Influence of Temperature and Host Plants on The Development of The Two-spotted Spider Mite, *Tetranychus urticae* Koch (Acari: Tetranychidae)

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ABSTRACT : Duration of immature stages of the two-spotted spider mite, *Tetranychus urticae* Koch, reared on eggplant leaves at constant temperatures of 21, 25 and 29°C was determined. Developmental threshold of the immature stages was 10.4°C. The mean number of degree- days required by *T. urticae* to complete its development was 133.5 DD. The total mortality from egg to adult emergence was 32.14, 26.8 and 30.36% at 21, 25 and 29°C, respectively. Moreover, the greatest mortality occurred during the egg stage. Regarding host plant involved, *T. urticae* developed faster on peanut, *Arachis hypogae* L. (8.08 days), followed by cucumber, *Cucumis sativus* L. (9.31 days) and eggplant, *Solanum melongena* L. (9.37 days). These results indicated that the temperature and host plant affected the development time of *T. urticae*.

Key words: *Tetranychus urticae*; temperature; host plant; development.

INTRODUCTION

The two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) is one of the most serious pests on vegetables and crops in agriecosystem. Temperature is usually the environment factor with the greatest effect on development rate of mite stages. To quantify the effect of temperature on mite development, life stage of a species may be held at constant temperatures and the resultant development times can be used to estimate development rate curves **(Southwood, 1978)**. From these development rate curves, models can be formulated to predict development time as a function of temperature. The models are useful in making pest management decisions, or to be used as components of more comprehensive models for the investigation of population dynamics.

Host plants of spider mites differ in the degree of food quality, which either depend on the level of primary plant metabolites, or on the quantity and nature of secondary metabolites **(Rosenthal and Berenbaum, 1991)**. Many secondary metabolites found in plants have a responsibility in defense against herbivores, pests and pathogens. These compounds can perform as toxins, deterrents, digestibility reducers or act as precursors to physical defense systems **(Bennett and Wallsgrove, 1994; Balkema-Boomstra *et al.,* 2003)**.

Several studies have investigated the effects of temperature on development and reproduction of tetranychid mites on different host plants, such as *T. urticae* on cotton **(Carey and Bradley, 1982)**, *Tetranychus piercei* McGregor on banana **(Yueguan *et al.,* 2002)**, *Eutetranychus banksi* (McGregor) on sweet orange **(Badii *et al.,* 2003)**, *T. urticae* on beans **(Praslicka and Huszar, 2004)**, *T. urticae* on apple **(Kasap, 2004)**, *Tetranychus turkestani* Ugarov and Nikolski on eggplant **(Nemati *et al.,* 2005)**, *T. urticae* on eggplant **(Ju *et al.,* 2008)**, *Eutetranychus orientalis* (Klein) on Siris **(Imani *et al.,* 2009)**, *T. turkestani* on cucumber **(Karami Jamour, 2011)**, *T. urticae* on Pear **(Abd El-Wahed and El-Halawany, 2012)** and *T. urticae* on persimmon trees **(El-Halawany and Abd El-Wahed,2013)**.

However, few attempts have been made to determine the developmental threshold and the thermal units needed for development of *T. urticae* on some host plants, particularly in Egypt. Hence, the goal of this study was to evaluate the developmental threshold and the thermal requirements of *T. urticae* as a key pest on eggplant and the suitability of the three economically important host plants (i.e. eggplant, cucumber and peanut) to this mite species.

MATERIALS AND METHODS

This study was conducted in the laboratory of plant protection research at Assiut Governorate during the year of 2014. Three host plants [eggplant, *Solanum melongena* L. (Solanaceae); cucumber, *Cucumis sativus* L. (Cucurbitaceae) and peanut, *Arachis hypogae* L. (Fabaceae)] were used to investigate the development time and some life table parameters. Adults of *T. urticae* were collected from leaves of each host plant using a fine camel hair brush, the stock population of the mite was established in the laboratory by placing the adult stages on discs of related plants in Petri dishes (80 mm in diameter) with wetted cotton wool fixed on a disc of plastic foam (Mannaa, 1988). Newly deposited eggs (less than 24 hrs) were transferred singly to the disc of fresh eggplant leaves (20mm in diameter) placed on a water-saturated cotton in a Petri dish. Fifty six of mite eggs (egg on each disc) were incubated at each tested temperature of (21, 25 and 29°C) with a photoperiod of 16:8 (L:D) and 60±10 R H and observed daily until hatching. The newly-hatched larvae (< 12 hours-old) were reared in each experimental temperature and provided with clean eggplant leaves as a source of food until emergence of the adults.

The same above-mentioned procedures were conducted with the three host plants (eggplant, cucumber and peanut) at 25°C to assess development times of these eggs and other immature stages until reaching adulthood for each host plant.

Data obtained were statistically analyzed using analysis of variance and means were compared according to Duncan's Multiple Range test (Duncan, 1955). Obtained results of each immature stage of *T. urticae* were used to calculate the development threshold (t_0) according to linear regression model: Y= a + bx, whereas, (Y) is the rate of development (100/duration) at temperature (X) °C, a is the intercept on the Y axis, b is the regression coefficient and the lower development threshold (t_0) = -a/b. On the other hand, thermal units (TU) required for the development of each mite stage were calculated according to Mangat (1977); thermal units (DD's)= T ($t-t_0$) where, T-development time, t- temperature in degree centigrade and t_0- lower development threshold.

Also, the obtained data were used to form a concise statement for every interval of age, the number of deaths (d_X), the number of survivors at the beginning of the age class X (l_X), the rate of mortality (q_X), the numbers living between the ages X and X+1, which is the age structure (L_X) and survival rate within stage (S_X).

RESULTS AND DISCUSSION

1. Development time of the immature stages:

The results in Table (1) show that the incubation period of *T. urticae* decreased as temperature increased. It averaged 5.59±0.74; 3.94±0.34 and 2.59±0.25 days at 21, 25 and 29°C, respectively. The duration of larval, protonymph and deutonymph stages decreased gradually as temperature increased from 21 to 29°C. The larval stage durated 2.37±0.1; 1.85±0.05 and 1.18±0.12 days at 21, 25 and 29°C, successively. The periods of protonymph and deutonymph stages lasted for 2.40±0.18 and 2.24±0.09; 1.67±0.18 and 1.91±0.21; 1.75±0.03 and 1.68±0.04 days at the same degrees of temperature, respectively.

Statistical analysis of data showed significant variation between the development periods of each immature stage of two-spotted spider mite at all tested temperatures. In addition, when the total development time (from egg to adult emergence) is compared among all tested temperatures, the variation is significant.

Table (1): development periods (in days) of the immature stages of *T. urticae*, reared at different constant temperatures

Temp.(°C)	Development periods (in days)±SD				
	Egg	Larva	Protonymph	Deutoymph	Total (from egg to adult emergence)
21	5.59±0.74a	2.37±0.1a	2.40±0.18a	2.24±0.09a	12.60±0.72a
25	3.94±0.34b	1.85±0.05b	1.67±0.18b	1.91±0.21ab	9.37±0.1b
29	2.59±0.25c	1.18±0.12c	1.75±0.03b	1.68±0.04b	7.20±0.19c

*Mean in each column, followed by the same letter are not significantly different at 0.05 probability level

Data in Table (1) gave the possibility of calculating the developmental threshold (t_0) and the thermal units (TUs) required for the development of the immature stages of the mite according to **Mangat (1977)**. Hypothetical temperature threshold which was used in the estimation of (t_0) and (TUs) were chosen below the rearing temperatures of 21 and 29°C, Table (2). Data revealed that the threshold temperature for development of the immature stages of the mite on eggplant, as shown in Figure (1), was 10.4°C and the thermal units necessary to complete its development were about 133.5 day-degrees.

Table (2): Day-degrees (DD) necessary for the development of immature stages to adult stage of *T. urticae* using hypothetical temperature thresholds below rearing temperatures of 21 and 29°C

Temp. threshold (t_0)	Thermal units (DD's) = T ($t - t_0$)	
	21°C(T = 12.6)	29°C(T = 7.20)
7	176.4	158.4
8	163.8	151.2
9	151.2	144.0
10	138.6	136.8
11	126.0	129.6
12	113.4	122.4
13	100.8	115.2
14	88.2	108.0
15	75.6	100.8
16	63.0	93.6
17	50.4	86.4
18	37.8	79.2
19	25.2	72.0
20	12.6	64.8

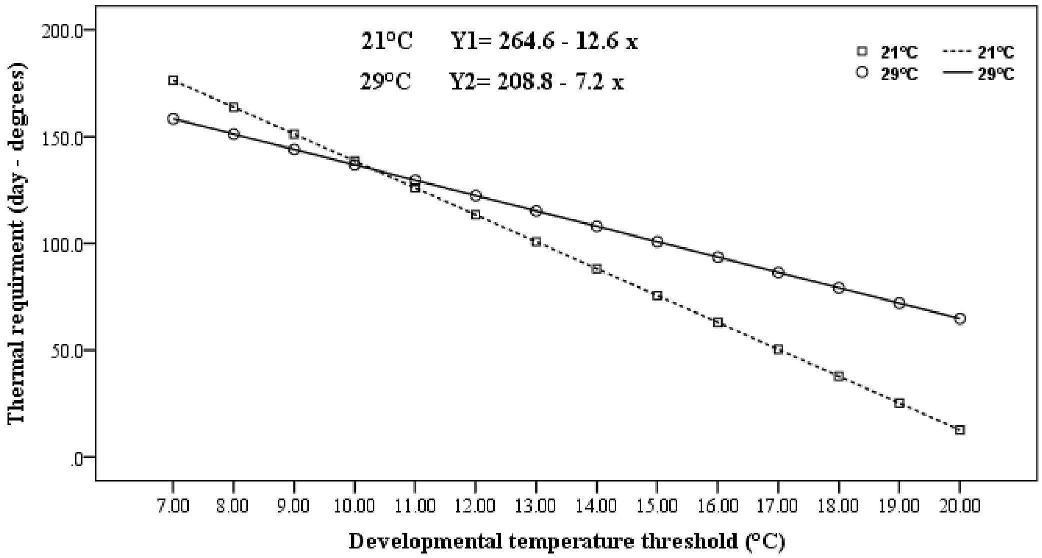

Fig. (1): Thermal units needed for the development of the immature stages of *T. urticae*.

2. Age-specific survival life table:

Data in Table (3) referred to the combined life table describing one pathway for age specific mortality of *T. urticae* immature stages reared at the three constant temperatures. Results indicated that the highest percentage (73.2%) of 56 two-spotted spider mite eggs successfully emerged as adults occurred at 25°C followed by (69.64%) at 29°C, while the lowest percentage

(67.86%) of adults emerged from the mite eggs was recorded at 21°C. Moreover, the life table of *T. urticae* indicated high mortality occurring during the early life stages against a distinct lower percentage of mortality as they reached adulthood.

Table (3): Life table of two spotted spider mite, *T. urticae* reared on eggplant leaves at different constant temperatures

Temp. (°C)	X	lx	Lx	dx	100qx	Sx
21	Eggs	56	48	15	26.79	73.21
	Larva	41	40	2	4.88	95.12
	Protoymph	39	38	1	2.56	97.44
	Deutonymph	38	38	0	0.0	100.0
	Adult	38	19	-	-	-
25	Eggs	56	52	7	12.50	87.50
	Larva	49	47	4	8.16	91.84
	Protoymph	45	43	3	6.67	93.33
	Deutonymph	42	41	1	2.38	97.62
	Adult	41	20	-	-	-
29	Eggs	56	50	12	21.43	78.57
	Larva	44	43	2	4.55	95.45
	Protoymph	42	41	2	4.76	95.24
	Deutonymph	40	39	1	2.5	97.5
	Adult	39	19	-	-	-

X = development stage
lx = number entering stage
Lx = number alive between stage X and X+1
dx = number that died in stage X
100qx = percent apparent mortality
Sx = survival rate within stage

3. Influence of host plant on the development time of *T. urticae*:

Obtained results in Table (4) elucidated insignificant variation between the two host plants, eggplant and cucumber in case of the total development period of *T. urticae*, whereas significant variation between peanut and each of eggplant and cucumber for the total development period (F=18.28; df=2; p=0.00001). The development period of different stages of *T. urticae* indicated that larval stage development occupied the first rank (1.51±0.41 days) followed by (1.72±0.11, 1.82±0.13 and 3.87±0.46 days) for protonymph, deutonymph and egg stages, subsequently with significant differences (F=1272.03; df=4; p=0.00001).

Table (4): Length of the development period of *T. urticae* as influenced by host plant (in days) at constant temperature of 25°C

Hosts	Developmental periods (in days)				Average
	Egg	Larva	Nymph	Total (from egg to adult emergence)	
Eggplant	3.94Ab*	1.85Ad	3.58Ac	9.37Aa	4.69A
Cucumber	4.31Ab	1.52Ad	3.48Ac	9.31Aa	4.65A
Peanut	3.35Bc	1.17Ad	3.56Ab	8.08Ba	4.04B
Average	3.87b	1.51d	3.54c	8.92a	

*detectable differences are indicated by capital letters in host plants within each column and lower case in stages within each row.

Voluminous of studies are available on the biology of *T. urticae* on different host plants. However, it would be uphill to compare the present results with others, as rearing conditions (temperature as well as host plant) were different. As a discussion, the results of the present study clearly showed the effect of temperature and host plants on development time and mortality of immature stages were in agreement with previous results have been reported by many authors. Immature development times of *T. urticae* were 12.60, 9.37 and 7.20 days at 21, 25 and 29°C, respectively. **Praslicka and Huszar (2004)** found that the length of development times of *T. urticae* on *Capsicum annuum* L. were 12.9, 10.10 and 7.0 days at 20, 25 and 30°C. While, **Nemati *et al.* (2005)** observed the developmental times of *T. turkestani* on eggplant were 30.32, 17.41, 9.98 and 5.71 days at 15, 20, 25 and 30°C, respectively. **Whereas, Ju *et al.* (2008)** reported (25.8 days at 17°C) for *T. urticae* on eggplant. **Romeih *et al.* (2013)** also, reported that the total development time of *T. urticae* males was significantly influenced by the rose cultivars and ranged between 12.01 and 7.88 at 20°C; 6.84 and 3.44 at 25°C; and 5.35 and 2.57 days at 30°C. Moreover, our findings at 25°C are close to those recorded on different host plants by **(Skirvin and Williams, 1999)** 11.7 days; **(Kasap, 2004)** 10.0 and 9.3 days; **(Rajakumar *et al.*, 2005)** 12.36 and 10.7 days for female and male, respectively, and **(Razmjou *et al.*, 2009)** 9.38 days.

The lower temperature threshold of 10.4°C for *T. urticae*, computed by linear regression, is similar to the 10.57°C reported by **Ali (2002)** on cotton, but this value was lower than those reported by **Ju *et al.* (2008)** for *T. urticae* (12.8 and 12.5°C) for male and female on eggplant and by **Nemati *et al.* (2005)** for female *T. turkestani* (13.4°C) on eggplant, as well as **Riahi *et al.* (2013)** for *T. urticae* (12.1 and 13.8°C) for male and female on peach. While, the value of temperature threshold is higher than the 8.4°C reported by **Kasap (2004)** on apple.

The mean number of degree-days required by *T. urticae* to complete its development was 133.5DD, which was closer to 140.33 and 131.88DD for female and male, respectively, required by *T. turkestani* to complete its development **(Jamour and Shishehbor, 2012)** and was higher than those of **Ju *et al.* (2008)**

on eggplant (80.5 and 74.7DD) for female and male, respectively; and **Nemati *et al.* (2005)** for female *T. turkestani* (102.0DD) on eggplant. While, these was lower than those of (160.2 and 174DD) for females and males of *T. urticae* **(Riahi *et al.,* 2013)**; (172.4DD) reported for female **(Najafabadi and Zamani, 2013)**. on apple by **Kasap (2004)** and (155DD) estimated by **Ali (2002)** on cotton. The total mortality from egg to adult emergence was 32.14, 26.8 and 30.36% at 21, 25 and 29°C, respectively. Similar results have been stated by **(Riahi *et al*., 2011)** 27.45 to 68.5% of eggs developed to maturity on peach, whereas **Saeidi (2011)** mentioned that 74-88% of eggs completed its maturity. Immature stages mortality rate ranged also from 11.65 to 18.75% on different bean cultivars **(Najafabadi and Zamani, 2013)**. In addition, among immature stages, the greatest mortality occurred during the egg stage was in accordance with the results of **(Najafabadi and Zamani, 2013)**.

The difference among the three host plants; eggplant, cucumber and peanut was further confirmed by the statistical analysis. Therefore, obtained results from these experiments showed a better performance of *T. urticae* on peanut leaf discs than cucumber and eggplant. This was shown in the development times of *T. urticae* (8.08, 9.31 and 9.37days) for peanut, cucumber and eggplant, in respect. Similar results have been also observed on various host plants **(Praslicka and Huszar, 2004** and **Razmjou *et al.*, 2009)**. The difference in the development of the mite on different hosts may have been caused by quality, accessibility or actual ratio of nutrients, as indicated by **Wermelinger *et al.* (1985)**. In addition, variations among the other aspects and parameters included in this article might be due to the differences to either the mite species or to the adopted techniques.

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الملخص العربى

تأثير الحرارة والعوائل النباتية على تطور أكاروس العنكبوت ذو البقعتين

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أجريت هذه الدراسة بهدف معرفة تأثير درجات الحرارة الثابتة على تطور آكاروس العنكبوت ذو البقعتين *Tetranychus urticae* عند تربيته على أوراق الباذنجان كواحد من محاصيل الخضر التي تصاب بشدة بهذا الآكاروس، وكذلك دراسة تأثير العوائل النباتية المختلفة مثل الخيار والفول السوداني على تطور هذا الآكاروس.

وقد أوضحت النتائج انه عند تربية الآكاروس على أوراق الباذنجان واستخدام درجات حرارة 21 ، 25 ، 29°م فأن فترة تطور الآكاروس تقل مع زيادة درجة الحرارة (12.60، 9.37، 7.20 يوم على التوالي). دلت النتائج أيضا أن عتبة النمو للأطوار الغير كاملة كانت 10.4 درجة مئوية ، كما أن آكاروس العنكبوت ذو البقعتين يحتاج 133.5 وحدة حرارية يوميا حتى يكمل تطوره.

تم دراسة نسبة الوفيات عند كل درجة حرارة وقد وجد أن أعلى نسبة وفيات تحدث عند درجة حرارة 21°م (32.14%) يليها عند درجة حرارة 29°م (30.36%) وأخيرا عند درجة حرارة 25°م (26.8%) ، وان أعلى نسبة وفيات تحدث في طور البيضة عند درجات الحرارة المختلفة.

عند دراسة تأثير اختلاف العوائل النباتية على تطور آكاروس العنكبوت ذو البقعتين عند تربيته على درجة حرارة 25°م ، وجد أن الفول السوداني هو أفضل عائل لتطور آكاروس العنكبوت ذو البقعتين يليه الخيار وأخيرا الباذنجان، ويتضح ذلك من خلال طول فترة التطور حيث سجلت أقل فترة تطور على الفول السوداني ثم الخيار وأخيرا الباذنجان (8.08، 9.31، 9.37 يوم ، على التوالي).