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Article

Interaction between biological aspects of *Tetranychus urticae* Koch (Acari: Tetranychidae) and some chemical composition in two colored *Acalypha wilkesiana* Müll. Arg. (Malpighiales: Euphorbiaceae) leaves

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ABSTRACT
Acalypha wilkesiana is considered a great tool for rearing *Tetranychus urticae* in the laboratory; it has two colors of leaves i.e., green and red. The leaf pigment content and some chemical properties were observed in this study to examine the correlation between the biology of *T. urticae* and the physio-biochemical features of the green and red leaves of *A. wilkesiana*. Results showed that *T. urticae* individuals achieved faster growth and a greater number of eggs deposited by females when feeding on *A. wilkesiana* with greener leaves, which contained higher levels of photosynthetic pigments (chlorophyll a and b, and total carotenoids). There was a significant positive correlation ($P \leq 0.05$) between *T. urticae* female hatchability, egg deposited/female, and daily rate with contents of total carbohydrate, total carotenoids, soluble sugars, chlorophyll a, and chlorophyll b. For male biology, there was a significant positive correlation ($P \leq 0.05$) between *T. urticae* male life span, immature stages, and life cycle with contents of total phenols, and anthocyanin. These results indicated the role of chemical components of *Acalypha* leaves in the biological aspects of *T. urticae*.

KEYWORDS: *Acalypha wilkesiana*, biological aspects, correlations, leaf chemical analysis, two-spotted spider mite.

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INTRODUCTION

Authors try to stimulate modified methods for *Tetranychus urticae* Koch (Acari: Tetranychidae) mass rearing as (Bustos *et al*. 2016) demonstrated that 7 to 14 day-old bean plants infested with 45 or 62 *T. urticae*/plant could reach 25,000 individuals/plant, having 50% of these preys at the preferred stages for the predator *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae). Several authors reared stock culture of *T. urticae* on fresh leaves of *Acalypha* for use in experiments to evaluate the effectiveness of pesticides, plant extracts, and others, as well as in mass rearing in large numbers to feed predators on them (Sholla 2016; Ahmed *et al*. 2021; Momen and Abdel-Khalek 2021; Saad Nouran *et al*. 2021; Abdelwines and Ahmed 2022; Elkady *et al*. 2022; Nagah *et al*. 2022; Safar *et al*. 2022; Hassan *et al*. 2023). Most authors agree that a small number of components of leaf quality affect preference by generalist herbivores. However, herbivore preference is determined not only by

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intrinsic plant attributes and herbivore biology but also by the environmental context (Pérez-Harguindeguy *et al*. 2003). The coevolution theory for red leaf colors considers redness as a handicap signal against herbivores. Selection of total phenolic content as a variable was based on their assumed anti-herbivore function and their common biosynthetic origin with anthocyanin. In senescing leaves, in three out of the four studied species a significant and strongly positive correlation between signal strength (redness) and actual defensive potential (total phenolic) was found (Karageorgou *et al*. 2008). Anthocyanin pigments are synthesized in the leaves of many plants; however, the adaptive significance of these pigments is not entirely understood. It has been postulated that their red colors may function as visual signals through coevolution between herbivorous insects and their host tree species (Menzies 2013); because of difficulties associated with two-spotted spider mites control and huge economic losses, there is much interest in the search for alternative control measures, especially biological control. Therefore, this study aims to know the effect of the leaf color of *Acalypha wilkesiana* Müll. Arg. (Malpighiales: Euphorbiaceae) on *T. urticae* biological aspects by evaluating some chemical compositions to understand any possible relationships between them and important life history parameters of *T. urticae* in order to recognize the most suitable leaves for increasing its population to be used as food for the predatory mites, as a bio-control agent against different pests.

MATERIALS AND METHODS

Rearing of Tetranychus urticae *under laboratory conditions*

From *Ricinus communis* L. (Euphorbiaceae) plants growing in Fayoum Governorate, the two-spotted spider mites *T. urticae* were collected. The leaves were examined under a stereomicroscope in the acarology laboratory, Plant Protection Department, Faculty of Agriculture, Fayoum University. After identifying the mite, green and red copperleaf shrubs (*A. wilkesiana*) leaves were arranged individually in 9 cm diameter Petri dishes with the upper surface resting on a cotton pad moistened with water. The mite was raised using the procedures outlined in (Abdelwines and Ahmed 2022; Safar *et al*. 2022). A cotton strip soaked in water (1 cm wide) was placed around each leaf as a barrier and to keep mites from escaping. By adding drops of water as needed, the appropriate moisture was maintained. Leaves maintenance and replacement occurred weekly. Mites were cultured under optimum conditions in the laboratory to get a continuous supply of mites.

Duration of developmental stages, longevity and fecundity of T. urticae *individuals on green and red* A. wilkesiana *leaves*

Acalypha wilkesiana leaf discs in green and red, each measuring 3 cm in diameter, were arranged individually up-side-down in Petri dishes, with cotton wool pads soaked in water. Females were isolated, mated and arranged separately on leaf replicates. Females were moved to stock culture as soon as the eggs were laid. Larvae were raised throughout their whole life cycle. Newly hatched larvae were observed twice daily, and the periods of the egg, larval, protonymphal, and deutonymphal stages, as well as the total number of immatures, life cycle, and lifespan, were determined. Additionally, measurements were made throughout the pre-oviposition, oviposition, post-oviposition, and lifespan periods. Each female's egg production was counted. At the first indication of degradation, the individuals were switched to new leaf discs. Incubator settings of 25 ± 2 °C and 60 ± 5% RH were used for the experiments.

Chemical analysis of A. wilkesiana *leaves*

Chemical analysis of leaf samples was carried out using 10 definite leaves of the same age for each color which were transferred to the Faculty of Agriculture Research, Cairo University for chemical analysis. Some specific chemical constituents of *Acalypha* leaves were determined as follows:

Determination of photosynthetic pigments

Total carotenoids and chlorophyll were determined colorimetrically according to Holden (1965), while the determination of Anthocyanin was performed according to Akladious and Mohamed (2018).

Determination of organic compounds

Total phenol content was determined by Folin-Ciocateu method as modified by (Singleton and Rossi 1965). Total carbohydrates were extracted from the plant leaves and prepared for assay according to (Crompton and Birt 1967). Determination of total soluble sugars: according to (DuBois *et al.* 1956).

Statistical analysis

The data were statistically analyzed by applying one way ANOVA with the Gen STAT (version 11) (VSN International Ltd., Oxford, UK). Differences among means were tested with the utilization of the LSD test (Waller and Duncan 1969) at P < 0.05. Pearson's correlation coefficients were carried out with the utilization of the R software (version 4.1.2, https://CRAN.R-project.org, accessed on 17 September 2023)

RESULTS

The *Acalypha* green and red leaves were both suitable hosts for *Tetranychus urticae*. Leaf coloration exhibits notable differences in their impact on the biological aspects of *T. urticae*. Data in Tables 1, 2 and 3 showed the effect of leaf coloration on the biology of *T. urticae* individuals.

Effect of Acalypha *leaf color on the egg incubation period of* T. urticae

Our findings indicated that differences in leaf color had no significant impact on the duration of eggs incubation (P = 0.145, 0.610) for females and males, respectively. Females required 2.8 and 3.3 days upon feeding on green and red leaves, respectively, whereas the males took 3.0 and 3.13 days. (Tables 1, 3).

Table 1. Effect of *Acalypha* leaf color on durations in days (Mean ± SE, Range) of *T. urticae* females' different stages reared at 25 ± 2 °C and 60 ± 5% RH.

***Acalypha* leaf color**	**Incubation period**	**Larva**		**Protonymph**		**Deutonymph**		**Total Immature stages**	**Life cycle**
		A	**Q**	**A**	**Q**	**A**	**Q**		
Green	2.8 ± 0.2 (2–4)	1.5 ± 0.2 (1–2)	1.0 ± 0.0 (1–1)	1.35 ± 0.2 (0.5–2)	0.95 ± 0.1 (0.5–1)	1.2 ± 0.2 (0.5–2)	1.0 ± 0.1 (0.5–2)	7. 0 ± 0.5 (5.0–9.0)	9.8 ± 0.5 (7–12)
Red	3.3 ± 0.3 (2–4)	1.4 ± 0.2 (1–2)	1.1 ± 0.1 (1–2)	1.6 ± 0.2 (1–3)	1.2 ± 0.2 (1–3)	1.3 ± 0.2 (1–2)	1.3 ± 0.2 (1–2)	8.3 ± 0.5 (6.0–11.0)	11.6 ± 0.7 (9 –15)
P-value	0.145	0.673	0.331	0.396	0.241	0.682	0.151	0.08	0.041*

Means within the same column been significantly different at P < 0.05 and high significantly different at P < 0.01 according to LSD test.

Effect of Acalypha *leaf color on the immature stages of* T. urticae

There was no discernible difference in the duration of the active and quiescent stages of immaturity as the total immature was reported at (7.0 and 8.3 days) and (5.2 and 7.27 days) for females and males, respectively, when feeding on green and red leaves. For females, leaf color didn't affect the total immature stage significantly (P = 0.08) as opposite to males which were affected significantly (P = 0.000). It was clear that the male mite immature stages had a shorter overall growth period than the female immature stages. Both female and male of *T. urticae* completed their life cycles on the two different colored *Acalypha* leaves; the results of their biological aspects, including developmental periods of immature are given in Tables 1 and 3. The immature developmental durations of *T. urticae* including the incubation, larval, and nymphal periods were influenced by the different colored leaves. Furthermore, the total developmental duration from egg to adult for females and males was significantly affected by different leaves (P = 0.041 and 0.001) and recorded 9.8 and 11.6 days for females and 8.3 and 10.4 days for males on green and red leaves, respectively (Tables 1, 3).

Table 2. Effect of *Acalypha* leaf color on longevity and life span in days (Mean ± SE, Range) and fecundity of *T. urticae* females reared at 25 ± 2 °C and 60 ± 5% RH.

Acalypha leaf color	PoP[1]	OP[2]	Post-OP[3]	Longevity	Life span	TNDE[4]	ANED[5]/ female/day	Hatchability (%)
Green	1.2 ± 0.2 (1–3)	5.7 ± 0.4 (4–8)	1.1 ± 0.1 (1–2)	8.0 ± 0.4 (6–10)	17.7 ± 0.4 (15–19)	33.8 ± 3.7 (19.0–48.0)	5.87 ± 0.5 (3.8–9.2)	96.64 ± 1.7 (86.9–100)
Red	1.4 ± 0.2 (1–2)	8.5 ± 1.0 (5–14)	1.3 ± 0.2 (1–2)	11.2 ± 1.14 (8–17)	22.8 ± 1.33 (17–31)	18.8 ± 1.5 (13.0–29.0)	2.43 ± 0.3 (1.07–4.6)	82.2 ± 5.7 (46.2–100)
P-value	0.449	0.015*	0.288	0.015*	0.002**	0.001**	0.000**	0.025*

[1] PoP = Pre-ovipostion Period; [2] OP = Ovipostion Period; [3] Post-OP = Post-Ovipostion Period; [4] TNDE = Total number of deposited eggs; [5] ANED = Average number of eggs deposited.
Means within the same column been significantly different at P < 0.05 and high significantly different at P < 0.01 according to LSD test.

Table 3. Effect of *Acalypha* leaf color on durations in days (Mean ± SE, Range) of *T. urticae* males' different stages reared at 25 ± 2 °C and 60 ± 5% RH.

Acalypha leaf color	Incubation period	Larva		Protonymph		Deutonymph		Total immature stages
		A	Q	A	Q	A	Q	
Green	3.0 ± 0.17 (2–4)	0.87 ± 0.06 (0.5–1)	0.9 ± 0.1 (0.5–2)	0.9 ± 0.05 (0.5–1)	0.87 ± 0.06 (0.5–1)	0.83 ± 0.06 (0.5–1)	0.77 ± 0.07 (0.5–1)	5.2 ± 0.24 (4.0–7.0)
Red	3.13 ± 0.19 (2–4)	1.4 ± 0.13 (1–2)	1.13 ± 0.09 (1–2)	1.27 ± 0.11 (1–2)	1.13 ± 0.10 (1–2)	1.2 ± 0.11 (1–2)	1.13 ± 0.09 (1–2)	7.27 ± 0.38 (6.0–10.0)
P-value	0.610	0.001**	0.095	0.009**	0.02*	0.006**	0.003**	0.000**

Means within the same column been significantly different at $p < 0.05$ and high significantly different at P < 0.01 according to LSD test

Effect of Acalypha *leaf color on the fecundity of* T. urticae

The findings showed that color variation had no significant effects (P = 0.449 and 0.228) on pre-oviposition period (1.2 and 1.4 days) or post-oviposition period (1.1 and 1.3 days), for green and red leaves respectively, but had a highly significant impact (P = 0.001) on the total number of deposited eggs per female (33.8 and 18.8 eggs per female), and their daily rate, which was recorded (5.87 and 2.43 eggs per day), (P = 0.000).

Similarly, a significant difference was observed for the duration of oviposition period on the different colored leaves; the oviposition period was significantly shorter on green leaves (P = 0.015) and it was longer on red ones and recorded 5.7 days 8.5 days on green and red leaves, respectively. When *T. urticae* was raised on green leaves instead of red ones, the percentage of eggs that hatched was estimated 96.6 and 82.2 %, respectively with significant differences (P = 0.025) (Table 2).

Effect of Acalypha *leaf color on the longevity, life cycle and life span periods of* T. urticae

Feeding on green and red leaves resulted in a significantly varied life span period for females and males (17.7 and 22.8) and (13.6 and 16.8) days, (P = 0.002 and 0.001), respectively.

Also, resulted in significantly varied female longevity (p = 0.015), while male longevity, varied insignificantly among the two different colored leaves (P = 0.13). Female and male longevities of *T. urticae* were longest on red leaves, but shortest on green ones recording (8.0 and 11.2), (5.5 and 6.4), while life cycle was recorded (9.8 and 11.6) and (8.3 and 10.4) when feeding on green and red leaves, respectively. Therefore, based on the previous results, feeding on green *Acalypha* leaves shortened female durations compared with feeding on the red ones (Tables 1, 2, 4).

Table 4. Effect of *Acalypha* leaf color on life cycle, longevity and life span in days (Mean ± SE, Range) of *T. urticae* males reared at 25 ± 2 °C and 60 ± 5% RH.

Acalypha leaf color	Life cycle	Longevity	Life span
Green	8.3 ± 0.25 (7–10)	5.5 ± 0.41 (3-10)	13.6 ± 0.41 (11 – 17)
Red	10.4 ± 0.4 (8– 13)	6.4 ± 0.42 (5–10)	16.8 ± 0.5 (14–20)
P-value	0.001**	0.130	0.001**

Means within the same column been significantly different at P < 0.05 and highly significantly different at P < 0.01 according to LSD test

Chemical analysis of Acalypha wilkesiana *leaves*

As shown in Tables 5 and 6 some biochemical contents found in both green and red *Acalypha* leaves were determined including phytosynthetic pigments as Anthocyanin, Chlorophyll a and b and total carotenoids as well as some organic substances including total phenols, total carbohydrates and total soluble sugar. Highly significant differences were found between their concentrations in green and red leaves (P = 0.000).

The result of the quantitative analysis for some pigments of *Acalypha* leaves is shown in Table 5. All determined pigments were greater in green leaves than in red leaves except for Anthocyanin. Our results showed that *A. wilkesiana* red leaves have higher total phenol content than green ones (0.2 and 0.39), but have lower total carbohydrates and total soluble sugar contents recording (64.52 and 42.52) and (27.31 and 19.78) of green and red leaves, respectively with highly significant differences between their concentrations in green and red leaves (P = 0.000).

Table 5. Biochemical analysis of green and red *Acalypha* leaves pigments.

***Acalypha* leaf color**	**Anthocyanin (µg/g)**	**Chlorophyll a (Mg/g)**	**Chlorophyll b (Mg/g)**	**Total carotenoids (µg/100g)**
Green	0.7 ± 0.02	10.76 ± 0.01	17.11 ± 0.04	1046.03 ± 1.83
Red	2.51 ± 0.12	5.33 ± 0.12	4.32 ± 0.12	871.59 ± 0.73
P-value	0.000**	0.000**	0.000**	0.000**

Table 6. Biochemical analysis of green and red *Acalypha* leaves.

***Acalypha* leaf color**	**Total phenols (g/100g)**	**Total carbohydrates (g/100g)**	**Total soluble sugar (g/100g)**
Green	0.2 ± 0.004	64.52 ± 0.62	27.31 ± 0.18
Red	0.39 ± 0.007	42.52 ± 0.33	19.78 ± 0.22
P-value	0.000**	0.000**	0.000**

Relations

Pearson's correlation analysis was constructed to illustrate associations among studied parameters of the chemical analyses of green and red *Acalypha* leaves and the *T. urticae* female and male characteristics as presented in Figures 1 and 2. Pearson's correlation analysis among chemical parameters of *Acalypha* leaves and the *T. urticae* female characteristics revealed the interactive connection between chemical parameters of *Acalypha* leaves with the *T. urticae* female characteristics as presented in Figure 1. The results indicated a significantly positive (P-value ≤ 0.05) correlation between *T. urticae* female hatchability, egg/female, and daily rate with contents of total carbohydrate, total carotenoids, soluble sugars, chlorophyll a, and chlorophyll b; while, there was significant negative correlation (P-value ≤ 0.05) between above mentioned traits with life span and longevity, oviposition period and life cycle of *T. urticae* females. Total phenols and anthocyanin showed significant negative correlation with *T. urticae* female hatchability, egg/female, and daily rate. These results indicated the role of chemical components of *Acalypha* leaves in the development of *T. urticae* females.

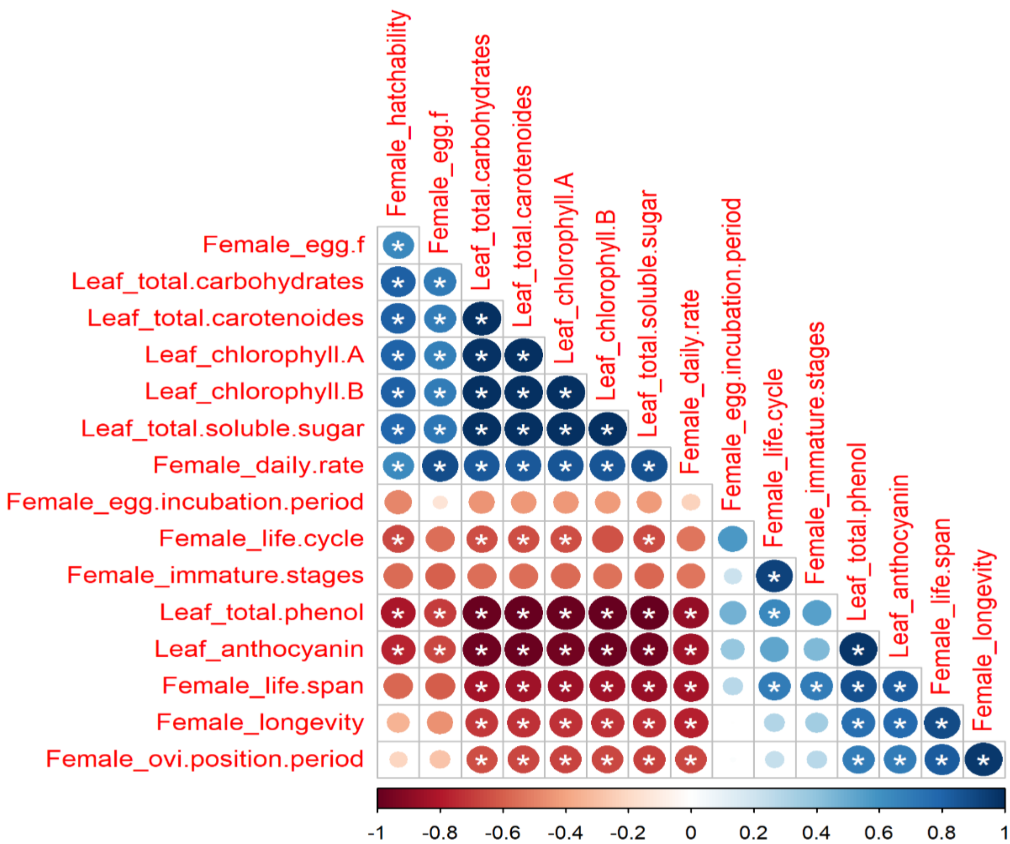

Figure 1. Graph of Pearson's correlation analysis among the different studied leaf parameters including the chemical analysis of *Acalypha* leaves and the *T. urticae* female characteristics. The colors represent variations in the obtained data. * indicates the significant at P-value < 0.05.

Pearson's correlation analysis among chemical parameters of *Acalypha* leaves and *T. urticae* male characteristics was evaluated. The results, presented in Figure 2, indicated a significantly positive (P-value < 0.05) correlation between *T. urticae* male life span, immature stages, and life cycle with content of total phenols, and anthocyanin content. However, there was significantly negative correlation (P-value < 0.05) between *T. urticae* male life span, immature stages, and life cycle with the contents of total soluble sugars, chlorophyll a, chlorophyll b, carotenoids, and total carbohydrates. Additionally, the contents of total soluble sugars, chlorophyll a, chlorophyll b, carotenoids, and total carbohydrates revealed a positive correlation with each other.

From correlation analysis, it is shown that *T. urticae* female fecundity is related to chemical constituents of different colored *Acalypha* leaves (green and red). Contents of total carbohydrate, total carotenoids, soluble sugars, chlorophyll a, and chlorophyll b are correlated with mite fecundity as the higher their values, the greater the female fecundity. While anthocyanin and total phenol are also correlated with mite fecundity, the higher their values, the lower the female fecundity.

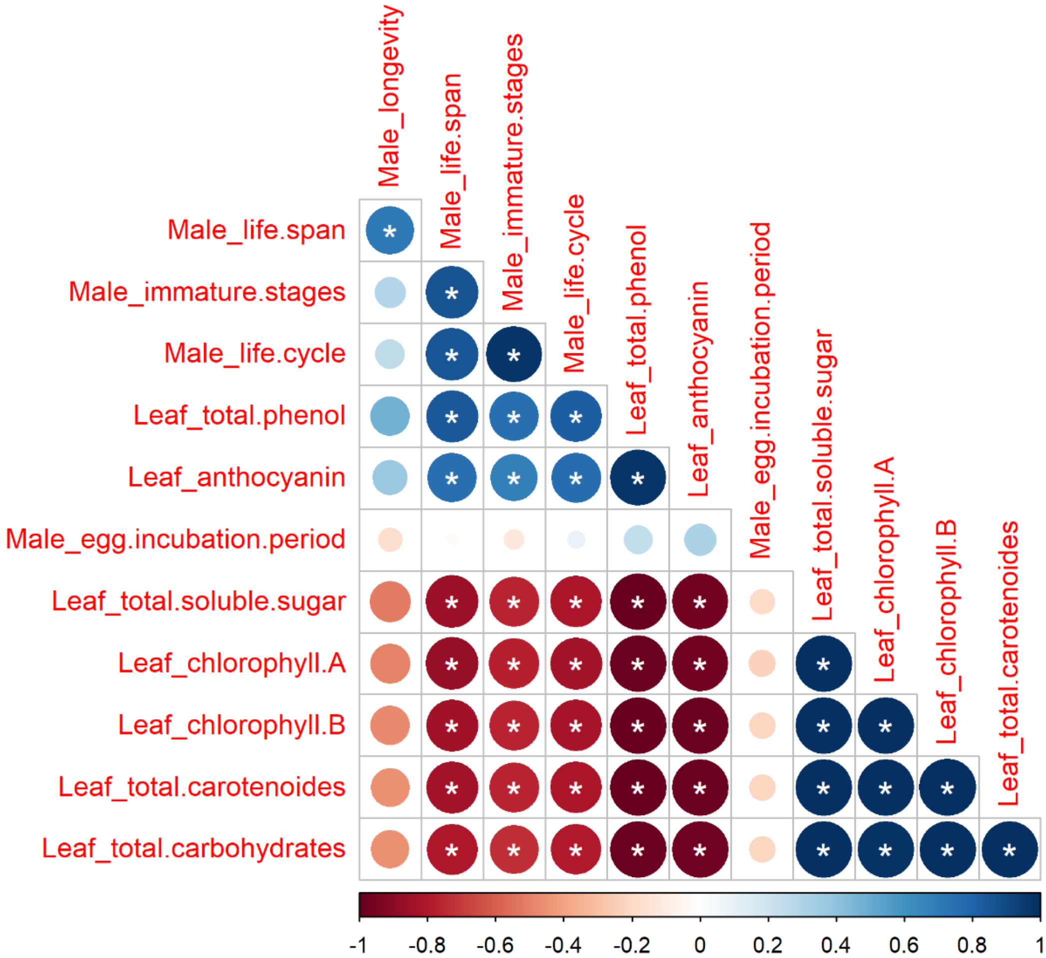

Figure 2. Graph of Pearson's correlation analysis among the different studied leaf parameters including the chemical analysis of *Acalypha* leaves and the *T. urticae* male characteristics. The colors represent variations in the obtained data. * indicates the significant at P-value < 0.05.

DISCUSSION

Two spotted spider mite, *Tetranychus urticae* is one of the most serious plant pests among spider mites, with a broad host range and an extensive record of pesticide resistance (Grbic *et al.* 2011; Yano *et al.* 1998; Santamaria *et al.* 2020). Previous studies have demonstrated that individual populations of *T. urticae* did not develop similarly when reared on various potential plant hosts (Grbic *et al.* 2011). The red spider mite is required to be raised well in the laboratory in huge numbers to use in various laboratory experiments, on the one hand, as prey for various biological enemies, and on the other hand, to use it in experiments to evaluate pesticides, plant extracts, nano-materials, mixtures, etc. In Egypt, many researchers are raising it on the *Acalypha* plant, which has leaves of different colors in the laboratory (Sholla 2016; Ahmed *et al.* 2021; Momen and Abdel-Khalek 2021; Saad *et al.* 2021; Abdelwines and Ahmed 2022; Elkady *et al.* 2022; Nagah *et al.* 2022; Safar *et al.* 2022; Hassan *et al.* 2023). Therefore, this study focused on determining the optimal option to raise it better, in addition to clarifying the reason for this preference in relation with the components of the leaves. Few previous reports have examined whether such a variation in leaf color could affect the biological aspects of *T. urticae*. In our study, this variation was determined between two different-colored *Acalypha* leaves, green and red. Our results showed a lower preference and more defense of *T. urticae* toward *Acalypha welkesiani* red leaves, while greenish plant leaves were the most preferred by this mite species and more suitable for its rearing. It is possible that the leaves' chemical components affected the oviposition period, life cycle, longevity, life span, and fertility of females. The obtained results demonstrate that *A. wilkesiana* leaves are a food source for *T. urticae*. At 25 °C, mites could survive successfully and complete their life cycle on two different colored plant leaves. Comparing green to red leaves, green leaves had a higher concentration of total carbohydrates, total soluble sugar, chlorophyll a and b, and total carotenoids. On the contrary, the red leaves had a higher concentration of anthocyanin and total phenols than the green leaves.

Female adult longevity, oviposition period, and life cycle duration were shorter when mites were reared on green leaves than red ones. According to other researchers (Razmjou *et al.* 2009; Golizadeh and Razmjou 2010; Golizadeh *et al.* 2017), shorter developmental times and higher reproduction of herbivore species on a host plant indicate the higher susceptibility of the plant. It was demonstrated in numerous studies that the fecundity of spider mite females differs on various host plants (Yano 1998; Razmjou *et al.* 2009; Khanamani *et al.* 2012; Golizadeh *et al.* 2017; Shoorooei *et al.* 2018). Two-spotted spider mites feeding on red leaves resulted in a reduction of their biological parameters in relation to the content values obtained. Differences in the chlorophyll content noted in this experiment can affect leaf acceptance and may explain the different number of eggs laid on various colored leaves in the present study. Red leaves, which contained the highest amount of anthocyanin and total phenols, were the least accepted by spider mites, and *T. urticae* females feeding on them had low fertility.

Presumably, in the present study, the composition of *Acalypha*-tested colored leaves also influenced the acceptance and plant colonization by spider mites, as well as their biological parameters. Red leaves, which showed the lowest susceptibility to *T. urticae* feeding, were characterized by a high content of anthocyanin and total phenols. Similarly, in this experiment, the total and daily fecundity recorded on green leaves were higher than red ones. These results suggest that the quantity and/or quality of nutritional contents of green leaves were more appropriate for two-spotted spider mites than the red ones, as both of them were cut from the same plant.

It has been found that phenolic compounds can act as a mite defense factor, making the plant less palatable to invasive pests (Kielkiewicz and van de Vrie 1983; Larson and Berry 1984; Pratyusha 2022). These findings are in agreement with Pratyusha (2022), who reported that phenolic substances are the most resistant metabolites produced by plants. The enhanced phenols in plants behave as toxins toward insect feeding, microbial growth, and a mode of induced defense generated by the plant to defend against natural pests. These secondary metabolites may have inhibited mites' ability to feed on red leaves. Similarly, Dabrowski and Bielak (1978) discovered that *T. urticae* fecundity was affected upon feeding on different host plant species or cultivars that differ in phenolic compound levels. Moreover, Kulbat (2016) indicated that phenolic compounds play an essential role in plant growth, development, and its defensive systems. These differences between development periods and fecundity when *T. urticae* was fed on colored leaves were in agreement with El-Saiedy *et al*. (2013), who illustrated a negative relationship between mite infestation levels and total phenolic compounds when fed on sweet pepper cultivars, while a positive relationship was detected with total carbohydrates. In the current study, a positive correlation was obtained between total carbohydrate level and soluble sugars and *T. urticae* female hatchability, egg/female rate, and daily rate. Plant carbohydrates are important nutritional resources for plant pests, and the increased amount of these dietary components in infested leaves can be considered part of the strategy of two spotted spider mites to increase fitness and improve both reproduction and mass movements (Deans *et al*. 2016). In the same context, other studies suggested that elevated levels of carbohydrate and soluble sugars may provide a suitable source of energy for enhancing the daily growth rate of *T. urticae* females.

The obtained results for increasing longevity of females (8.0 and 11.2 days) when reared on green and red leaves, respectively, are in agreement with Sedaratian *et al*. (2009), who found that an increase in longevity in females may be a significant physiological adaptation for pests to continue their generation when food quality is adequate, because only a small percentage of females are able to survive.

Certain compounds in the host plant can also influence the fecundity of pests by either enhancing or reducing their capacity for reproduction (Price *et al.* 1980). Our results showed that the fecundity of spider mites was significantly lower on red leaves than on green leaves. The fecundity of *T. urticae* (33.8 and 18.8 eggs with a daily rate of 5.87 and 2.43 eggs per day) when fed on green and red *Acalypha* leaves was in agreement with those obtained by Mohamed *et al*. (2020), who found that mite fecundity was 19.66 eggs per female when reared on pepper leaves. Riahi *et al.* (2013) also found that each female deposited 40.09 eggs with a daily rate of 2.34 eggs on peach leaves at 25 °C. The current results showed that the developmental durations and reproduction of *T. urticae* are significantly different among two types of leaves ($P < 0.05$). In this work, the required time for the adult female *T. urticae* life cycle was 9.8 and 11.6 when feeding on green and red *Acalypha* leaves, respectively. Our results of the biology of *T. urticae* on leaves of *A. wilkesiana* are similar to those reported by Sholla (2016), who investigated the biology of *T. urticae* on fresh acalypha, *A. marginates* leaves, at 26 °C. The larval, protonymphal, and deutonymphal stages lasted 2.05, 1.87, and 2.17 days, respectively, at 26 °C with a life cycle of 10.85 days. The incubation period was 4.76 days. However, the obtained results for total immature stage (7.0 and 8.3 days for females and 5.2 and 7.27 days for males on green and red leaves, respectively) were different from those obtained by Kumral *et al.* (2019), who found that the total developmental time was 9.16 to 11.47 days for females and 7.67 to 10.12 days for males when feeding on seven eggplant cultivars.

Previous findings indicated that host plant quality can affect many life-history traits of pests (Berenbaum 2001; Praslika and Huszar 2004; Atalay and Kumral 2013; Marinosci *et al*. 2015; Osman *et al.* 2019). The life table parameters have been used to evaluate the susceptibility or resistance of several host plants to various insect pests (Sedaratian *et al.* 2011). When feeding on three host plants, castor bean, sweet potato, and mulberry, the duration of total immature stages correlated insignificantly positively with nitrogen and potassium leaf contents in any of the host plants. In the case of phosphorus and total chlorophyll contents, the correlations were negatively significant in the hosts sweet potato and mulberry but insignificantly positive with castor bean (Elsadany 2018). To respond with particular defense systems in response to herbivores, plants rely on various strategies to detect them. Previous research revealed a correlation between the impact of mite attacks and several plant biochemicals that significantly affect herbivorous pests and their life cycle traits such as longevity, fertility, and survival rate (Nikooei *et al*. 2015). The development of pests, survival rate and reproduction, and life table parameters were impacted by the quality of the host plant (Fathipour *et al.* 2019).

On the other hand, Cheng *et al.* (2018) studied three pepper strains that were crossed to produce F1 pepper plants and attacked by whiteflies. They found that the purple-colored population's anthocyanin content improves the pepper plants' protection against whitefly attacks. Furthermore, Zhong *et al*. (2019) observed that Asian citrus psyllids (Hemiptera: Psyllidae) were stimulated by the flavonoids in Chongyi wild mandarin. Also, Chongyi wild mandarin's higher salicylic acid and lower jasmonic acid levels make it attractive to Asian citrus psyllids compared to wild kumquat, 'Gannan zao' navel orange, and orange jasmine. According to the literature, the investigation suggests that the chemical composition may be crucial for plant physiological processes, including defense against environmental stresses such as herbivore infection (Harborne 1984; Hahlbrock and Scheel 1989; Cuvelier *et al.* 1996).

Finally, mite rearing on both green and red *Acalypha* leaves in this investigation provided new data on the effect of different leaf color on the biological aspects of *T. urticae* to assess which one is more suitable than the other for rearing mites in the laboratory.

CONCLUSION

In conclusion, this study showed that development periods and reproduction of *T. urticae* were influenced by chemical components of plant leaves including chlorophyll a, chlorophyll b, total carbohydrates, soluble sugars, total phenols, and anthocyanin. Therefore, significant differences in the biological aspects of *T. urticae* were recorded when spider mite was fed on both red and green *Acalypha* leaves. The greatest values of egg deposited and hatchability were on green leaves than on red ones. Therefore, this can be used to create a mite culture in the laboratory, to use the reared individuals in biological control experiments as food for predators, as well as its use in experiments to evaluate the efficiency of plant extracts, essential oils, nano-compounds, etc.

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برهم‌کنش بین جنبه‌های زیستی *Tetranychus urticae* Koch (Acari: Tetranychidae) و برخی ترکیبات شیمیایی در برگ‌هایی از دو رنگ *Acalypha wilkesiana* Müll. Arg. (Malpighiales: Euphorbiaceae)

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چکیده

گیاه *Acalypha wilkesiana* ابزاری عالی برای پرورش *Tetranychus urticae* در آزمایشگاه در نظر گرفته می‌شود و دو رنگ برگ یعنی سبز و قرمز دارد. در این مطالعه محتوای رنگدانه برگ و برخی خواص شیمیایی برای بررسی همبستگی بین زیست‌شناسی *T. urticae* و ویژگی‌های فیزیکی و بیوشیمیایی برگ‌های سبز و قرمز *A. wilkesiana* بررسی شدند. نتایج نشان داد که افراد *T. urticae* در هنگام تغذیه از *A. wilkesiana* با برگ‌های سبزتر، که حاوی میزان بیشتری از رنگدانه‌های فتوسنتزی (کلروفیل a و b و کاروتنوئید کل) بودند، به رشد سریع‌تری دست یافتند و تعداد تخم‌های بیشتری را ماده‌ها گذاشتند. همبستگی مثبت و معنی داری (P ≥ ۰/۰۵) بین تخمگذاری ماده *T. urticae*، تخم گذاشته شده/ماده و میزان تخمگذاری روزانه با محتوای کربوهیدرات کل، کاروتنوئید کل، قندهای محلول، کلروفیل a و کلروفیل b وجود داشت. برای زیست‌شناسی نر، همبستگی مثبت معنی‌داری (P ≥ ۰/۰۵) بین طول عمر نر *T. urticae*، مراحل نابالغ و دورهٔ زندگی با محتوای فنل کل و آنتوسیانین وجود داشت. این نتایج حاکی از نقش ترکیبات شیمیایی برگ های گیاه *Acalypha* در جنبه های بیولوژیکی *T. urticae* بود.

واژگان کلیدی: *Acalypha wilkesiana*، جنبه‌های زیستی، همبستگی، تجزیه و تحلیل شیمیایی برگ، کنهٔ تارتن دولکه‌ای.

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