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Original article

Effect of host preference and micro habitats on the survival of *Tetranychus urticae* Koch (Acari: Tetranychidae) in Saudi Arabia

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ABSTRACT

Objective: Control of pests is essential to save the loss of economically important plants. Biological and environmental control became the most important interventions of choice. The two-spotted spider mite Tetranychus urticae is a herbivorous mite which is considered to be a harmful pest. The objective of the study was to investigate the effect of host preference on the survival and distribution of *Tetranychus urticae*.
Methods: Specimens of *T. urtica* were collected from *Solanum melongena* plants grown at Al Qaseem University. Eggs were transferred individually to the bottom surface of leaves of certain plants namely: *Phasoelus vulgaris* (beans), *Solanum melongena* (eggplant), *Fragaria ananasa* (Strawberry), *Citrus sinensis* (Orange), and *Cucumis sativus* (Cucumber) and reared on those plants under optimum conditions. The effect of climatic conditions and the type of the plant host on the survival of mature and immature stages of *T. urtica* has been observed.
Results: The total growth period length of the immature stage of the male mites was found to be shorter than the growth period of the female immature stages. The peak of this period was recorded in *Citrus sinensis* followed by *Cucumis sativus* then *Solanum melongena*, *Phasoelus* vulgaris, and *Fragaria ananasa.*
Conclusion: These results may lead to the screening process of comparatively resistant herbal species to be used in the management of *T. urticae*.

1. Introduction

Tetranychus urticae, the two-spotted spider mites, are cosmopolitan pests of a wide range of crops such as cucumber, strawberry, orange, eggplant, and beans (Eniko Gyuris et al., 2018). They are some of the most threatening economic pests and often require selective control interventions which might not be easy due to the rising resistance to the most recommended insecticides. These mites often inhabit the below side of leaves, where they feed and induce straps that coat specific parts of the leaf, this phenomenon decreases the efficacy of insecticidal control (Numa et al., 2015; Sarwar and Sattar, 2013).

The extent of deterioration of leaves caused by *T. urticae* is obvious in the ply and length of the leaves (Bianchi et al., 2006; Estrella et al., 2020). The diet of *T. urticae* is usually chloroplasts of cells especially the bottom of the leaf, whereas the upper surface of the leaf develops creamy-colored punctuations, which may alter to darker brown color upon the feeding of mites. Park and Lee (2002) studied the impact of damage due to the attack of *T. urticae* on *Cucumis sativus* and reported that on the abaxial leaf surface, adult *T. urticae* damaged the spongy parenchyma as well as part of the palisade parenchyma, whereas immature *T. urticae* fed only the spongy parenchyma. Infestation with *T. urticae* will significantly affect the net photosynthetic rate, chlorophyll content, and thereby the greenness of the leaves. Besides the loss in the number of leaves their ability to alter photosynthetic rate after the mite infestation was estimated to be a hundred each minute (Silvere et al., 2017; Hajar and Annie, 2012).

The fast rate of development, high fecundity, and arrhenotoky in *T. urticae* let them quickly reach a harmful population level under favorable conditions that subsequently lead to a rapid decline in host plant quality. (Kanika Tehri, 2014). There are some good reports on the within-plant distribution of *T. urticae* on different plant hosts (Tollerup et al., 2013; Choi et al., 2022). Choi et al (2022) have reported that on strawberry plants, optimal sampling units of *T. urticae* were the fifth, fifth, or sixth, and sixth oldest leaves for adult and immature motiles as well as eggs.

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Because of difficulties associated with their control and huge economic losses, there is much interest in the search for alternative control measures, especially biological control. Hence, this study aimed to investigate the effect of host preference of *Tetranychus urticae* on their survival and distribution.

2. Materials and methods

2.1. Samples collection and rearing

Adults and eggs of *T. urtica* were collected from *Solanum melongena* plants grown in greenhouses in the research center of Faculty of Agriculture and Veterinary Sciences, Al Qaseem University. These insects were reared on bean plants under laboratory conditions (26 °C, 70% Relative humidity (RH) for three weeks.

Thirty eggs were separated using a zero-size brush under a binocular microscope (X100 lens magnification). Eggs were transferred individually to the bottom surface of leaves (1 inch^2 area) of the following plants:

(a) *Phaseolus vulgaris* (Beans)
(b) *Solanum melongena* (Eggplant)
(c) *Fragaria ananasa* (Strawberry)
(d) *Citrus sinensis* (Orange)
(e) *Cucumis sativus* (Cucumber)

Replicates were placed on wet cotton pieces on petri dishes (10 cm diameter). Drops of water were added to the dishes daily to keep the cotton moist. Plant leaves were changed weekly for transferring the hatching mite individuals gently using brushes.

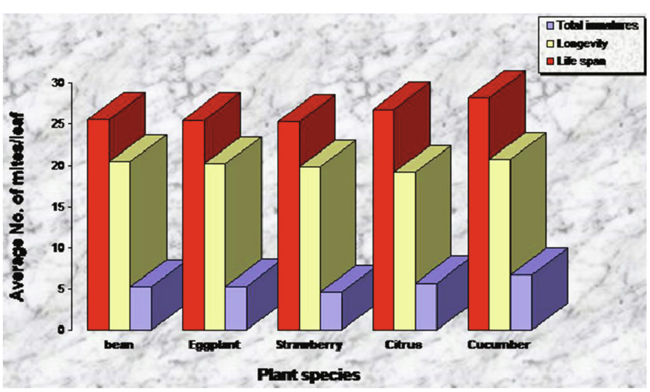

Fig. 1. Effect of different textures on duration of developmental stages, (longevity) of *Tetranychus urticae* adult females.

2.2. Recording time tables data

The number of hatched eggs was recorded and the hatching proportion was calculated. The incubation period until hatching, larval stage, and pupal stages (including protonymphal and deutonymphalstages) were also registered once a day.

2.3. Sex ratio estimation

After emergence from the pupal stages number of adult males and females stage was recorded to calculate the sex ratio using the following formula:

$$\text{Sex ratio} = \text{Number of hatched females}/\ \text{Total number of hatched adults}$$

The obtained parentage was analyzed using the life table parameter to forecast the females ratio in the next generation. (Charly et al., 2020; Sayed et al., 2012).

2.4. Adult's life span

The life span of adult males was estimated. Each newly emerged female was located with a male (obtained from the mite colony) for her entire life then the pri-oviposition, the oviposition, and the post- oviposition periods were estimated. Methods of (Birch, 1948; Andrewartha and Birch, 1954; Abou-Setta et al., 1986; Ismail, 2004) were adopted for calculating the longevity of mites as well as estimating the total number of laid eggs and the daily oviposition rate in order to calculate the life table parameters using the following formula:

$$\text{Average generation duration } (T) = \frac{(\Sigma Lx\ Mx.\ x)}{\Sigma LxMx}$$

Where:

L = Number of viable females per day.
X = The actual age of the female (/day).
Mx = Number of females per generation or special fertility rate per day (x).
Lx = Survival rate per day (x).
R_0 = Replication rate per generation duration ($\sum$LxMx).
T = Average generation duration.
R^m = Average normal growth.
E^{rm} = Average daily replication.

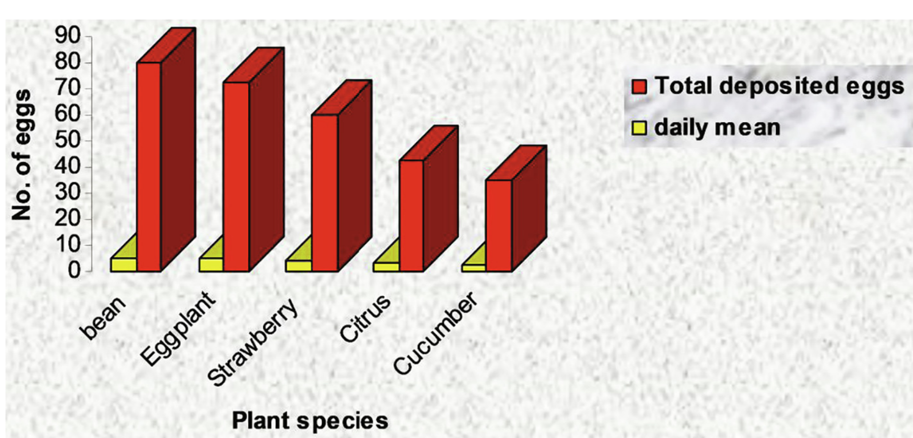

Fig. 2. Effect of different textures on total and daily mean of deposited eggs of *T. urticae* adult females.

3. Results

3.1. Effect of type of plant hosts on the longevity of eggs of T. urticae

Results exhibited that variation of the plants' surfaces on which *T. urticae* were reared had no significant impact on the incubation period of the eggs hatching which ranged between 3.2 and 4.1 days for males while it was 3.8–4.9 days for females (Fig. 1). On the other hand, the type of the surface of plants hosts, the leaves' texture, bristles, and glands on the leaves have an impact on both mature and immature stages of *T. urticae* (Figs. 2 and 3).

Fig. 3. Proportion of total deposited eggs of *T. urticae* on different plant leaves (%).

3.2. Effect of type of plant hosts on the longevity of larvae of T. urticae

Coinciding with the impact on the egg hatching, the type of plant's surface did not affect the longevity of the larval stage which was 2.7–2.8 days when the mites reared on the leaves of *Citrus sinensis* and *Cucumis sativus*. In contrast to this, the longevity of the larval stage diminished significantly when female larvae reared on *Solanum melongena, Fragaria ananasa,* and *Phasoelus vulgaris* respectively (Figs. 4–7; Table 1). Contrary to this, larval periods of the male larvae did not affect significantly when reared on the three plants (Table 1). For the female protonymphs results showed that leaves of *Citrus sinensis* insignificantly affected the growth period of these females when reared on them while the effect was significant when they reared on *Solanum melongena, Phasoelus vulgaris,* and *Fragaria ananasa* (Table 1).

3.3. Effect of type of plant hosts on the longevity of pupae of T. urticae

Results showed an insignificant difference between the growth period of the second pupal stage (deutonymph) compared to the growth period of the first pupal stage (protonymph) when reared on the same plant. In contrast to this, the growth period of deutonymph significantly extended to 2.6–2.8 days when grown on *Citrus sinensis* and *Cucumis sativus* respectively while the growth period was 1.8, 1.9, and 1.8 days when the pupae grown on *Solanum melongena, Phasoelus vulgaris*, and *Fragaria ananasa* plants respectively (Table 1).

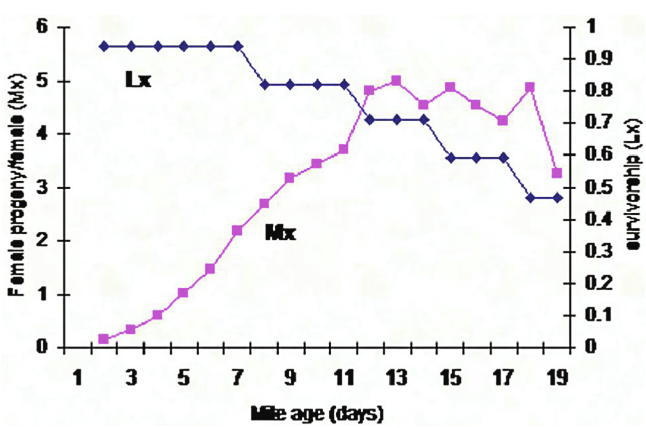

Fig. 4. Development duration of *T. urticae* reared on bean leaves.

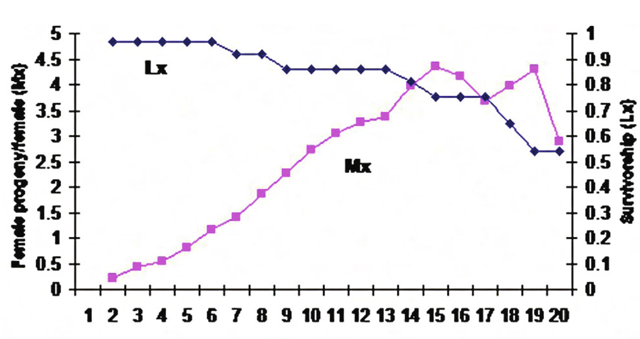

Fig. 5. Development duration of *T. urticae* reared on eggplant leaves.

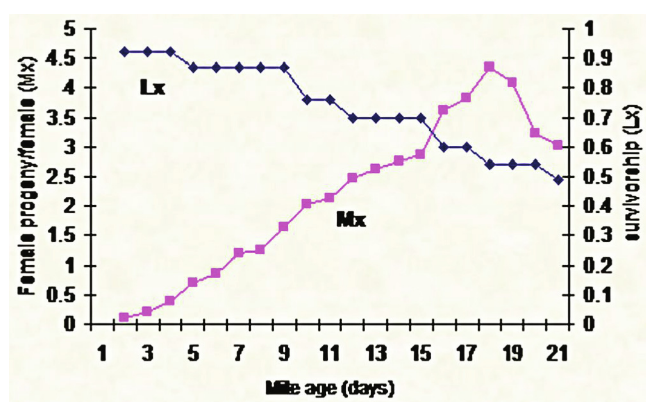

Fig. 6. Development duration of *T. urticae* reared on strawberry leaves.

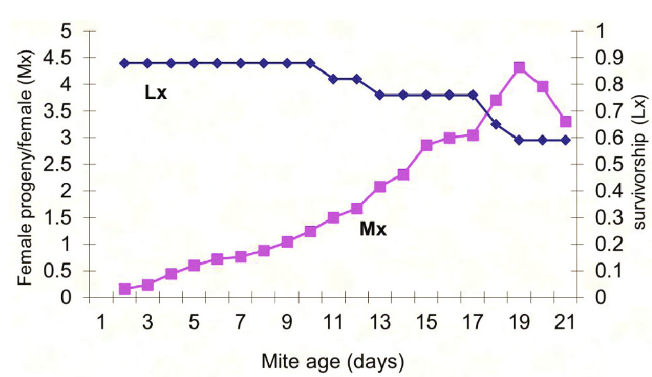

Fig. 7. Development duration of *T. urticae* reared on Citrus leaves.

Table 1
Duration of incubation period and development of immature stages (days) of *Tetranychus urticae reared* on different plant leaf-surfaces and kept at 26 C° and 70% RH.

Plant species	No. Sex		Incubation period		Developmental stages						Total		Sex ratio %
					Larva		Protonymph		Deutonymph				
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	
Bean	16	14	3.8 a ± 0.06	3.2 ab ± 0.03	1.8b ± 0.02	1.6 a ± 0.02	1.5b ± 0.04	1.3b ± 0.04	1.9b ± 0.07	1.8b ± 0.07	5.2b ± 1.04	4.7b ± 1.02	74
Eggplant	15	13	3.6 a ± 0.07	3.3 ab ± 0.04	1.9b ± 0.07	1.5 a ± 0.06	1.6b ± 0.03	1.4b ± 0.06	1.8b ± 0.06	1.6b ± 0.04	5.3b ± 1.05	4.5b ± 1.03	72
Strawberry	14	14	4.2 a ± 0.09	3.6 a ± 0.03	1.6b ± 0.04	1.6 a ± 0.06	1.6b ± 0.04	1.3b ± 0.06	1.8b ± 0.06	1.7b ± 0.06	5.0b ± 1.02	4.6 a ± 1.16	69
Citrus	14	13	4.5 a ± 0.04	3.8 a 0.06	2.7 a ± 0.04	1.6 a ± 0.03	2.3 a ± 0.06	1.8 ab ± 0.03	2.6 a ± 0.10	2.3 a ± 0.09	7.6 a ± 1.02	5.7b ± 1.46	72
Cucumber	15	14	4.9 a ± 0.06	4.1 a ± 0.06	2.8 a ± 0.04	1.9 a ± 0.07	2.4 a ± 0.04	2.2 a ± 0.07	2.8 a ± 0.09	2.6 a ± 0.07	8.0 a ± 1.40	6.7 a 1.32	71
L.S.D.(P < 0.05)			0.82	0.67	0.06	0.12	0.46	0.69	0.42	0.56	0.98	0.86	–

Data were subjected to the Micro-Computer Program COSTAT, one way ANOVA using Student-Newman Keuls Test, where means with the same letter aren't significantly different (P < 0.05).

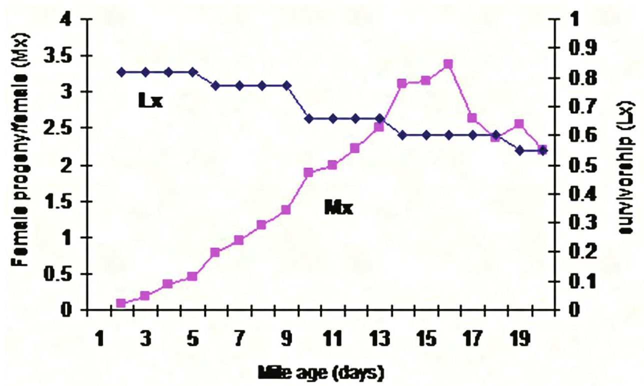

Fig. 8. Development duration of *T. urticae* reared on cucumber leaves (A, B, C, D, E): Life table parameters (Mx, Lx) of *Tetranychus urticae* reared on five different plant leaves in laboratory.

3.4. Effect of type of plant hosts on the longevity of both mature and immature stages of T. urticae

Results showed insignificant effect of the type and texture of *Citrus sinensis* and *Cucumis sativus* on the growth of the immature stages of *T. urticae* (8 and 7.6 days respectively) while these two factors had a significant effect on the growth of the immature stages of these mites when grown on *Solanum melongena, Phasoelus vulgaris*, and *Fragaria ananasa* (5.2, 5.3, and 5 days respectively) (Fig. 8, Table 2).

Results also showed that the total growth period length of the immature stage of the male mites was shorter than the growth period of the female immature stages. The peak of this period was recorded in *Citrus sinensis* followed by *Cucumis sativus* then *Solanum melongena, Phasoelus vulgaris,* and *Fragaria ananasa* (Table 1, Fig. 8).

3.5. Effect of type of plant on life table parameters of Tetranychus urticae reared on different plant leaf surfaces and kept at 26 °C and 70% RH

Results showed that mites have net reproductive rates (R_0) of 38.07, 37.55, 28.45, and 27.28 times during generation periods (T) 14.48, 15.75, 17.18, and 18.16 days when reared on eggplant followed by *Phasoelus vulgaris*, *Fragaria ananasa*, and *Citrus sinensis* respectively while rearing on *Cucumis sativus induced* the least duplication rate where R_0 was 21 time during a life span of 18.63 days (Table 3).

The intrinsic rate of natural increase (r^m) was 0.25, 0.19, 0.17, 0.16 individual (female)/ day when reared on *Fragaria ananasa*, *Phasoelus vulgaris*, and *Citrus sinensis* respectively.

4. Discussion

Determination of factors affecting the survival of *T. urticae* is crucial to deciding the best biological and environmental control of this pest. Besides, discovering the exact microhabitats that *T. urticae* prefer to inhabit, it is useful to exact certain parts of plants with insecticides instead of spraying the whole vegetation when chemical control is found to be the intervention of choice (Wekesa et al., 2011).

Results of this study revealed that the type and texture of plants have variance effects on the growth of mature (both sexes) and immature stages of *T. urticae* where the longest growth period of the spider was recorded when reared on *Cucumis sativus* hosts. This may be due to the rough texture of *Cucumis sativus* leaves which may retard the movement and activity of the immature stages. Diminished activity may therefore affect the ability of these stages to absorb the herbal succulents. An inadequate amount of carbohydrates will affect the viable activities of the mites such as molting. This may be the cause of the prolonged growth periods (Lewis, 1995).

Table 2
Duration of different intervals and longevity (days) of adult male and female of *Tetranychus urticae* reared on different plant leaf-surfaces and kept at 26 C° and 70% RH.

Plant species	Adults						Longevity		Life span	
	Preoviposition		Oviposition		Postoviposition					
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Bean	1.3b ± 0.64	–	16.4 a ± 1.86	–	2.7b ± 0.62	–	20.4 a ± 1.67	17.6 a ± 1.28	25.6c ± 1.48	22.3 ab ± 1.86
Eggplant	1.4 b ± 0.82	–	15.7 a ± 1.72	–	3.1 b ± 0.74	–	20.2 ab ± 1.48	16.8 a ± 1.42	25.2 c ± 1.62	21.3 b ± 1.46
Strawberry	1.6 b ± 0.74	–	14.3b ± 1.36	–	3.9 ab ± 0.46	–	19.8 ab ± 1.69	17.3 a ± 1.23	24.8 c ± 1.41	21.9 b ± 1.37
Citrus	2.2 ab ± 0.68	–	12.7 c ± 1.42	–	4.2 a ± 0.81	–	19.1b ± 1.56	15.4 a ± 1.08	26.77 b ± 1.21	21.1 b ± 1.28
Cucumber	2.8 a ± 0.87	–	13.2 bc ± 1.26	–	4.7 a ± 0.92	–	20.7 a ± 1.86	16.5 a ± 1.13	28.7 a ± 2.16	23.2 a ± 1.84
L.S.D. (P < 0.05)	0.48	–	1.02	–	0.62	–	1.04	1.08	1.42	1.16

Data were subjected to the Micro-Computer Program COSTAT, one-way ANOVA using Student-Newman Keuls Test, where means with the same letter aren't significantly different (P < 0.05).

Table 3
Life table parameters of *Tetranychus urticae* reared on different plant leaf surfaces and kept at 26 °C and 70% RH.

Plant surface	Mean generation time T (days)	Net reproductive rate (R_o)	Intrinsic rate of increase (r^m)	Finite rate of increase (e^{rm})
Bean	14.480	38.072	0.251	1.285
Eggplant	15.757	37.558	0.230	1.258
Strawberry	17.181	28.452	0.194	1.215
Citrus	18.616	27.280	0.173	1.102
Cucumber	18.632	21.211	0.167	1.103

These findings coincide with the results of another study which recorded that the total immature stages and life cycle were shortest when spider mite was fed on mulberry leaves. The greatest values of reproduction rate and hatchability were on mulberry leaves than on other crops and followed by castor bean (Nizam Uddin et al., 2015). The developmental and reproduction rate of *T. urticae* is influenced by tissue nutrient content for the host plant whereas Elsadany (2018) also reported that the sex ratio of *T. urticae* was highest on castor bean leaves. The results also showed that larval periods of the male larvae did not affect significantly when reared on the three plants while for the female protonymphs, results showed that leaves of *Citrus sinensis* insignificantly affected the growth period of these females when reared on them. In contrast to this, the effect was significant when they reared on *Solanum melongena*, *Phasoelus vulgaris*, and *Fragaria ananasa*.

Results also showed that mites achieved the peak of net reproductive rate (R0) when reared on an eggplant while rearing on *Cucumis sativus* induced the least duplication rate. The mean qualitative increase (rm) was the most when the mites reared on *Fragaria ananasa*. Coinciding with this, a previous study indicated that the choice of host plant species will affect how fast spider mite populations reach damaging levels in a culture where the slowest population growth was observed on the bean species with rm = 0.214 (Jabraeil et al., 2009). Depending on these findings, it is recommended to grow plants that are frequently infested by parasitic mites around crops as an herb- prophylaxis to prevent them from being attacked.

Finally, it can be inferred that host plants play a considerable role in the susceptibility of *T. urticae*. This is agreed with the findings of another study which recorded that spider mites are susceptible to acaricides and abamectin could be used as a puissant chemical for controlling spider mites (Tarikul, 2018).

5. Conclusion

The present work discussed the feeding preference of pests as a way to evaluate their population ecology. *Tetranychus urticae* is an agriculture pest mite with limited knowledge about its ecology and feeding preference. Such information is very important to its control and hence the effect of the feeding environment on its population was evaluated. The type of food shows a great effect on the number of laid eggs and their quality. Beans appear as the best host for the number of egg-laying. On the other hand, there was no clear significant impact of food type on longevity, although the rate of development shows great variation. Male larval stage developed faster than female, especially on citrus. More work is needed to get a complete understanding of the ecology of *Tetranychus urticae* and the present work forms a small step in this direction.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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