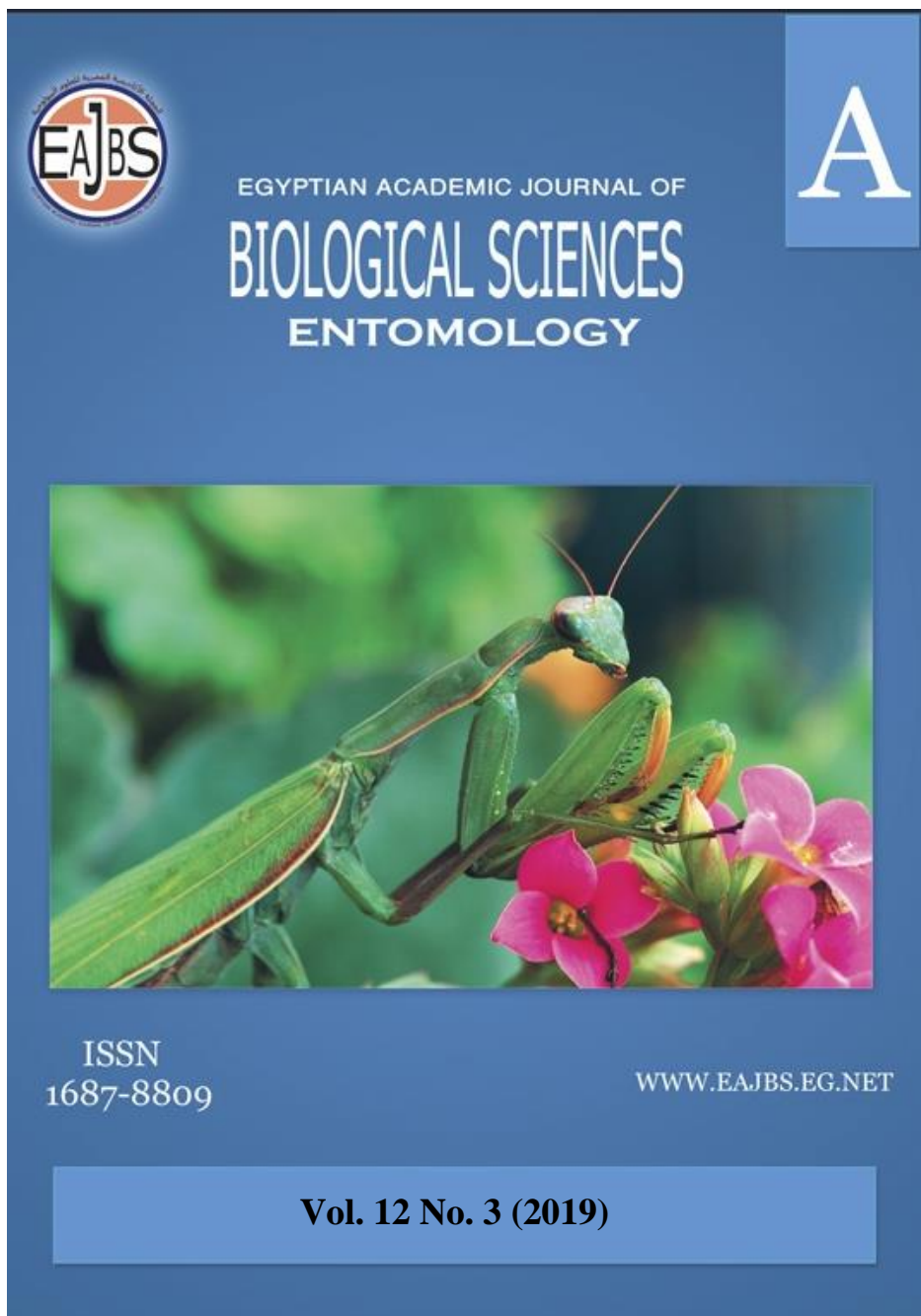


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Effect of Two Egyptian Cotton Varieties on Development and Life Table of the Two-Spotted Spider Mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) in Relation to Leaf Chemical Contents

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ABSTRACT

The development and life table of the two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) were studied when reared on two Egyptian cotton varieties: Giza 86 and Giza 90 at laboratory conditions of $27\pm 2^{\circ}\text{C}$ and $60\pm 5\%$ R.H. Results cleared that the development of *T. urticae* female was significantly affected by cotton variety. Immatures developmental time was shorter on Giza 90 (3.82 days) than Giza 86 (9.86 days). The adult female longevity averaged 12.29 and 16.65 days on Giza 90 and Giza 86, respectively. In addition, the values of Net reproductive rate (R_0), Intrinsic rate of natural increase (r_m) and Finite rate of increase per day (λ) of *T. urticae* were (65.04, 0.407 and 1.502 days) and (31.95, 0.184 and 1.202 days) on Giza 90 and Giza 86, respectively. The female fecundity recorded 98.63 and 71.00 eggs / female on Giza 90 and Giza 86, respectively. The mean generation time (T) and generation doubling time (DT) values were the lowest on Giza 90 (10.27, 1.702 days) than Giza 86 (18.82, 3.766 days), respectively. A positive significant correlation was recorded between development, fecundity of *T. urticae* female and availability leaf nitrogen content.

INTRODUCTION

Cotton (*Gossypium* spp.) (Fam. Malvaceae) is one of the most important crops and widely produced agricultural and industrial crops in the world that grown in more than 100 countries on about 2.5% of the world's arable land, making it one of the most significant in terms of land use after food grains and soybeans (Townsend and Liewellyn, 2007).

The Egyptian cotton, *Gossypium barbadense* L. is a strategic crop with glorious history in Egypt. It is accounted as main source of Egyptian economy, its impact on the economic development of the country is well established and it is rightly known as the white gold in Egypt.

At least 33 tetranychid mite species (Acari) are pests of cotton varieties (*Gossypium* spp.) throughout the world, of which the most serious are *Tetranychus urticae* Koch, *T. ludeni* Zacher, *T. turkestanii* (Ugarov & Nikolski), *T. cinnabarinus* (Boisd.) (Leigh, 1985). The mite, *T. urticae* feeds on various species of plants and attacks more than 200 host plants belonging to orchard, vegetable, green house and field crops world-wide (van de Vrie *et al.*, 1972; Jeppson *et al.*, 1975; Skorupska, 2004).

In Egypt, cotton plants are attacked by the spider mite, *T. urticae* which is considered one of the major pests of cotton plants that causes a huge damage in cotton yields and lowers its category (Zaher, 1984). It is well recognized that the host plant quality affects the development and survival of plant feeding of its herbivores, by impairing growth, lowering resistance to diseases and reducing fecundity (Price *et al.*, 1980, Adango *et al.*, 2006). For optimizing the chemical control of this pest or initiating other types of pest management, a detailed knowledge of mite biology and of the factors affecting population growth is required.

Therefore, the present work aims to study the life history and life table parameters of *T. urticae* reared on two cotton varieties Giza 86 and Giza 90 at $27 \pm 2^\circ\text{C}$ and $60 \pm 5\%$ R.H. under laboratory conditions. In addition, the correlation between development of the spider mite and phytochemical contents of tested cotton leaves was investigated.

MATERIALS AND METHODS

Tested cotton varieties:

Two cotton varieties Giza 86 (G. 86) and Giza 90 (G. 90) cultivated in Sharkia and Sohag Governorates, respectively; during season 2016 were used in the study. The information related to the two cotton varieties were provided by the Cotton Research Institute, Agricultural Research Center, Egypt, (Table 1). Leaf samples of both cotton varieties collected from cotton fields in vegetation stage in paper bags to the laboratory

Table 1. Information related to cotton varieties Giza 86 and Giza 90.

Varieties	Pedigree	Category	Current position	Location
Giza 86	Giza 75 \times Giza 81	Long staple	Commercial variety	Sharkia
Giza 90	Giza 83 \times Dendara	Long staple	Commercial variety	Sohag

The Spider Mite, *T. urticae* Rearing Technique:

The original colony of the spider mite, *T. urticae* was supplied from heavily infested cotton leaves which have got from Zagazig district, Sharkia Governorate, Egypt, during season 2016. It was maintained separately on leaf discs (5 cm in diameter) of cotton varieties G. 86 and G. 90 for rearing the spider mite culture in laboratory conditions at $27 \pm 2^\circ\text{C}$ and $60 \pm 5\%$ R.H. The discs were put on cotton wool pad in Petri-dishes and supplied with water to maintain the leaf discs fresh and prevent mite escaping.

Experimental Procedures:

Leaf disc technique was used to study the biology of *T. urticae*. Female mites were released on the abaxial surface of each tested cotton varieties G. 86 and G. 90, which put on cotton bed in Petri-dishes (10 cm in diameter).

Ten gravid females of the mite were taken from mite culture and released on leaf discs (3 cm in diameter) of cotton varieties for obtaining sufficient number of eggs. After 24 h, females were removed. Just before female emergency (deutonymph), one male from the main colony were added to each leaf disc to assure mating.

Thirty newly larvae were placed singly on fresh cotton leaf discs (2.5 cm in diameter) for both cotton varieties in Petri-dishes. The duration of different stages of the spider mite on each cotton varieties were recorded. Discs were examined twice daily and all biological aspects were recorded until death of mite individuals.

Phytochemical Analysis Procedures of Tested Cotton Varieties:

Leaf samples of the cotton varieties G. 86 and G. 90 cultivated in 2016 season at

Sharkia and Sohag Governorates, respectively, were collected during the vegetation growth period, cleaned, washed with distilled water and left to dry at room temperature in appropriate air flow until the samples drying then leaves were grinded into fine powder. Nitrogen, phosphorus and potassium were estimated according to the methods of Sadasivam and Manickam (1991), Murphy and Riely (1962), Amin and El-Halafawy (2001/2002), respectively. Total carbohydrates and total proteins were also determined as the methods described by Crompton and Birt (1967), Bradford (1976), respectively.

Statistical Analysis:

Data were analyzed by one-way analysis of variance (ANOVA) to test the significant difference between mean values and correlation coefficient between certain biological aspects of the spider mite and chemical contents of tested cotton leaves were separated by Duncan's multiple range test (Duncan, 1955). Life table parameters were estimated using a BASIC computer program of Abou-Setta *et al.* (1986) for female reared on various tested cotton varieties. This program is based on Birch's method (1948) for the calculation of an animal's life table. Constructing a life table, using rates of age-specific (L_x), and fecundity (M_x) for each age interval (x) was assessed. The following population growth parameters were determined: the mean generation time (T), gross reproduction rate (GRR) ($=\sum M_x$), the net reproductive rate (R_o), the intrinsic rate of increase (r_m), the finite rate of increase ($\exp r_m$), and the doubling time (DT). The life tables were prepared from data recorded daily on developmental time (egg to first egg laid), the number of deposited eggs, the fraction of eggs reaching maturity and the survival of females. Interval of one day was chosen as the age classes for constructing the life table.

RESULTS AND DISCUSSION

Obtained data revealed that *T. urticae* developed through egg, larva, protonymph, deutonymph and adult when reared on cotton varieties G. 86 and G. 90 in laboratory at $27\pm 2^\circ\text{C}$ and $70\pm 5\%$ R.H. (Table 2).

Duration of Different Mite Stages on Tested Cotton Varieties:

The egg stage hatched after 3.29, 3.58 days for female, 2.56, and 3.37 days for male when fed on discs of cotton varieties G. 86 and G. 90, respectively (Table 2). Total immatures lived longer on G. 86 than G. 90 averaged 9.86 and 3.82 days for female and 9.62 and 3.09 days for male, respectively. The same trend was recorded in the case of life cycle averaged 13.15 and 7.40 days for female and 12.18 and 6.46 days for male, on G. 86 and G. 90, respectively.

Influence of Cotton Varieties on Adult Female Longevity and Fecundity of *T. urticae*:

The pre-oviposition period of *T. urticae* adult female averaged 1.89 and 0.61 days, when fed on G. 86 and G. 90, respectively. The adult female longevity was longer on G. 86 than G. 90 averaged 16.65 and 12.29 days. The number of deposited eggs per female and daily rate of *T. urticae* averaged 71 and 3.74 eggs when fed on G. 86, but it averaged 98.63 and 8.02 eggs on G. 90. The life span was longer on G. 86 than G. 90 and lasted 29.80 and 19.66 days, respectively (Table 3).

Table 2. Duration in days of developmental stages of *T. urticae* fed on leaves of cotton varieties G. 86 and G. 90 at $27 \pm 2^\circ\text{C}$ and $60 \pm 5\%$ R.H.

Stages	Sex	Duration (in days) on cotton varieties:		LSD _{0.05}
		Giza 86 (Mean \pm S.E.)	Giza 90 (Mean \pm S.E.)	
Egg	♀	3.29 \pm 0.20 b	3.58 \pm 0.10 a	0.286
	♂	2.56 \pm 0.08 b	3.37 \pm 0.08 a	0.229
Larva	♀	3.33 \pm 0.16 a	1.57 \pm 0.09 b	0.379
	♂	2.85 \pm 0.12 a	1.20 \pm 0.09 b	0.295
Protonymph	♀	3.35 \pm 0.12 a	1.00 \pm 0.08 b	0.280
	♂	3.03 \pm 0.12 a	0.89 \pm 0.07 b	0.290
Deutonymph	♀	3.18 \pm 0.10 a	1.25 \pm 0.08 b	0.268
	♂	3.74 \pm 0.06 b	1.00 \pm 0.08 b	0.199
Total immatures	♀	9.86 \pm 0.43 a	3.82 \pm 0.14 b	0.534
	♂	9.62 \pm 0.16 a	3.09 \pm 0.15 b	0.447
Life cycle	♀	13.15 \pm 0.27 a	7.40 \pm 0.15 b	0.637
	♂	12.18 \pm 0.19 a	6.46 \pm 0.19 b	0.612

Data expressed as mean \pm standard error (S.E.). Values followed by a different letter in the same row are significantly different ($p \leq 0.05$).

Table 3. Effect of cotton varieties on longevity and fecundity of *T. urticae* adult female at $27 \pm 2^\circ\text{C}$ and $60 \pm 5\%$ R.H.

Female stages	Cotton varieties		LSD _{0.05}
	Giza 86 (Mean \pm S.E.)	Giza 90 (Mean \pm S.E.)	
Pre-oviposition (in days)	1.89 \pm 0.21 a	0.61 \pm 0.07 b	0.457
Oviposition (in days)	13.16 \pm 0.47 a	10.11 \pm 0.37 b	1.203
Post-oviposition (in days)	1.59 \pm 0.19 a	1.58 \pm 0.08 a	0.430
Adult longevity (in days)	16.65 \pm 0.59 a	12.29 \pm 0.38 b	1.426
Life span (in days)	29.80 \pm 0.64 a	19.66 \pm 0.44 b	1.582
Fecundity (no. eggs/female)	71.00 \pm 1.41 b	98.63 \pm 3.08 a	6.879
Daily rate (no. eggs/day/female)	3.74 \pm 0.07 b	8.02 \pm 0.46 a	0.946

Data expressed as mean \pm standard error (S.E.). Values followed by a different letter in the same row are significantly different ($p \leq 0.05$).

Effect of Cotton Variety on Life Table Parameters for *T. urticae*:

The presented data in Table (4) cleared that the shortest mean generation time (T) of *T. urticae* was 10.27 days on G. 90 variety, while the longest was 18.83 days on G. 86 variety. The highest net reproductive rate (R_0) was affected by cotton varieties as (R_0) values averaged 65.04 and 31.95 when female mite fed on G. 90 and G. 86, respectively. The intrinsic rate of natural increase (r_m) values was 0.184 and 0.407 individuals/♀/day when fed

on G. 86 and G. 90 variety, respectively. The highest finite rate of increase (λ) was 1.202 and 1.502 days on G. 86 and G. 90, respectively. On the other hand, the doubling time (DT) recorded 3.766 and 1.702, while gross reproductive rate (GRR) ranged between 38.86 and 79.14 on G. 86 and G. 90, respectively.

The obtained data is in agreement with that, the intrinsic rate of natural increase (r_m) is a key demographic parameter useful for predicting the population growth potential of an animal under given environmental condition (Birch, 1948), because (r_m) reflects an overall effect on development, reproduction and survival (Southwood and Hendersen, 2000).

Table 4. Effect of two cotton varieties on life table parameters of *T. urticae*.

Parameters	Cotton varieties	
	Giza 86	Giza 90
Mean generation time in days (T)	18.83	10.27
Net reproduction rate (R_0)	31.95	65.04
Intrinsic rate of increase per day (r_m)	0.184	0.407
Finite rate of increase per day (λ)	1.202	1.502
Generation doubling time (DT)	3.766	1.702
Gross reproductive rate (GRR)	38.86	79.14

Relationship between Biological Aspects of *T. urticae* and Chemical Contents of Tested Cotton Varieties:

Total carbohydrates, total proteins, nitrogen, phosphorus, and potassium were estimated in vegetation growth period of cotton varieties G. 86 and G. 90 during season 2016. As shown in Fig. (1, B-C) data and statistical analysis cleared that total proteins and nitrogen contents ranged between 25.20 and 4.477 mg/gm dry weight for the significant susceptible cotton variety G. 90 but averaged between 21.07 and 3.753 mg/gm dry weight for the significant tolerant variety G. 86, respectively.

The same trend was recorded in the case of potassium content; its values were 405 and 384 m mol/gm dry wt. for G. 90 and G. 86, respectively (Fig. 1, D). As for phosphorus content among the cotton variety G. 90 and G. 86 averaged 650.667 and 379.667 μ g/gm dry wt. (Fig. 1, E).

On the contrary, the total carbohydrates content recorded the high content in the significant tolerant variety G. 86 compared to G. 90 averaged 55.333 and 38.967 mg/gm dry weight of cotton leaves, respectively (Fig. 1, A).

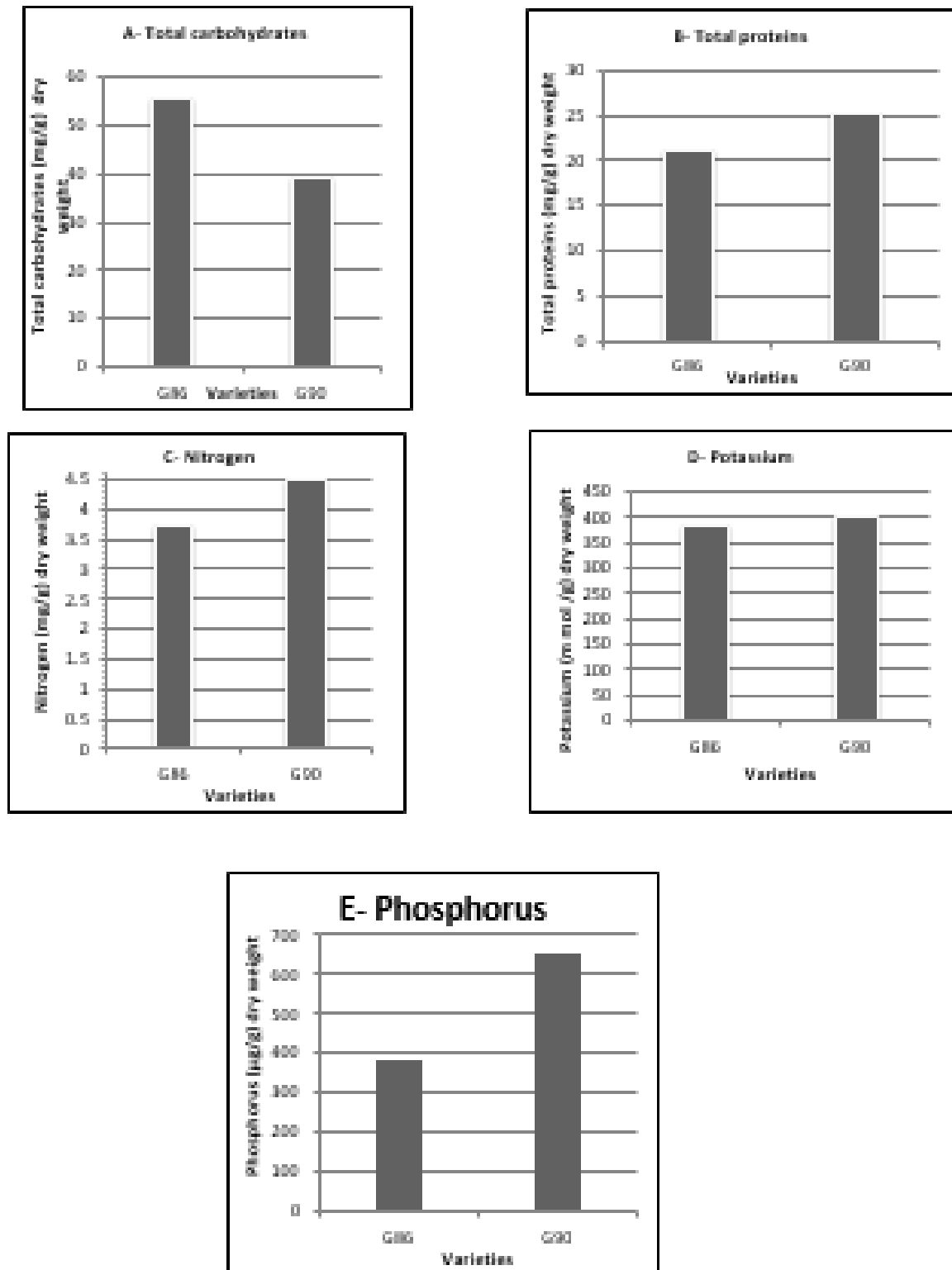


Fig. 1, A-E. Phytochemical components of cotton varieties dried leaves, Giza 86 and Giza 90 during season 2016.

Correlation between Mite Development and Chemical Contents of Tested Cotton Leaves:

Data in Table (5) cleared the positive insignificant correlation between phytochemical contents of G. 86 variety total carbohydrates and total immatures, life cycle, longevity and life span of spider mite *T. urticae* that recorded 0.765, 0.552, 0.516 and 0.389 except with fecundity gave negative insignificant (recorded -0.979); while it recorded negative insignificant correlation between total proteins, total immatures, life cycle and longevity of *T. urticae* (recorded -0.912, -0.829 and -0.996), except with life span and fecundity they were positive insignificant recording 0.661 and 0.605, respectively; in case of nitrogen gave negative insignificant correlation with total immatures and life span they recorded -0.203 and -0.876 except with life cycle, longevity and fecundity gave positive insignificant (recorded 0.314, 0.123 and 0.646, respectively); while phosphorus recorded negative insignificant correlation with total immatures, life cycle, longevity and life span (recorded -0.479, -0.578, -0.169 and -0.697) except with fecundity recording positive insignificant correlation gave 0.841, respectively and potassium recorded positive significant correlation with life cycle recording 0.999, positive insignificant correlation with total immatures recording 0.986 and 0.879 except with life span and fecundity gave negative insignificant correlation recording -0.132 and -0.946, respectively.

Table 5. Correlation coefficient between phytochemical contents of cotton varieties Giza 86 and some biological aspects of *T. urticae*.

Phytochemical contents	Total immature	Life cycle	Longevity	Life span	Fecundity
Total carbohydrates (mg/gdw)	0.765	0.552	0.516	0.389	- 0.979
Total proteins(mg/gdw)	- 0.912	- 0.859	- 0.996	0.661	0.605
Nitrogen (mg/gdw)	- 0.203	0.314	0.123	- 0.876	0.646
Phosphorus (μ g/gdw)	- 0.479	- 0.578	- 0.169	- 0.697	0.841
Potassium (m mol/gdw)	0.986	0.999*	0.879	- 0.132	- 0.946

Results in Table (6) cleared correlation between chemical contents of cotton leaves of variety Giza 90 and some biological aspects of *T. urticae* gave positive insignificant correlation between total carbohydrates and life cycle and longevity recorded 0.991 and 0.362 except with total immatures, life span and fecundity recorded negative insignificant correlation gave - 0.637, - 0.637 and - 0.491, respectively; in case of total proteins recorded negative insignificant correlation with total immatures and life span recorded - 0.991 and - 0.952 except with life cycle, longevity and fecundity recorded 0.819, 0.899 and 0.952, respectively; while in case of nitrogen gave positive insignificant correlation with total immatures, life span and fecundity recorded 0.789, 0.789 and 0.668 except with life cycle and longevity recorded - 0.997 and - 0.555, respectively; positive significant correlation recorded between phosphorus and total immatures, life cycle and fecundity gave 0.967, 0.967 and 0.997, respectively, and 0.957, 0.957 and 0.891 with potassium, respectively, except with life cycle and longevity which recorded negative insignificant correlation gave (- 0.539, - 0.998*) with phosphorus and (- 0.901, - 0.817) with potassium, respectively.

Table 6. Correlation coefficient between phytochemical contents of cotton variety Giza 90 and some biological aspects of *T. urticae*.

Phytochemical contents	Total immature	Life cycle	Longevity	Life span	Fecundity
Total carbohydrates (mg/gdw)	- 0.637	0.991	0.362	- 0.637	- 0.491
Total proteins (mg/gdw)	- 0.991	0.819	0.899	- 0.991	0.952
Nitrogen (mg/gdw)	0.789	- 0.997	- 0.555	0.789	0.668
Phosphorus (μ g/gdw)	0.967	- 0.539	- 0.998*	0.967	0.997
Potassium (m mol/gdw)	0.957	- 0.901	- 0.817	0.957	0.891

Positive relationship was found between mite infestation and both nitrogen and protein contents in cotton leaves. The same results were obtained by Mead *et al.* (2010) when they tested different maize varieties against *T. urticae*. In addition, Ahmed (1994) suggested that resistance of host plants to mite infestation might be attributed to low protein and amino acid contents in leaves, which provided less nutritive diet for the spider mite *T. urticae*. Hanna *et al.* (1982) observed a reduction in the duration of pre-oviposition period and increase in oviposition period as the nitrogen contents increased. In addition, Trindade and Chiavegato (1999) observed that nitrogen and phosphorus deficiency or potassium excess caused reduction in the reproduction rate of *T. urticae*. Also, Maia and Busoli (1992) stated that the relationship between nitrogen contents and reproduction of *T. urticae* population by recording a reduction in the duration of pre-oviposition period and increase in oviposition period as the nitrogen contents increased. Atwa *et al.* (1987) stated that the total amounts of protein and potassium in leaves of the host plant did not effect on development of spider mite; on the other hand, amino acids and carbohydrate content were positively correlated with the development and female fecundity of *Eutetranychus annecki* Mayer and *T. urticae*. The correlation between biological aspects of *T. urticae* and both leaf nitrogen and total protein contents may be explained by Hoffland *et al.* (2000) who stated that the protein concentration in tomato leaves is positively correlated with nitrogen availability. The obtained results are in agreement with Tulisalo (1972) who reported that fecundity of *T. urticae* was independent of variations in type and levels of carbohydrates because of different pathways for carbohydrates metabolism exist. In addition, Zaher *et al.* (1980) recorded insignificant positive correlation between infestation of soybean with *T. urticae* and leaf nitrogen content. On the contrary, Magouz *et al.* (2006) and El-Sanady *et al.* (2008) reported a negative correlation between the population density of moving mite stages and nitrogen contents in soybean leaves. The obtained data are in agreement with Taha *et al.* (2014) who stated that cotton genotype Giza 90 was the most susceptible to *T. urticae* infestation during 2010 and 2011 seasons. On the contrary, Wilson (1993) reported that *T. urticae* populations were unaffected by cotton varieties in Australia.

It is concluded that cotton variety Giza 90 was the suitable one for two-spotted spider mite because of its shorter immature developmental period and higher reproduction and intrinsic rate of natural increase.

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ARABIC SUMMARY

تأثير صنفين من القطن المصري علي تطور و جدول الحياة للحلم العنكبوتي ذو البقعتين *Tetranychus urticae* Koch و علاقته بتراكيب الورقة الكيمياء

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تمت دراسة تطور و جدول حياة الحلم العنكبوتي ذو البقعتين عند تربيته علي صنفين من القطن المصري و هما: جيزه 86 و جيزه 90 في ظروف المعمل علي درجة حرارة 27 ± 2 درجة مئوية و رطوبة نسبية 5 ± 60 % و أظهرت النتائج تأثر أنثي الحلم معنويًا بصنف القطن. و قد أوضحت النتائج أن فترة نمو الأطوار غير الكاملة أقصر علي صنف جيزه 90 (3.82 يوم) مقارنة بالصنف جيزه 86 (9.86 يوم). بينما بلغ متوسط فترة طول العمر للأنثي البالغة 12.29 و 16.65 يومًا عند تربيتها علي صنف جيزه 90 و جيزه 86، علي التوالي. بالإضافة إلى ذلك سجلت قيم معدل التكاثر (Ro) و معدل الزيادة الطبيعي (rm) و المعدل المحدود للزيادة في اليوم (λ) للحلم العنكبوتي ذو البقعتين فكانت (65.04 ، 0.407 و 1.502 يوم) و (31.95 ، 0.184 و 1.202) أيام في الجيزة 90 و الجيزة 86 ، علي التوالي. وايضا سجلت خصوبة الإناث 98.63 و 71.00 بيضة / أنثي في الجيزة 90 و الجيزة 86 ، علي التوالي. و أظهرت النتائج ان متوسط ومدة الجيل (T) وقيم مضاعفة الجيل (DT) في الصنف جيزه 90 (10.27 ، 1.702 يومًا) اقل من الصنف جيزه 86 (18.82 ، 3.766 يومًا) ، علي التوالي. و أظهرت النتائج وجود علاقة معنوية موجبة بين نمو و خصوبة إناث الحلم العنكبوتي ذو البقعتين مع توفر المحتوي النيتروجيني لأوراق القطن.