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Suitability of three vegetable crops for development and reproduction of *Tetranychus urticae* Koch (Acari: Tetranychidae)

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The biology of the two-spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae) as influenced by feeding on leaves of eggplant *Solanum melongena* var. *esculenta*, hot pepper *Capsicum fruitescens* and sweet pepper *Capsicum annuum* were investigated under laboratory conditions at 29 ± 2 ºC and 60 ± 5% RH. It was noticed that, host plant significantly influenced development and reproduction of *T. urticae*. Rearing on leaves of eggplant recorded significantly shorter developmental time and greater total reproduction rates of this mite species. Adult female longevity, oviposition period and fecundity were greater when the mite reared on eggplant leaves (17.27 days; 14.13 days and 45.39 eggs), respectively. On the other hand the shortest longevity (12.87 days), the least oviposition period (10.20 days) and the lowest fecundity (19.07 eggs) were recorded with leaves of hot pepper. Moderate values of these biological parameters were recorded with leaves of sweet pepper. The mite showed greatest preference for eggplant followed by sweet pepper and hot pepper. Obtained data indicated that, the host plant quality was a highly significant factor affecting population growth parameters of this acarine pest. These results may have some practical implications in management program of *T. urticae.*

Keywords: *Tetranychus urticae*; biological parameters; vegetable crops; host suitability.

INTRODUCTION

The two-spotted spider mite Tetranychus urticae Koch (Acari: Tetranychidae) is a worldwide damaging acarine pest of many agricultural crops including vegetables (Helle and Sabelis, 1985). Host plant quality and environmental conditions particularly temperature in combination with humidity are of the important factors affecting population growth characteristics of this mite species on different host plants (Henneberry 1962, 1963; Baoping et al., 2004; Wekesa et al., 2011; Karami-Jamour and Shishehbor 2012; Riahi et al., 2013; Yan-Lan et al., 2013; Modarres Najafebadi et al., 2014; Gomes Neto et al.2017; Castro et al., 2018). In many parts of the world including Egypt, eggplant Solanum melongena, hot pepper Capsicum frutescense and sweet pepper Capsicum annuum are of the most popular vegetable crops. These crops have been found to extensively attacked by numerous arthropod pests particulary members of the family Tetranychidae, that are widely spread during the growing season (Gázquez et al., 2011; Abou-Zaid et al., 2012; Jeong-Hwan et al., 2012; Nadini et al., 2012; Maklad et al., 2014). Field observations carried out by (Abou-Zaid et al., 2012; Sarwar, 2013; El-Laithy et al., 2013). revealed markedly differences among these solanaceous crops in their acceptance and preference for the two-spotted spider mite *T. urticae*. In this laboratory study detailed developmental rate and fecundity data on the two-spotted spider mite T. urticae when reared on leaves of eggplant, hot pepper and sweet pepper plants correlated with protein content of

leaf tissues of each crop were discussed to clarify the impact of host plant on some biological characteristics of this acarine pest..

MATERIALS AND METHODS

Host plants

The vegetable crops used in this study are eggplant, *Solanum melongena*; hot pepper, *Capsicum frutescense* and sweet pepper, *Capsicum annuum*, which are commonly grown as an important Solanaceous vegetable crop in Egypt.

Mite colonies

Adults of the two-spotted spider mite *Tetranychus urticae* were originally collected from castor bean *Ricinus communis* L. leaves at the farm of Faculty of Agriculture, Zagazig University. These mites were separately reared on the investigated crops transplanted into compost in plastic pots (20cm diameter x 15cm length). Infested plants were kept in a greenhouse for several generations before conducting the experiments.

Plant materials

The investigated vegetable crop transplants were separately transplanted into comopost in plastic pots (14 cm diameter and 16 cm length) and maintained in the laboratory. No acaricides or fertilizers were used. All pots were irrigated in the same time. After two weeks clean leaves of these crops were taken and used to make leaf discs for using in the rearing experiment.

Rearing substrates

The two-spotted spider mite T. urticae was reared according to the methods of Gotoh (1986) and Pontier et al., (2000). Fresh leaf discs of the investigated crops (one inch in diameter each) were used as rearing substrate. Leaf discs were placed singly with the lower surface up on water saturated pad in an open petri dish to prevent desiccation of the leaf discs (Razmjou et al., 2009). Suitable moisture was maintained by adding few drops of water when needed. A narrow strip of cotton saturated with water was placed periphery of each leaf disc to prevent mite escape. When leaf discs began to deterirate, resident mite individuals were transferred to new leaf discs (Pontier et al., 2000).

Mite rearing

This experiment was conducted in the laboratory of Acarology, Plant Protection Department, Faculty of Agriculture, Zagazig University at 29 ± 2 ºC, 60 ± 5 % RH and photoperiod of 14:10 (L:D) hr. to estimate the incubation period, immature developmental time to adult, adult female longevity and reproduction of T. urticae when reared on the abovementioned tested vegetable crops. A total of 50 mated females from each crop colony were isolated and placed singly on 50 leaf discs for each crop, left for 12 h and allowed to lay eggs. Immediately after the egg deposition, female and excess eggs were removed leaving only one egg per leaf disc. The laid eggs were reared until reaching to adulthood. All leaf discs were checked twice daily. Incubation period, duration of each immature stage of development and immature mites survivorship were recorded with stereo-microscope. To estimate longevity and reproduction of T. urticae separately, females in teleiochrysalis stage were individually transferred onto leaf discs together with one adult male for mating (Razmjou et al., 2009). Rearing units were examined daily and the number of eggs laid per female was calculated until all the experimental females died. Leaf discs were replaced by fresh one when necessary. During the experiment mite individuals were carefully handled with a fine camel hair brush. Obtained results were subjected to statistical analysis using F test according to Snedecor and Cochran (1980). Determination of protein of leaf tissues content of the investigated vegetable crops was carried out in the Central Laboratory of Faculty of Agriculture, Zagazig University according to the method recommended by the Association of Official and Analytical Chemists (AOAC, 1999). Some biological characteristics of T. urticae were correlated with average protein content of leaf tissues of the investigated vegetable crops by calculating the simple Correlation Coefficient according to Costat Statistical Software (2005) .

RESULTS

The average duration of various stages of the two-spotted spider mite *T. urticae* when reared on eggplant; hot pepper and sweet pepper are presented in Tables (1, 2). The investigated vegetable crop leaves have been found to be suitable for development and reproduction of the two-spotted spider mite *T. urticae*, but they were significantly differed (P = 0.05) in their effect on some biological characteristics of this mite

species. The findings of this study are in harmony with similar studies by other authors on Tetranychid mites in many respects but differ distinctly with others.

Total maturation time

Data in (Table 1) revealed significant effect of the tested host plant leaves on the total developmental time from egg to adulthood of *T. urticae*. Distinict decrease in the duration of life cycle was recorded on eggplant leaf discs (8.17 days), while the other two crops *i.e.* sweet pepper and hot pepper recorded (9.07 and 9.77 days), respectively. Similarly, Uddin et al., (2015) reported that, this period for the same mite species was significantly longer on bean cultivar IPSA Seam1 than the other tested cultivars. Similar results were obtained by Elsadany (2018) who reported that, life cycle of *T. urticae* durated 9.9 days on mulberry leaves. The highest survival rate of *T. urticae* immature stages (86.67%) was recorded on eggplant, this value averaged 80.00% and 66.67% on sweet pepper and hot pepper, respectively. Lower values of immature stages survival for this mite species varied from 57-59% on soybean cultivars Hach and Hobxwill were recorded by (Razmjou *et al*. 2009). These results are close to the results of (Boaping *et al*. 2004) who found that survival rates of *Tetranychus truncatus* female were 89.8, 84.3 and 61.6 days on cucumber; kidney bean and aubergine, respectively.

Oviposition

On the studied vegetable crops, the time from maturation to the first egg (pre-oviposition period) was short and ranged from 1.07 days on eggplant to 1.2 days on sweet pepper (Table 2). Females reared on eggplant leaves continued ovipositing eggs for significantly longer ovipositional period (14.3 days) and laid significantly greater number of eggs (45.39 eggs) with the highest daily ovipositional rate of 3.22 eggs/ female/day. Before the female of *T. urticae* death, it stopped egg laying for a period averaging 1.53; 1.67 and 2.07 days on hot pepper; sweet pepper and eggplant leaf discs, respectively at 29 ± 2 ºC (Table 2). Gotoh (1986) reported that adult female of the spider mite *Tetranychus viennensis* when reared on deciduous oak at 25 ºC laid 43 eggs during ovipositional period of 15.09 days with a daily mean of 3.02 eggs/female/day and most females of this mite species died within one or two days after the end of oviposition. Also, these results nearly agree with data obtained by (Chahine *et al.*, 1994) who reported that adult females of *T. urticae* laid 55.2 eggs as a total number when fed on common bean leaves at 22 ºC. The total number of eggs laid per female of *T. urticae* on soybean leaves was 58.66 in the laboratory at 25 ± 2 ºC (Abd-Elaal, 2015).In this study the daily ovipositional pattern of *T. urticae* female on the aforementioned vegetable crops were markedly different (Figure 1). Mean number of deposited eggs per female per day increased during the first 10 days on eggplant leaves. In this regard Carey and Bradley (1982) found that the maximum daily egg production of *T. urticae* lasted from day 5 to day 11.

Generation time

Data in (Table 1) showed that the mean generation period of T. urticae was significantly influenced by kind of host plant. Generation period durated a considerably longer time (10.9 days) on hot pepper leaves. Hanna et al. (1981) reported that generation period of T. urticae durated 11.38 days at 27 ± 2 ºC when mite fed on soybean cultivar Hampton. A markedly shorter generation time for this mite species (13.64 days) was recorded when mite fed on common bean leaves (Abd-Elaal 2015). The time needed by female of Tetranychus truncatus to complete a generation on kidney bean, soybean and maize in the laboratory (28 ºC) were 9.3; 9.6 and 11.6 days, respectively (Boaping et al., 2004) that nearly similar to our findings.

Adult female longevity and life span

The average duration of adult female longevity and life span (from egg to death) of *T. urticae* were significantly different among the tested vegetable crops. The longest periods of longevity (17.27 days) and life span (25.43 days) were recorded on eggplant leaves. The total adult longevity of *T. viennensis* was 17.58 days when reared on deciduous Oak at 25 ºC (Gotoh, 1986) that nearly similar with results in this study on eggplant leaves (Table 2). Moreover, Chahine *et al*. (1994) indicated that adult female of *T. urticae* lived 11 days when fed on common bean leaves in the laboratory at 22 ºC that lower than results in this paper. Life span of *T. urticae* durated 34.53 days when female fed on soybean leaves at 27 ± 2 ºC that higher than our findings (Shehata, 2010).

Table 1: Duration of various stages (days) of *Tetranychus urticae* reared on leaves of three vegetable crops at 29 ± 2 ºC and 60 ± 5% RH.

Mite stage	Vegetable crop			L.S.D. 0.05
	Egg plant	Hot pepper	Sweet pepper	
Egg	2.43±0.042	2.53±0.083	2.47±0.083	-
Larva	1.87±0.034	2.37±0.034	2.13±0.034	-
Protonymph	1.60±0.042	2.13±0.034	1.93±0.042	-
Deutonymph	2.27±0.039	2.73±0.066	2.53±0.042	-
Total immatures	5.74±0.039 c	7.23± 0.039 a	6.60± 0.042 b	0.123
Life cycle	8.17±0.052 c	9.77± 0.039 a	9.07± 0.042 b	0.138
Generation period	9.23±0.039 c	10.90±0.068 a	10.27±0.039 b	0.156
Life span	25.43±0.013 a	22.63± 0.193c	23.33± 0.159b	0.506

Notes: Means followed by the same letters are not significantly different at 0.05% level according to Duncan's multiple range test. ±SE (Standard Error)

Table 2: Longevity and Fecundity of *Tetranychus urticae* reared on leaves of three vegetable crops at 29 ± 2 ºC and 60 ± 5% RH.

Crops	Duration (in days)				Deposited eggs	
	Pre-oviposition	Oviposition period	Post-oviposition	Longevity	Total average	Daily mean
Eggplant	1.07	14.13 [a]	2.07	17.27 [a]	45.39 [a]	3.22 [a]
Hot pepper	1.13	10.20 [c]	1.53	12.87 [c]	19.07 [c]	1.87 [c]
Sweet pepper	1.20	11.40 [b]	1.67	14.27 [b]	31.93 [b]	2.81 [b]
L.S.D 0.05	-_	0.301	-_	0.290	0.629	0.064

Notes: Means followed by the same letters are not significantly different at 0.05% level according to Duncan's multiple range test.

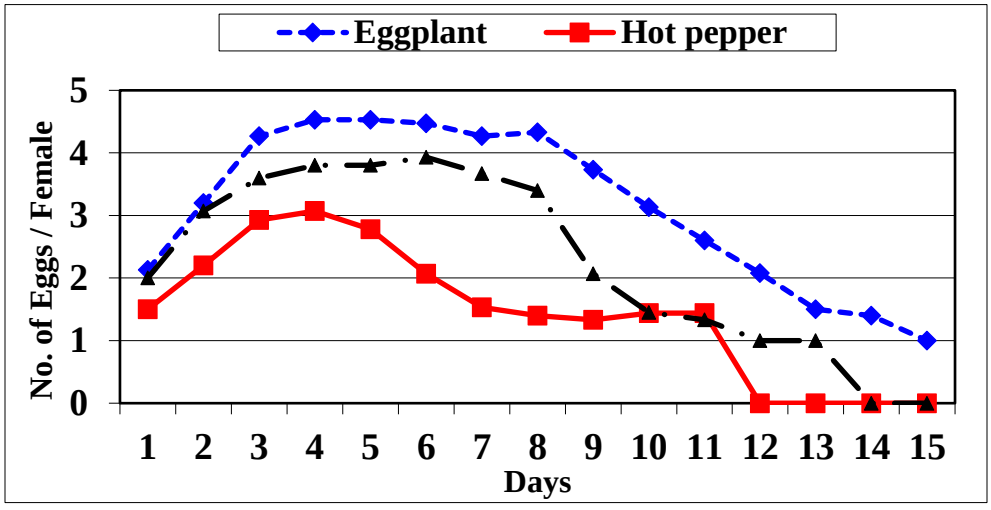

Figure 1: Average daily oviposition per female of *Tetranychus urticae* reared on leaves of three vegetable crops at 29 ± 2 ºC and 60 ± 5% RH.

Table 3: Correlation Cofficient values (r) between protein in three vegetable crop leaves and some biological aspects of *T. urticae*.

Crops	Protein (%)	Correlation Coefficient values (r)			
		Life cycle	Longevity	Fecundity	Life span
Eggplant	4.67 [b]	-0.96**	0.94*	0.93*	0.98**
Hot pepper	3.53 [c]	-0.75 ns	0.70 ns	0.29 ns	0.49 ns
Sweet pepper	4.93 [a]	-0.92*	0.96**	0.91*	0.91*
L.S.D	0.22	-	-	-	-

Notes: Means followed by the same letter are not significantly different at 0.05% level according to Duncan's multiple range test; ns = non significant; *significant; ** highly significant.

Correlation between some biological aspects of *T. urticae* and protein of host leaves

Data in (Table 3) showed significant difference in protein content of the investigated vegetable crops (P = 0.05). The higher protein content in sweet pepper (4.93%) and eggplant (4.67%) leaves could be suspected positively influenced, longevity, fecundity and life span of T. urticae females (Table 3). Significant negative effect was recorded with duration of life cycle when mite reared on the three crops (Table 3). In this regard Wermelinger et al., (1985) reported that nitrogen, water, amino acids and sugar content of apple leaves were positively correlated with weight and egg production of T. urticae and negatively correlated with development time and pre-oviposition period. The higher protein in Mung bean leaves positively affecting number of eggs laid by T. urticae females (Puspitarini et al., 2013).

DISCUSSION

From the previous results, it can be concluded that the investigated vegetable crops differ markedly in suitability as a host for this acarine pest *T. urticae*, when measured in terms of development, survival of immature stages and reproduction rates. Eggplant proved to be the most favorable host plant for *T. urticae* as it gained shortest life cycle, highest survival rate of immature stages and greatest fecundity. On country, hot pepper was the least preferable one, since it contained the lowest values of the abovementioned parameters.

CONCLUSION

Obtained data revealed that, quality of host plant (*e.g.* protein of host leaves) appeared to be one of the factors affecting population growth parameters of this mite species. Results of this study may provide useful informations for management of *T. urticae*, which is considered as one of the major acarine pests attacking these vegetable crops in Egypt.

CONFLICT OF INTEREST

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

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AUTHOR CONTRIBUTIONS

HAB designed and performleed the experiments and also wrote the manuscript. EMM and EAM designed experiments and reviewed the manuscript. All authors read and approved the final version.

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