly form of agriculture, provides organic food which is healthier because it does not contain synthetic chemicals traces. In contrast, traditional agriculture with non-controlled use of chemical resources have been reported to produce foods leading to cancer (Stolze 2000; Trewavas 2004; Nejadkoorki 2012; IFOAM 2018).

The Brassicaceae family has 341 genera and 3977 species. Vegetables from genus *Brassica* are being paid attention for several decades because numerous epidemiological studies provide evidence that diets rich in cruciferous vegetables are associated with lower risk of several types of cancer and other chronical diseases (Koch *et al.* 2012; Šamec and Salopek-Sondi 2019; Šamec *et al.* 2019). Kale (*Brassica oleracea* Acephala group) has much importance due to the rich amount of bioactive components as vitamin C, pro-vitamin A, glucosinolates, phenolic antioxidants, dietary fibre, micronutrients (Fe, Z and Mn) and macronutrients (Ca and Mg) (Ayaz *et al*. 2006; Cartea *et al.* 2008; Olsen *et al*. 2009). Also, *in vitro* and *in vivo* studies propose that kale plants have an optimistic impact on the avoidance of chronical diseases, as cardiovascular diseases (Kahlon *et al.* 2007; Kim *et al.* 2008; Kural *et al.* 2011) and cancer (Chung *et al.* 2002).

Lamiaceae is a very large group containing many genera and species. They have an economical value due to their pharmaceutical importance, as treatments of many diseases, such as obesity, Alzheimer's disease, dermatophytosis, and drug-resistant infections (Ali-Shtayeh *et al*. 2019). Also, Lamiaceae plants are active anti-cancers. *Mentha spicata* has a significant effect in treatment of many gastro-intestinal disorders (Rokaya *et al*. 2010). Also, it has anti-microbial, anti-cancer and anti-inflammatory properties (Kaefer and Milner 2008; Gathirwa *et al.* 2011; Hajighasemi *et al.* 2011).

The two-spotted spider mite (TSSM), *T. urticae* is an important agricultural worldwide pest that feeds on a wide range of hosts, including thousands of agricultural crops, fruit trees, tunnel vegetables, fresh herbs, medicinal and aromatic plants (Migeon *et al.* 2015; Migeon and Dorkeld 2019). Several investigations reported TSSM as a pest of Brassicaceae and Lamiaceae medicinal plants (Tollerup *et al*. 2013; Marić *et al*. 2018; Allam *et al*. 2018). The aims of this study were: (i) to compare life table parameters of the TSSM on *B. napus* var. *pabularia* and *B. oleracea* var. *palmifolia* (Brassicaceae), *M. spicata*, *M. longifolia* (Lamiaceae), (ii) to explore the plant nutritional contents and morphological characters to explain how plant sources affect the life table parameters of the TSSM.

MATERIALS AND METHODS

Plant source

Seedlings of tested organic Siberian (Russian) kale and Lacianto (Tuscan) kale were introduced from Egyptian Hydrofarms farm (KM 53 Cairo-Alex Desert Road, Inside Al Azzazy Village, Cairo, Egypt 30° 09' 07.0" N, 30° 51' 00.2" E). While, spearmint and Saudi mint seedlings were introduced from a private farm of organic medicinal plants in Fyoum Governorate (Kom Oshim, Fyoum, Egypt 29° 34' 40.9" N, 30° 55' 38.3" E). Parallel rows of the tested plants were cultivated in the greenhouse of Faculty of Agriculture, Cairo University (30° 01' 12.4" N, 31° 12' 32.6" E) as a source of traditional farming.

Nutrient content analysis

Two sets of experiments were carried out in the plant nutrition Laboratory, NRC, (i) organic plants, and (ii) traditional plants. Fresh samples of tested plants of both sets were dried in the oven at 70 °C. After drying, samples were processed using a mixture of sulfuric and perchloric acids. Plant nutritional content percentages were extracted to be analysed by the following methodologies according to Cottenie *et al*. (1982); nitrogen using Microkjeldahl technique, phosphorus by colorimetric technique, and potassium was determined using flame photometer.

The increasing percentage of a nutrient in the dry material of tested organic plants comparing to the same plants in traditional conditions (control), formula was designed as follows:

$$\left(\frac{\text{Sample after treatment (organic)} - \text{before treatment (control)}}{\text{before treatment (control)}} \times 100\right)$$

Scanning Electron Microscope (SEM) preparation

One cm^2 in diameter freshly cut leaves of four tested plants were prepared by Glutaraldehyde 3%, washing for one hour, then washed in a buffer for three times then transferred to 10–100% alcohol series for five minutes per each concentration. Samples dried and covered with Sputter/Carbon coater for scanning in Hitachi S-4700 field emission Scanning Electron Microscope.

Mites colony

Females of *T. urticae* were collected from infested kale leaves. Individuals were reared at laboratory conditions (27 ± 2 °C and 65 ± 10% RH). The rearing substrate was leaves of Siberian kale, placed upsidedown on water-saturated cotton in plastic Petri-dishes 15 cm. Stock colonies were kept for approximately three months before the experiments.

Experimental design

Tetranychus urticae eggs were transferred individually in leaf discs (3 cm^2). Four sets were made for each tested plant. Discs were placed onto moist cotton pads in small Petri-dishes (5 cm), each disc was a replicate, and each experiment contained 50 replicates.

The experimental units were examined every 24 hours to determine the immature development duration, pre-oviposition, oviposition, and post-oviposition. Progeny was reared to adulthood to calculate sex ratio of each food source according to formula as follows:

$$\left(\frac{Female}{\text{Female} + \text{Male}} \times 100\right).$$

Statistical analysis

Means were compared by SPSS© 20.00. Statistics for each analysis were based on cases with no missing data for any variable in the analysis. Data were analysed by one-way analysis of variance (ANOVA) and comparisons were performed by Tukey's test and Student's *T*-test. Life table parameters were calculated using a computer program based on Birch (1948) formulas: The age-specific survival (*lx*), The age-specific fecundity (*mx*) = born females/female, the net reproductive rate (R_0) = Σ ($l_x m_x$), the intrinsic rate of increase (r_m) = Σ ($e^{-rm} l_x m_x$) =1, the mean generation time (*T*) = $\frac{lnRc}{r}$, the finite rate of increase (λ) = e^{rm}, the doubling time (*DT*) = $\frac{ln2}{r}$ was calculated according to Mackauer (1983), and the Gross reproductive rate (*GRR*) = Σ (m_x) according to Kairo and Murphy (1995). Variances and standard errors of the population parameters (r_m, R_0, λ and *T*) analysed by SPSS® Tukey's uses harmonic mean sample size (n) = 31.

RESULTS

Development, longevity and fecundity of Tetranychus urticae *females*

The plants of Brassicaceae and Lamiaceae have significant effects on the developmental duration, female longevity, fecundity and the life span of *T. urticae*. *Brassica napus* var. *pabularia* has the shortest developmental duration and life cycle (14.06 ± 0.15) days, while the longest duration was recorded in *M. longifolia* (21.92 ± 0.25) days, (F = 63.40, *P* = 0.000) (Table 1). Adult female longevity was significantly affected by the plant variety, when it was short in *B. napus* var. *pabularia* (14.71 ± 0.24 days), moderate in *B. oleracea* (16.00 ± 0.26 days) and *M. spicata* (19.73 ± 0.30 days), the longest female longevity was 21.40 ± 0.23 days recorded in *M. longifolia* when (F = 46.16, *P* = 0.000). Female life span was significantly the shortest when fed *B. napus* var. *pabularia* (28.77 ± 0.31 days), and was the longest when fed *M. longifolia* (43.32 ± 0.34), (F = 45.91, *P* = 0.000) (Table

2).

Table 1. Post-embryonic developmental duration (days) (mean ± SE) of *Tetranychus urticae* females fed on four organic medicinal plants, *B. napus* var. *pabularia*, *B. oleracea* var. *palmifolia*, *M. spicata* and *M. longifolia* at 28 ± 2 °C, 75 ± 5% RH.

Plant cultivars	Brassicaceae		Lamiaceae		F-test
	B. napus	***B. oleracea***	***M. spicata***	***M. longifolia***	
N	31	31	30	31	
Egg	4.00 ± 0.00	4.00 ± 0.00	4.00 ± 0.00	4.00 ± 0.00	-
Larva	1.29 ± 0.08 d	2.00 ± 0.14 c	3.03 ± 0.10 b	3.74 ± 0.13 a	88.08*
Quiescent	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00	-
Protonymph	2.10 ± 0.05 d	2.68 ± 0.90 c	3.27 ±0.08 b	4.16 ± 0.14 a	85.34*
Quiescent	1.22 ± 0.10 c	1.22 ± 0.07 c	1.73 ± 0.08 b	2.00 ± 0.00 a	32.77*
Deutonymph	2.65 ± 0.09 d	3.30 ± 0.12 c	4.17 ± 0.13 b	4.48 ± 0.10 a	62.16*
Quiescent	1.81 ± 0.07 c	1.87 ± 0.06 c	2.37 ± 0.10 b	2.55 ± 0.10 a	21.42*
Total life cycle	14.06 ± 0.15 d	16.10 ± 0.22 c	19.57 ± 0.24 b	21.92 ± 0.25 a	63.40*

Means within rows, followed by the same letter are not significantly different (Tukey). ANOVA test's df = (3, 119)
(*) significant at $P \leq 0.01$

Table 2. Biological parameters of *Tetranychus urticae* female; longevity and life span (mean ± SE) on four organic medicinal plants at 28 ± 2 °C, 75 ± 5% RH.

Plant cultivars	Brassicaceae		Lamiaceae		F-test
	B. napus	***B. oleracea***	***M. spicata***	***M. longifolia***	
N	31	31	30	31	
Pre-oviposition	2.13 ± 0.06 c	2.39 ± 0.10 b	2.53 ± 0.10 b	2.68 ± 0.09 a	22.95*
Oviposition	11.10 ± 0.18 d	12.00 ± 0.20 c	15.36 ± 0.24 b	16.71 ± 0.21 a	90.13*
Post-oviposition	1.48 ± 0.10 d	1.61 ± 0.09 c	1.83 ± 0.07 b	2.00 ± 0.00 a	10.06*
Total longevity	14.71 ± 0.24 d	16.00 ± 0.26 c	19.73 ± 0.30 b	21.40 ± 0.23 a	46.16*
Life span	28.77 ± 0.31 d	32.06 ± 0.40 c	39.30 ± 0.40 b	43.32 ± 0.34 a	45.91*

Means within rows, followed by the same letter are not significantly different (Tukey). ANOVA test's df = (3, 119)
(*) significant at P ≤ 0.01

Table 3. Biological parameters; fecundity and sex ratio of *Tetranychus urticae* females (mean ± SE) fed on four organic plant varieties at 28 ± 2 °C, 75 ± 5% RH.

Plant cultivars	Brassicaceae		Lamiaceae		F-test
	B. napus	***B. oleracea***	***B. napus***	***B. oleracea***	
Total fecundity	92.94 ± 1.16 a	81.16 ± 1.25 b	63.30 ± 1.07 c	50.26 ± 0.95 d	56.50*
Daily fecundity	6.38 ± 0.15 a	5.12 ± 0.12 b	3.23 ± 0.08 c	2.36 ± 0.05 d	87.40*
Sex ratio (%)	65.50	61.00	59.45	55.64	

Means within rows, followed by the same letter are not significantly different (Tukey). ANOVA test's df = (3, 119)
(*) significant at P ≤ 0.01

Fecundity of Tetranychus urticae

Owing to feeding, there were significant differences in the fecundity and sex ratio of *T. urticae* females. The highest fecundity rate was recorded in *B. napus* var. *pabularia* (92.94 ± 1.16 eggs/♀ and 6.38 ± 0.15 eggs/♀/day), while the lowest fecundity rates were recorded in *M. longifolia* (50.26 ± 0.95 eggs/♀ and 2.36 ± 0.05 eggs/♀/day). Significant differences were reported in the fecundity rate between four organic feeding sources, at probability level 99%, the total number of eggs per a female ($F = 56.50$, $P = 0.000$), and the daily number of eggs deposited per female (eggs/♀/day) ($F =$

87.40, P = 0.000) (Table 3).

Life table parameters of Tetranychus urticae

Feeding on the four tested plant varieties resulted in the highest value for *T. urticae* fed *B. napus* var. *pabularia* of intrinsic rate of increase (r_m) was 0.228 ± 0.02 individuals/female/day; the net reproductive rate (R_0) was 60.85 ± 2.10; the finite rate of increase (λ) was 1.25 ± 0.10, the shortest mean generation time (T) was 18.24 ± 1.10 days, the shortest doubling time (DT) was 3.08 ± 0.15 days and highest gross reproductive rate (*GRR*) was 63.44 ± 2.13. The lowest value for *T. urticae* fed *M. longifolia* of intrinsic rate of increase (r_m) was 0.121 ± 0.03 individuals/female/day; the net reproductive rate (R_0) was 27.87 ± 1.15; the finite rate of increase (λ) was 1.13 ± 0.00, the longest mean generation time (T) was 27.34 ± 1.00 days, the highest doubling time (DT) was 5.70 ± 0.20 days and lowest gross reproductive rate (*GRR*) was 28.10 ± 2.00 (Table 4).

Table 4. Demographic parameters (± SE) of *Tetranychus urticae* females on four organic medicinal varieties, *B. napus* var. *pabularia*, *B. oleracea* var. *palmifolia*, *M. spicata* and *M. longifolia* at 28 ± 2 °C, 75 ± 5% RH.

Plant variety	*B. napus*	*B. oleracea*	*M. spicata*	*M. longifolia*
r_m	0.228 ± 0.02 a	0.189 ± 0.01 b	0.148 ± 0.01 c	0.121 ± 0.03 d
R_0	60.85 ± 2.10 a	49.51 ± 1.21 b	37.67 ± 1.53 c	27.87 ± 1.15 d
λ	1.25 ± 0.10 a	1.21 ± 0.20 ab	1.16 ± 0.35 ab	1.13 ± 0.00 b
T	18.24 ± 1.10 d	20.61 ± 1.42 c	24.54 ± 0.95 b	27.34 ± 1.00 a
Dt	3.08 ± 0.15 d	3.66 ± 0.22 c	4.69 ± 0.50 b	5.70 ± 0.20 a
GRR	63.44 ± 2.13 a	50.62 ± 1.45 b	38.41 ± 1.10 c	28.10 ± 2.00 d

Means within rows, followed by the same letter are not significantly different (Tukey, $P \leq 0.01$).

The rate of survival (*Lx*) (percent of surviving females at the instant x) and the rate of female progeny per female (*Mx*) (number of female eggs laid per female per day) for *T. urticae* fed on *B. napus* var. *pabularia*, *B. oleracea* var. *palmifolia*, *M. spicata* and *M. longifolia* are shown in figure 1.

Plant nutrient content analysis

Significant differences resulted when one-way analysis (ANOVA) of plant nutritional contents among the dry material of four tested organic medicinal plants were analyzed; for nitrogen (N) (F = 8.68, P = 0.000); phosphor (P) (F = 9.90, P = 0.000); sodium (Na) (F = 5.12, P = 0.001), slightly significant in case of calcium (Ca) (F = 4.30, P = 0.01) and not significant for potassium (K) (F = 4.13, P = 0.03) (Table 5).

The nutrient increasing percentage was the highest in N amount for *B. napus* var. *pabularia* was 38.07%, also the P content; increasing percentage was 40.00% for *M. longifolia*, and *M. spicata* recorded the highest increasing percentage of K and Na of 32.72% and 23.08%, respectively. The highest increasing amount of Ca was recorded in *B. oleracea* var. *palmifolia* (23.75%) (Table 5).

There were significant differences within the Brassicaceae group *B. napus* var. *pabularia* which was higher than *B. oleracea* var. *palmifolia* in the percentage of potassium (T = 2.60, P = 0.000), calcium (T = 9.43, P = 0.000), and slightly higher in nitrogen content percentage (T = 2.87, P = 0.008). Phosphorus resulted lower percentage (T = 1.06, P = 0.03). While no significance was detected in sodium (T = 0.68, P = 0.113) (Table 6).

High significant differences were recorded within Lamiaceae group. Phosphorus, potassium and sodium showed non-significant differences. *Mentha longifolia* was higher than *M. spicata* in the nitrogen percentage content; it recorded 4.84 ± 0.02 (T = 5.56, P = 0.000), but was lower in the calcium percentage (T = 6.72, P = 0.000) (Table 6).

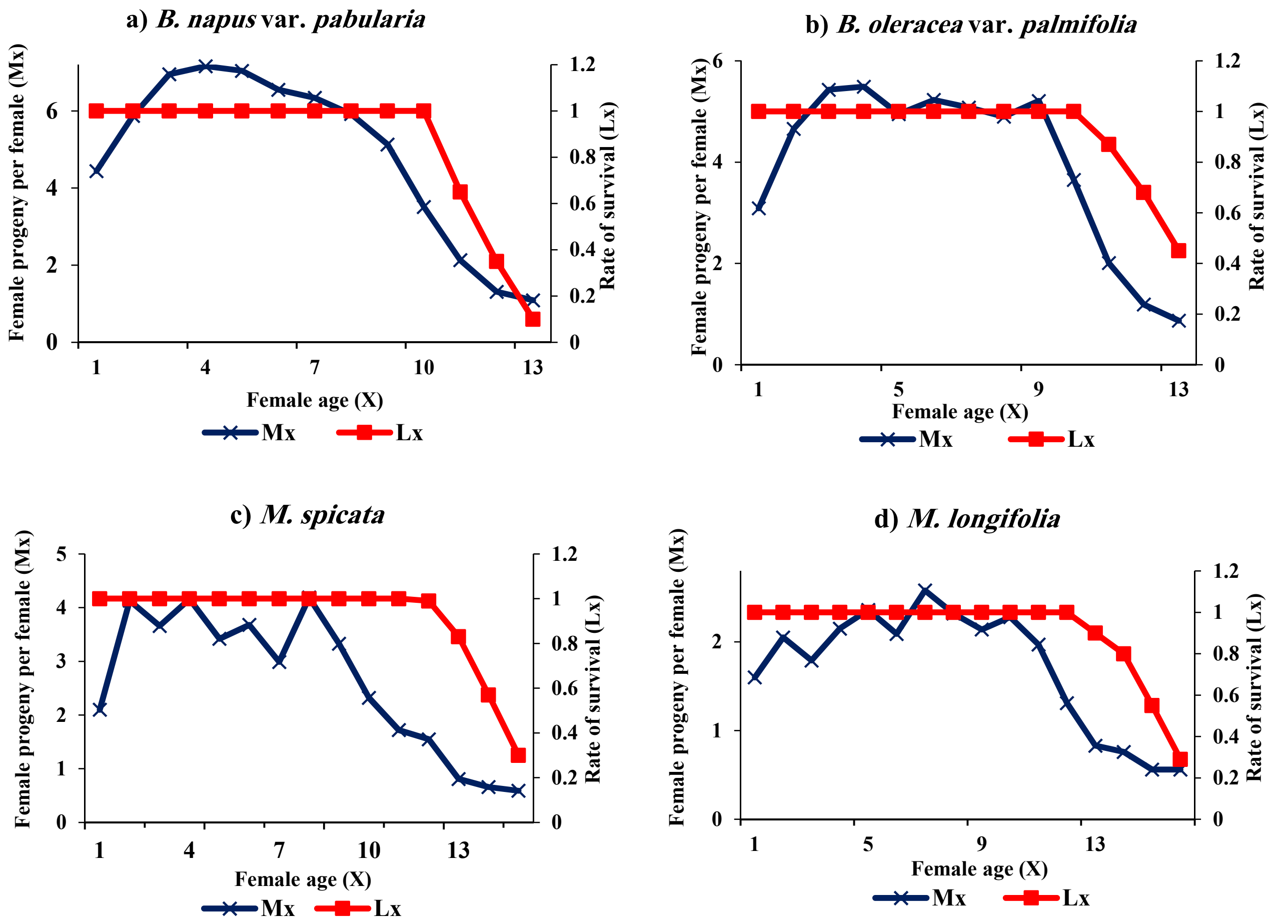

Figure 1. Female progeny per female (*Mx*) and rate of survival (*Lx*) of *Tetranychus urticae* on four organic medicinal plants varieties, **a.** *Brassica napus* var. *pabularia*; **b.** *Brassica oleracea* var. *palmifolia*; **c.** *Mentha spicata*; **d.** *Mentha longifolia*, at 28 ± 2 °C, 75–80% RH.

Table 5. Nutritional content (mean ± SE) and nutrient increasing percentage in dry material of four organic medicinal plant varieties, *B. napus* var. *pabularia*, *B. oleracea* var. *palmifolia*, *M. spicata* and *M. longifolia* at 28 ± 2 °C, 75 ± 5% RH.

Nutrient percentage \ Organic plant var.		Brassicaceae		Lamiaceae		F-test
		B. napus	***B. oleracea***	***M. spicata***	***M. longifolia***	
N	Organic	4.86 ± 0.01 a	4.63 ± 0.02 b	4.05 ± 0.05 c	4.84 ± 0.02 a	**8.68***
	Control	3.52 ± 0.00	3.51 ± 0.10	3.68 ± 0.02	4.00± 0.10	
	Increasing percentage	**38.07**	**31.91**	**10.10**	**21.00**	
P	Organic	0.31 ± 0.00 b	0.35 ± 0.01 b	0.46 ± 0.01 a	0.42 ± 0.01 a	**9.90***
	Control	0.30 ± 0.53	0.29 ± 0.00	0.35 ± 0.04	0.30 ± 0.06	
	Increasing percentage	**3.33**	**20.69**	**31.43**	**40.00**	
K	Organic	0.71 ± 0.01 a	0.57 ± 0.01 b	0.73 ± 0.02 a	0.73 ± 0.01 a	**4.13**^{ns}
	Control	0.57 ± 0.02	0.55 ± 0.72	0.55 ± 0.00	0.56 ± 0.05	
	Increasing percentage	**24.56**	**3.64**	**32.72**	**30.36**	
Na	Organic	0.60 ± 0.01 a	0.62 ± 0.01 a	0.32 ± 0.02 b	0.30 ± 0.02 b	**5.12***
	Control	0.56 ± 0.02	0.55 ± 0.00	0.26 ± 0.05	0.28 ± 0.00	
	Increasing percentage	**7.14**	**12.73**	**23.08**	**7.15**	

Table 5. Continued.

Nutrient percentage \ Organic plant var.		Brassicaceae		Lamiaceae		F-test
		B. napus	*B. oleracea*	*M. spicata*	*M. longifolia*	
Ca	Organic	1.22 ± 0.05 a	0.99 ± 0.01 b	1.30 ± 0.02 a	0.93 ± 0.01 b	**4.30***
	Control	1.15 ± 0.00	0.80 ± 0.05	1.18 ± 0.20	0.90 ± 0.07	
	Increasing percentage	**6.1**	**23.75**	**10.17**	**3.33**	

The means followed by similar letters in the row are not significantly different (Tukey), sample size (n) = 15. ANOVA test's df = (3, 46).
(ns) not significant, and (*) significant at P ≤ 0.01

Table 6. Comparison of plant nutritional contents (mean ± SE) intra Brassicaceae and intra Lamiaceae.

Plant varieties	Brassicaceae			Lamiaceae		
	B. napus	*B. oleracea*	T-test	*M. spicata*	*M. longifolia*	T-test
N	4.86 ± 0.01 a	4.63 ± 0.02 a	2.87*	4.05 ± 0.05 b	4.84 ± 0.02 a	5.56*
P	0.31 ± 0.00 a	0.35 ± 0.01 a	1.06 ns	0.46 ± 0.01 a	0.42 ± 0.01 a	1.20 ns
K	0.71 ± 0.01 a	0.57 ± 0.01 b	2.90*	0.73 ± 0.02 a	0.73 ± 0.01 a	0.12ns
Na	0.60 ± 0.01 a	0.62 ± 0.01a	0.68 ns	0.32 ± 0.02 a	0.30 ± 0.02 a	2.25 ns
Ca	1.22 ± 0.05 a	0.99 ± 0.01 b	9.43*	1.30 ± 0.02 a	0.93 ± 0.01 b	6.72*

The means followed by similar letters in the row are not significantly different, sample size (n) = 15.
(ns) not significant, and (*) significant at *P* ≤ 0.01

Scanning Electron Microscopy (SEM)

Morphological properties of tested plants results are shown in Figures 2 and 3. Tested Brassicaceae leaves have absent glandular trichomes, Siberian kale leaf has palmate shape, margins are lobed, and the leaf is very curly, the number of stomata significantly increases in the lower surface. While Tuscan kale leaf is flat with wedge shaped and acute base, its margins are semi-crenate. Tested Lamiaceae were rich glandular leaves, oil glands were dominant within the upper surface, and the lower surface has large number of stomata.

DISCUSSION

Feeding of the two-spotted spider mite is similar to plant-feeding insects, this multi-host pest has mouthparts adapted for a sucking mode of feeding (Park and Lee, 2002) provided with a stylet varying in length from 100 µm to 150 µm (Sances *et al.* 1979). A comprehensive study of Bensoussan *et al.* (2018) showed the feeding mechanism of the TSSM; first, the stylet penetrates the leaf without damaging the epidermal cellular layer, second, mites suck parenchyma cells without a preference for a cell type of this layer, third, the duration of feeding process ranges from some minutes to about half an hour approximately. Bensoussan *et al.* (2016) demonstrated that mite feeding is not affected by the host plant preference, so plant damages caused by TSSM feeding are due to limited damages of plant tissues and feeding process regularly causes a death of a particular cell. The limited feeding of *T. urticae* on cells within the mesophyll layer indicates the mite's preference for these cells; the origin for this preference is unknown.

Mainly, the phytophagous fed to get adequate nutrients needed for vital activities, they may also consume a wide range of plant defence compounds, which interfere with their physiological processes (Howe and Jander 2008). A terminology by Mothes-Wagner (1985) proposed the anatomy of TSSM's digestive system, it is structured as a foregut, midgut and hindgut. During digestion process, phytoelements are fragmented to release nutrients, enzymes, etc. which are needed in mite's metabolism. Reproduction and web formation are the largest actions consuming energy sources (Saito 1977; Blaazer *et al.* 2018).

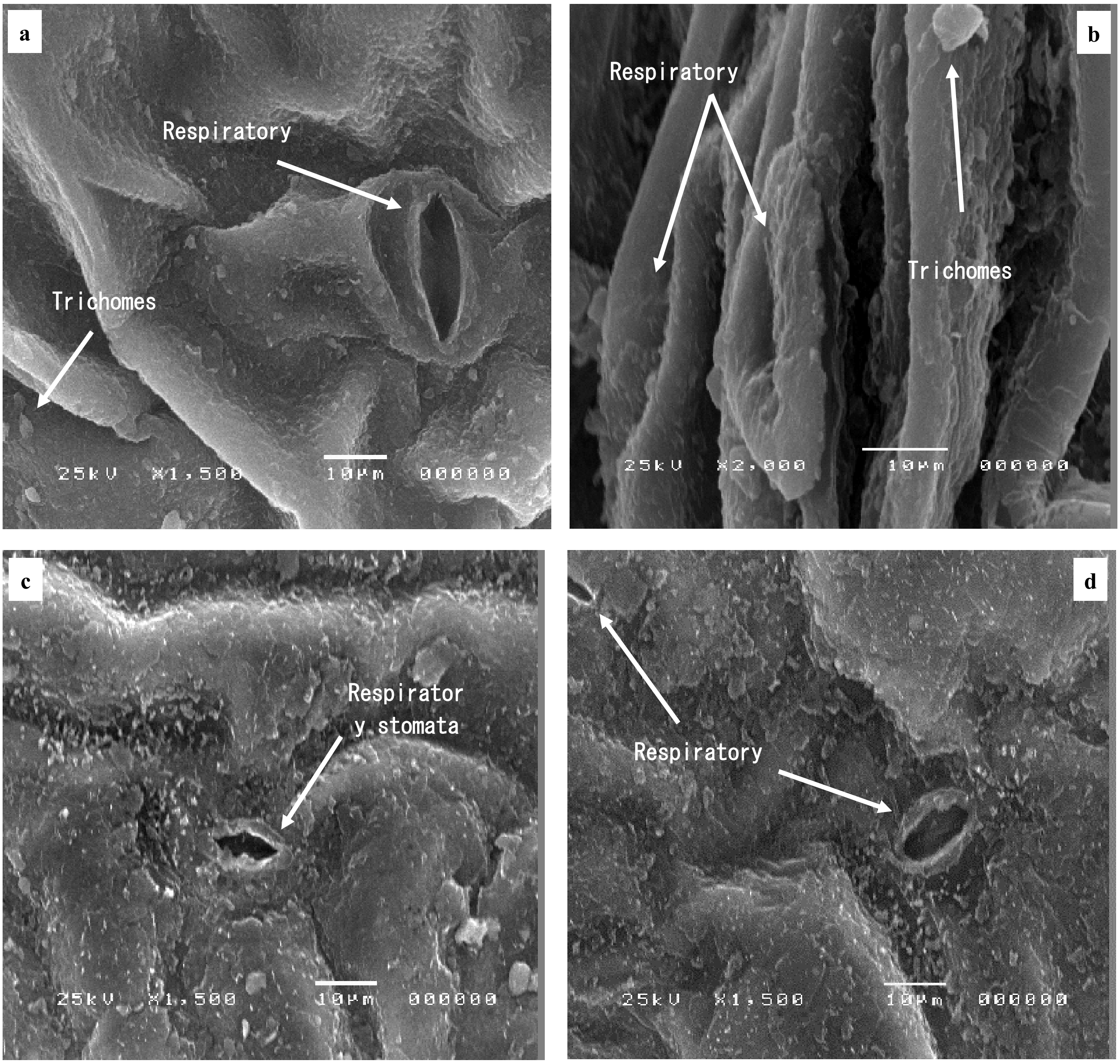

Figure 2. Scanning electron micrographs (SEM) of tested organic Brassicaceae plant leaf surfaces 10 µm, 1500× – **a, b.** Red Russian kale, *Brassica napus* var. *pabularia* (upper and lower leaf surfaces respectively); **c, d.** Tuscan kale, *Brassica oleracea* var. *palmifolia* (upper and lower leaf surfaces respectively).

In insects, the distribution of nutrients occurs through the haemolymph circulating within the haemocoel that is in direct contact with the sink tissues, nutrients stored in fat bodies as glycogen and lipid droplets (Arrese and Soulages 2010). Oppositely, mites do not have fat bodies (Mothes-Wagner 1985). TSSM tissues are compact, without cavity which could be linked to the haemocoel. TSSM digests plant nutrients in the gut. Though, along the TSSM's digestive system, it is not clear how and where these plant defence nutrients act to reduce mite's ability to recover nutrients (Blaazer *et al.* 2018).

Hunter (1964) proposed that organic treated plants provided a better balance of soil nutrients than the chemically fertilized (in traditional agricultural) and/or untreated plants. Plants in organic conditions are significantly larger, and also nutritionally and chemically different than those in traditional growing soil. Organic plants have better predacious mite species distribution (El-Banhawy *et al*. 1998), and are physiologically better to fight phytophagous attacks (Culliney and Pimentel 1986). The most vital function of phosphorus (P) is storage and transfer of energy in the form of adenosine triphosphate (ATP). Zeidan (2007) reported that organic fertilization increases P levels in soil, which caused an increase in protein, K, Fe, Mn and Zn in plant contents.

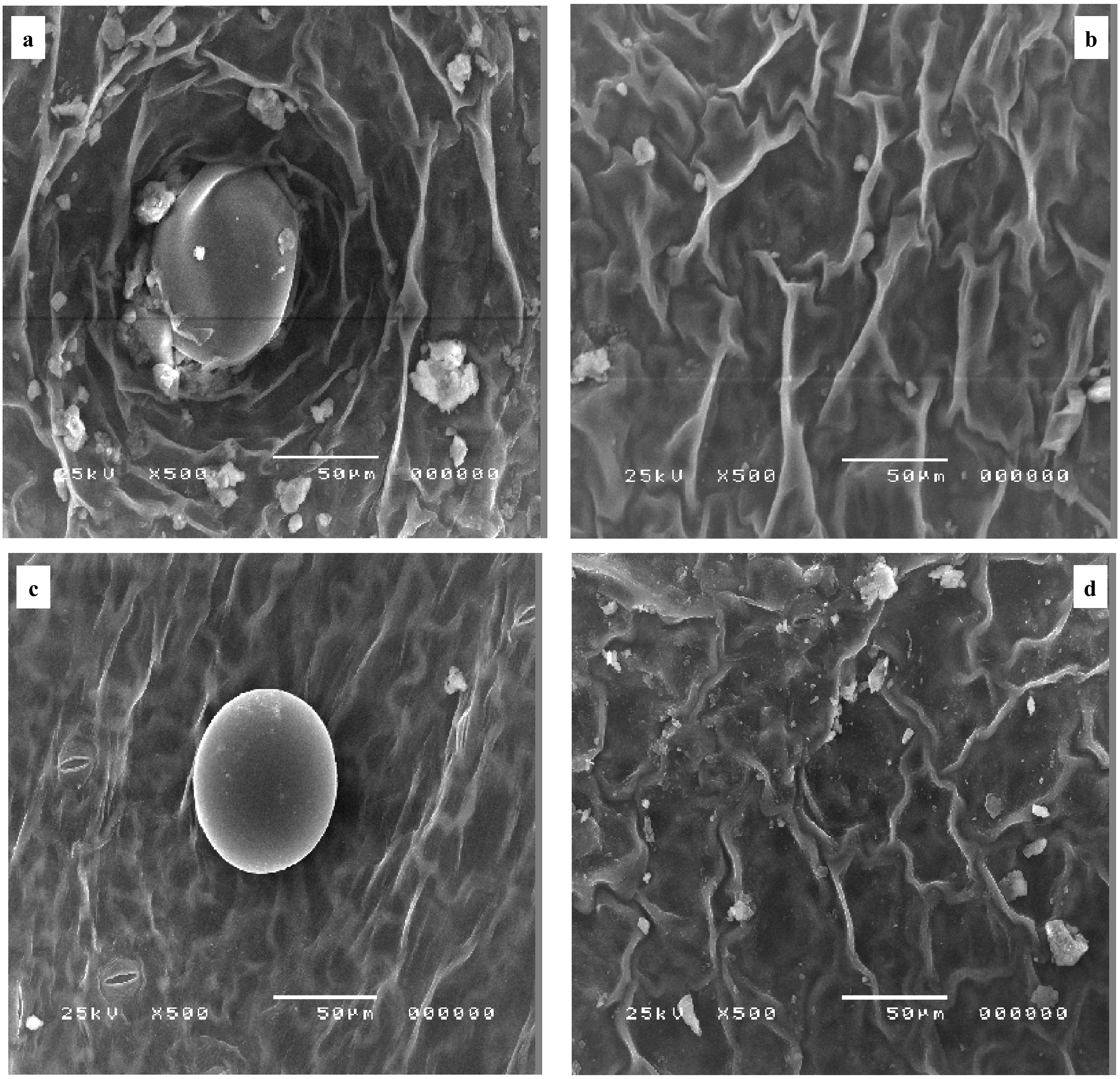

Figure 3. Scanning electron micrographs of tested organic Lamiaceae plant leaf surfaces 50 µm, 500× – **a, b.** Spearmint *Mentha spicata* (upper and lower leaf surfaces respectively); **c, d.** Saudi mint *Mentha longifolia* (upper and lower leaf surfaces respectively).

Most tetranychid females need a nitrogen source to develop mature ovaries and egg production, and also a phosphorus source for energy. Papp *et al.* (2001) reported that high levels of N content of apple leaves resulted in increasing of fecundity and longevity of European red mite *Panonychus ulmi* (Koch). Fecundity differences could also be related to leaf morphology, which may be an evidence of the different number of eggs laid on different host plants (Skorupska 2004; Islam *et al.* 2017).

Romero and Benson (2005) showed leaf special structures (domatia) are shelters for predators, preventing phytophagous damaging leaves through feeding. It is proposed that mite feeding, development, fecundity and life table parameters could significantly be affected by the host plant morphology, and nutritional contents, owing to mite's physiological structure and digestion mechanisms.

It was obvious, in this study, however that in closely related plants, there were significant responses to plant source, on life time of the TSSM. Developmental duration, fecundity and life table parameters in different plant species and varieties supported those points in papaya (Moro *et al.* 2012), bean, papaya and jute (Islam *et al.* 2017), strawberry (Azadi Dana *et al.* 2018; Fahim *et al*. 2020), country bean (Uddin *et al.* 2017), eggplant (Kumral *et al.* 2019), regular and sweet pea (Abou-Elella and Abdel-Khalek 2020).

CONCLUSION

Plant-herbivore relation takes many forms, in case of TSSM feeding is widely diverse, and the plant nutritional content would absolutely affect its life and behaviour. When adequate plant minerals (N, P, Ca, etc.) are digested through the TSSM's gut, they reform as an ability to develop into adulthood in short time, short female longevity period, high amounts of offspring production. Oppositely, plants with highly active defence mechanisms, like trichomes, repellent essential oils, and plant minerals which have a defensive role, negatively affect the development, reproduction, and life history parameters of an herbivore.

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چگونه گیاهان دارویی ارگانیک بر آماره‌های جدول زندگی *Tetranychus urticae* (Acari: Tetranychidae) اثر می‌گذارند؟

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چکیده

در این بررسی، آماره‌های جدول زندگی کنهٔ تارتن دو لکه‌ای روی چهار گیاه ارگانیک متعلق به خانوادهٔ شب‌بوها: کلم قمری سیبری (روسی)، *Brassica napus* L. var. *pabularia* L.، کلم قمری لاسیانتو (توسکانی/ایتالیایی)، *Brassica oleracea* var. *palmifolia* و خانوادهٔ نعناییان: نعناع، *Mentha spicata* L. و نعناپونه، *Mentha longifolia* L. بررسی شدند. همچنین این مطالعه با هدف بررسی محتوای غذایی و ویژگی‌های ریخت‌شناسی گیاهان انجام شد تا توضیح داده شود که چگونه منابع گیاهی بر آماره‌های زندگی کنهٔ تارتن دو لکه‌ای تأثیر می‌گذارند. گیاهان در دو مکان ارگانیک کشت شدند: فرمانداری غزه (۳۰ درجه و ۹ دقیقه و ۷ ثانیه شمالی و ۳۰ درجه و ۵۱ دقیقه و ۰/۲ ثانیه شرقی) و فرمانداری فیوم (۲۹ درجه و ۳۴ دقیقه و ۴۰/۹ ثانیه شمالی و ۳۰ درجه و ۵۵ دقیقه و ۳۸/۳ ثانیه شرقی). آزمون‌ها در شرایط آزمایشگاهی ۲۸ ± ۲ درجهٔ سلسیوس و ۷۵–۸۰ درصد رطوبت نسبی انجام شدند. کنهٔ تارتن دو لکه‌ای کوتاه‌ترین دورهٔ زندگی، طول عمر، امید به زندگی، بیشترین مقدار افزایش ذاتی (r_m)، میزان خالص تولید مثل (R_0)، میزان متناهی افزایش (λ)، میزان تولید مثل ناخالص (*GRR*)، کوتاه‌ترین طول دورهٔ یک نسل (T) و زمان دو برابر شدن جمعیت را روی کلم قمری سیبری (از خانوادهٔ شب‌بوها) داشت. برگ‌های گیاهان با میکروسکوپ اسکن الکترونی اسکن شدند تا تعیین شود که چگونه بافت گیاه می‌تواند بر زیست‌شناسی کنهٔ تارتن دو لکه‌ای اثر بگذارد. محتویات غذایی گیاهان از نظر نیتروژن، فسفر، پتاسیم، سدیم و کلسیم اختلاف بسیار معنی‌داری را بین مادهٔ خشک چهار گیاه مورد آزمایش نشان دادند. نتیجه گرفته می‌شود که گیاه ارگانیک به طور قطع بر آماره‌های جدول زندگی و رفتار کنهٔ تارتن دو لکه‌ای اثر می‌گذارد. ارتباط گیاه–گیاهخوار از نظر محتویات غذایی و ویژگی‌های ریخت‌شناسی مهم است.

واژگان کلیدی: *Brassica napus* var. *pabularia*؛ *B. oleracea* var. *palmifolia*؛ خانوادهٔ شب‌بوها؛ خانوادهٔ نعناییان؛ *Mentha longifolia*؛ *M. spicata*؛ کشاورزی ارگانیک؛ محتویات غذایی گیاهان.

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