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Biological and Ecological Fitness of the Two-Spotted Spider Mite, *Tetranychus urticae* koch (Acari: Tetranychidae) on Certain Host Plants

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ABSTRACT

The comparative population growth parameters of the two-spotted spider mite, *Tetranychus urticae* Koch on cucurbits vegetable crops; Sudanian, Musk and Snake melons commonly planted in numerous districts of Egypt were studied. These parameters were estimated at 25 ± 1°C, 60 ± 5% R.H. and a photoperiod of 14:10 hrs.(L: D) daily. Developmental time, survival to adult stage and egg hatchability were similar among the three host plants, but significant variation in fecundity and longevity, resulting in large differences for population growth parameters. such as the intrinsic rate of natural increase (r_m), net reproductive rate (R_o) and finite rate of increase (λ). were detected. Sudanian melon was the most favorable host for the two-spotted spider mite with r_m (0.297), followed by Musk melon (0.243) off springs/female/day. The slowest population growth was observed on Snake melon with r_m (0.231) off springs/female/day.

Key words: Host plant; Cucurbits; Life Table; *Tetranychus urticae*.

INTRODUCTION

The two-spotted spider mite, *Tetranychus urticae* Koch is one of the most destructive pests. It attacks a broad range of crops (van de Vrie *et al.*, 1972). The divers host plant species may have been differently affected by this pest. Cucurbits vegetable crops, Sudanian, Musk and Snake melon are commonly planted in numerous districts of Egypt, El-Hosainia Plain, El-Sharkia governorate is one of it. Cucurbit crops are preferable for this pest which decreased its yields. The rapid developmental rate and high reproductive potential of *T. urticae* allow it to achieve damaging population levels very quickly under suitable conditions, resulting in an equally rapid decline of host plant quality. The importance of this mite pest is not only due to direct damage to plants including defoliation, leaf burning and even in excessive outbreaks plant death but also indirect damage to plants which decreases photosynthesis and transpiration (Brandenburg and Kennedy, 1987).

Cucurbits crops as mite host plants differ in their components that may be act as defense agent against herbivorous pests (Rosenthal and Berenbaum, 1991). Many secondary metabolites found in plants have a responsibility in defense against herbivores pests. 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). The population of the two-spotted spider mite has positive correlation with increasing the nutrient contents of cucurbits leaves i.e. crude proteins, carbohydrates and crude fats (Ibrahim *et al.*, 2008).

The population growth parameters of *T. urticae* such as developmental rate, survival, reproduction and longevity may vary in response to changes in temperature, host plant species, host plant nutrition, cultivar kind, phonological stage, exposure to pesticides, relative humidity, etc. (Sabelis, 1981; Brandenburg and Kennedy, 1987; Wermelinger *et al.*, 1991; Wilson, 1994; Dicke, 2000; James, 2002; Marcic, 2003 and Skorupska, 2004).

Biological knowledge, in particular life table attributes is a significant step to an improved reorganization of the population dynamics of pests. This information may be used as an important means in planning pest management program. On the other hand, host plants may have main effects on development, mortality and fecundity rates of spider mite population dynamics. Therefore, in order to expand a successful integrated pest management (IPM) program for *T. urticae*, it is vital to comprehend its life-history parameters on different host plants.

The objective of this research was to study the effect of certain cucurbits crops on the population growth parameters of the two-spotted spider mite that affect how fast the populations reach economic damage.

MATERIALS AND METHODS

Experimental procedures

Maintenance of the mite colony

This study was conducted in the Plant Protection Laboratory at El-Hosainia Agricultural Research Station in 2015. Where a laboratory strain of the two-spotted spider mite, *Tetranychus urticae* Koch, adopted technique of Gurguis *et al.* (1977) was followed. The strain of mites were collected from fields and reared in the laboratory on Kidney bean, *Phaseolus vulgaris* (L.) plants. The strain was kept in cheese cloth cage (60x 60 x 100 cm.) away from any pesticides contamination under constant conditions (25 ± 1°C and 60±5 % (RH) relative humidity and 14:10 hr. (L: D) daily illuminations. Leaves from a laboratory culture heavily infested with the two-spotted spider mite were distributed over the new foliage of the Kidney bean.These mites were subsequently maintained on potted related plants in a growth chamber without exposure to pesticides for at least three months under the constant conditions before conducting the experiments.

Host plants used

Three cucurbits host plants, Sudanian melon, *Sitrullus lanatus var. colocynthoides*, Musk melon, *Cucumis melon var. reticulatus* and Snake melon, *Cucumis melon var. flexuous* were planted under greenhouse conditions. Traditional agricultural practices were exercised. Four weeks after planting, fresh and clean leaves of each crop were collected and prepared as circular leaf discs (one inch diameter).

Biological aspects

To assess developmental time and life table parameters of *T. urticae* on each host plant, Twenty five Petri-dishes were used for each tested host plant. Four fresh leaf discs of each tested host plants were placed on water-saturated cotton in a Petri-dish (9cm in diameter). Two adult females of laboratory strain of mites were transferred by a fine brush to the lower surface of each leaf disc. The females were allowed to lay eggs for three hours, then the mites were removed from the Petri dish. All laid eggs were destroyed except one on each leaf disc. The eggs were incubated at 25°C until emerged and monitored daily through all stages to adulthood. The immature mite's survivorship and the sex ratio of the appearing mites were calculated (Gotoh and Nagata, 2001).

To evaluate mite fecundity, a newly emerged female and two males collected from the stock culture (to insure mating) were introduced to a 9 cm Petri dish with a fresh leaf disc of each host plant on water-saturated cotton. Each host plant leaf disc was substituted with fresh one every four days. The females were allowed to lay eggs. Eggs were counted and removed daily except those laid on the first five days; those were left to hatch until all experimental females died. In this way, we evaluated the fecundity of 20 two-spotted mite females per host plant and the percentage of hatchability was calculated (Gotoh and Gomi, 2003).

Life table parameters

Standard life table procedures and intrinsic rate of increase (r_m) for the two-spotted spider mite on certain host plants were estimated using the following equations (Brich, 1948 and Bengston, 1969):

Formula	Definition
x	Age of individuals in days.
l_x	Probability of an individual surviving to age x.
$_x$	Reproductive expecting of a female at age x.
$GRR = \Sigma m_x$	Gross reproductive rate, expected total number of female birth produced by a female which lives through all age.
$R_0 = \Sigma(l_x m_x)$	Net reproductive rate (number of daughters that replace average females in course a generation).
$T = \Sigma(x\, l_x m_x)/R_o$	Mean generation time (mean time elapsing between birth of parents and the birth of offspring).
$r_m = Ln(R_o)/T$	Intrinsic rate of increase (number of individuals produced per unit time).
λ= antilog (r_m)	Finite rate of increase.

Data analysis:

Developmental time, the proportion of immature mites surviving, longevity and fecundity of *T. urticae* were analyzed with analyses of variance (ANOVA). When the overall variation among the host plants was significant, post-hoc comparisons among means were carried out using Tukey tests at $P < 0.05$. Life table parameters including net reproductive rate (R_o), the generation time (T), intrinsic rate of natural increase (r_m) and finite rate of increase (λ) as well as their standard errors were estimated by the method of (Meyer *et al.*, 1986 and Carey, 1993) using the SAS System Software. The values for each treatment were subjected to an analysis of variance (ANOVA). Significance of differences between mean values of life table parameters was determined using Student's t test (Maia *et al.*, 2000).

RESULTS AND DISCUSSION

Developmental time of immature stages:

Table (1) clearly show that no significant variation among the three tested host plants was observed for the developmental time of the two-spotted spider mite eggs and nymphs; while the developmental time of mite larvae showed significant differences among host plant species. The period was 1.51 days on Musk melon, differed on each of on Sudanian (1.05) and Snake melon (1.12) days. The variation among the three host plants was melt away as total immature stage developmental period.

Female longevity and lifespan:

The adult longevity of the two-spotted spider mite as well as the total lifespan (from egg to death) varied significantly among the three host plants. The mites

Table (1): Developmental time of different stages of *T. urticae* on three cucurbits.

Host plant	Means of developmental time in days					
	Egg	Larva	Nymph	Total (immature stage)	Oviposition period	Female lifespan
Sudanian melon	4.52^a (22)	1.05^a (22)	3.68^a (22)	9.25^a (22)	12.57^a (19)	21.65^a (19)
Musk melon	4.17^a (24)	1.51^b (24)	3.71^a (24)	9.39^a (24)	12.16^a (17)	21.57^a (17)
Snake melon	4.21a (23)	1.12a (23)	3.83^a (23)	9.16^a (23)	5.23^b (20)	14.23^b (20)

Differences among cucurbits were determined by Tukey tests. Within columns, means followed by different letters are significantly different (P<0.05). The (n) value in the parentheses shows the number of the tested individuals.

Table (2): Number of eggs per female, egg hatchability, immatures survivorship and sex ratio of *T. urticae* on three cucurbits host plants.

Host plant	Means of parameters				
	Total No. of eggs/female	No. of eggs/female/day	Egg hatchability (%)	Immatures survivorship (%)	Sex ratio (%female)
Sudanian melon	83.16^a (19)	6.59 a (19)	92.5	87.5	85.6
Musk melon	65.53^{ab} (17)	5.05 a (17)	90.0	72.5	82.3
Snake melon	34.57^{bc} (20)	6.17 a (20)	89.1	72.5	81.1

For this parameter, differences among species host plants were determined by Tukey tests. Within columns, means followed by different letters are significantly different (P<0.05). The (n) value in the parentheses shows the number of the tested individuals.

Table (3): Life table parameters of *T. urticae* on three cucurbits host plants.

Host plant	Means of parameters			
	R_o	T (d)	r_m	λ (d)
Sudanian melon	53.84 a	13.45 a	0.297 a	1.345 a
Musk melon	29.13 b	13.96 a	0.243 b	1.274 b
Snake melon	11.25 c	10.59 a	0.231 b	1.259 b

Differences among host plants were determined by t-test pairwise comparison, based on estimates of variance for each parameter (Maia *et al.*, 2000). Within columns, means followed by different letters are significantly different (P<0.05).

survival and oviposition period were clearly longer on the Sudanian melon plants than on all other host plants. The means of *T. urticae* lifespan period of were 21.65 days on Sudanian melon, whereas this value was 21.57 and 14.23 days on Musk melon and Snake melon plants, respectively (Table1).

Sex ratio, survivorship, fecundity and hatchability

The sex ratio of the two-spotted spider mite on the three tested host plants was 81.1, 82.3 and 85.6 percent on Snake, Musk and Sudanian melon, respectively.

The survivorship of immature stages (from egg to adult) revealed that the mites on each of Musk and Snake melon had 72.5% chance for reaching adulthood, whereas Sudanian melon had 87.5% (Table 2).

The pattern of fecundity of mites indicated that the total number of eggs laid by each female exhibited significant differences among the three host plants. It was 83.16, 65.53 and 34.57 eggs per female on Sudanian, Musk and Snake melon, respectively, while no significant variation among host plants was observed for the number of eggs laid by each female per day. Due to much longer adult survival, mites laid about more than twice as many eggs on Sudanian melon compared with the Snake melon plants (Table 2).

Hatchability percentages were 89.1, 90.3 and 92.5% for deposited eggs of mites which feed on Snake, Musk and Sudanian melon, respectively (Table 2).

Life table parameters

Net reproductive rate (R_o) is the average number of female offspring produced by an average new born female during its entire life time. That means taking survivorship in consideration; on the contrary Gross Reproductive Rate (GRR) does not. The analysis of the net reproductive rate (R_o) of the two spotted spider mite indicated significant differences among three host plants (P < 0.05). The mites reared on Sudanian melon had the largest R_o value, followed by Musk melon; whereas on Snake melon had the smallest R_o value (Table 3).

Generation time (T) is the period required for a population to be replaced by a factor equal to (R_0). The obtained results revealed that the mean of generation time did not vary markedly among mites on the three host plans.

Only followed a different pattern, being shortest on Snake melon and highest on Musk melon (Table 3). The intrinsic rate of natural increase (r_m) defines as the actual rate of increase of a population under specified constant environmental condition in which space and food are unlimited when there are no mortality factors other than physiological ones. So, in the case of mites on the three host plants significant differences in r_m of *T. urticae* were found among the three host plant species ($P < 0.05$), ranging from 0.231 on Snake melon to 0.297 on Sudanian melon (Table 3).

The finite rate of increase (λ): it is obvious from the obtained results that the population increase in a similar fashion and exhibited the same hierarchy of performance, best on Sudanian melon, followed by Musk melon, the least was on Snake melon (Table 3).

Plant species are considered on the basis of its suitability as hosts for specific mites when measured in terms of mite survival, reproductive rates and acceptance by the pest population (van den Boom *et al.*, 2003; Greco *et al.*, 2006). Host plant species often differ in chemical profiles, thereby affecting host (i.e., herbivore) quality. So, host plant quality is a key determinant of the fecundity of herbivorous insects (Awmack and Leather, 2002).

The present results showed serious differences in the spider mite performance among three cucurbits plants tested in this study. Therefore, obtained results from these experiments showed a better performance of *T. urticae* on Sudanian melon leaf discs than on the other two host plants. This was shown not only in the fecundity and adult longevity but also in the female lifespan (Table 1). So, the mean number of eggs laid by *T. urticae* on Sudanian melon plant (83.16, eggs/female) was more than two times higher than those on Snake melon (34.57 eggs/female).

In addition, the mean of *T. urticae* lifespan was 21.65 days on Sudanian melon whereas this value was 21.57 and 14.23 days on Musk melon and Snake melon plants, respectively (Table 1).

Therefore, the better r_m of mite female found on Sudanian melon and followed by Musk melon compared with mites on Snake melon was mainly the result of the greater overall fecundity and longer adult oviposition period and lifespan of this pest. The poor performance of mites on snake melon was the result of poor fecundity, lower survivorship immature stages and shorter lifespan and adult oviposition period (Tables 1, 2 and 3). The r_m value of *T. urticae* estimated in the current study ranged from 0.231 to 0.297 individuals per female per day (Table 3). These values are close to those estimated for the spider mite reared on other host plants (Gotoh and Gomi, 2003; Kasap, 2003; Kafil *et al.*, 2007; Razmjou and Nemati, 2009).

In particular, some studies have documented that amount of performance and acceptance of the spider mite differs between plant species. For instance, van den Boom *et al.* (2003) found that the plant species vary in their degree of acceptance by the *T. urticae* population. Their results indicated that soybean, hop, golden chain and tobacco were highly acceptable to the spider mite, because almost 100% of the spider mites stayed on the plant; while eggplant, cowpea and thorn apple had a lower acceptable percentage at its value was about 65%. Besides, the findings of Greco *et al.* (2006) showed a high preference and better performance of *T. urticae* on strawberry leaves than on onion, leek and parsley leaves. This was shown not only in the fecundity but in the maximum number of offspring settled, as well. Several potential mechanisms could be responsible for this phenomenon including plant nutritional quality of the host plant and morphological or allelochemical features (Krips *et al.*, 1998; Agrawal, 2000; Dicke, 2000; Pietrosiuk *et al.*, 2003; Balkema-Boomstra *et al.*, 2003; Ibrahim *et al.*, 2008).

The present findings show that Sudanian melon is a more suitable host plant than Musk and Snake melon plants for the two-spotted spider mite. Therefore, this pest may be able to create quickly a large and damaging population on Sudanian melon plants, and this feature must be considered by growers in order to implement IPM programs for the two-spotted spider mite.

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