

Population dynamics of *Tetranychus urticae*, *Rhyncaphytoptus ficifoliae* and *Euseius scutalis* on two fig cultivars in Akhmim district, Sohag governorate, in relation to weather factors and plant phenology

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ABSTRACT

Fig, *Ficus carica* L. is the oldest deciduous fruit of all cultivated fruit crops. Fig is considered as one of the important fruit crops from an economic point of view especially in Egypt. Fig is liable for infestation by many pest species and diseases, which cause crop losses. The current study was carried out on two fig leaves' cultivars (e.g., Sultani and Parchment) cultivated in Akhmim district, Sohag governorate, in order to study the population densities of three mite species (e.g., *Tetranychus urticae* Koch, *Rhyncaphytoptus ficifoliae* Keifer, and *Euseius scutalis* (Athias-Henriot) on 15 Mar. 2020 to 10 Dec. 2021. The mean number per 30 leaves over the two years was respectively 247.3, 153.6, and 29.0 motile stages for the three studied species. The tetranychid mite, *T. urticae* showed two peaks on both cultivars per year with similar means. The first peak was at mid-June, and the second at mid-November and at the end of November in the first and second year, respectively. In general, the second peak was higher on 'Sultani', while the first one was higher on 'Parchment'. The eriophyid mite, *R. ficifoliae* showed also two peaks on both cultivars in the mid-June and late-November. The phytoseiid, *E. scutalis* showed two peaks at end of June and mid to end of November for both years. The results showed that the population densities of mite species on fig cultivars were affected by the ambient climatic conditions (i.e., temperature and relative humidity) in addition to the plant age emulating plant phenology. Plant age as third degree of polynomial had much more significant effect than weather factors.

Keywords: ecology, deciduous fruit, plant-feeding mites, predators, Eriophyidae, Tetranychidae, weather parameters.

INTRODUCTION

Fig, *Ficus carica* L. (Moraceae) is a deciduous tree with important produce consumed worldwide in both fresh and dried forms (Duke et al. 2002). Regions with warm winters and dry-hot summers (e.g., Turkey, Morocco, Egypt, Spain, California, Italy, and Brazil) are among the major producers of edible figs (Tous and Ferguson 1996). The fig fruit is appealing, energy and nutrient dense. Figs can supply about 20% of the daily required dietary fiber in a single serving, it contains potassium, omega-6 and omega-3 and fatty acids as well, it also aids in blood pressure and cholesterol regulation. The presences of many phytochemicals in figs are ascribed to their high therapeutic values (Hussain

et al. 2021). The phytosterols help in decrease cholesterol levels in blood (Bhattacharyya and Eggen 1984; Andriamarina et al. 1989; Laraki et al. 1991; Howard and Kritchevsky 1997).

Many pests and diseases attack fig orchards, and their nature and severity vary depending on cultivar, location, weather and cultural techniques. Pests on fig trees cause severe losses. The phytophagous mites feed directly on epidermal cells and sub epidermal tissue (e.g., mesodermal cells, leaves, and fruits) (Mesa et al. 2009; Beard et al. 2012).

Among these pests, several phytophagous mites, especially the eriophyoid bud and leaf mites which are injurious on Egyptian fig orchards. The most symptoms caused by those mites are rusting or surface browning, bud

blasting, impedance of new growth, bud distortion, and leaf choruses. Severe infestation may result in defoliation of branches or whole trees causing considerable damage and consequently affecting the yield (Abdel-Khalek 1993; El-Halawany et al. 1986; Ali 2006). Mite and insect predators play a natural role against phytophagous mites attacking fig orchards. Therefore, care must be taken when studying the natural role of those predators (Mannaa 1988; El-Halawany et al. 1990; Ahmed and Ibrahim 2001).

Thus, the aim of the present work is to study the population density of *T. urticae*, (Tetranychidae), *R. ficifoliae* (Eriophyidae), and *E. scutalis* (Phytoseiidae) on two fig cultivars (Sultani and Parchment) in Akhmim district, Sohag governorate. As well as effect of weather factors and plant age on both phytophagous mites population.

MATERIALS AND METHODS

Population densities

The current work was carried out on fig orchard (4200 m²), located at Akhmim district, Sohag governorate from 15 Mar. 2020 to 10 Dec., 2021. This region climate is relatively hot in summer (< 40°C) and cold in winter (> 10°C). Two fig cultivars (e.g. Sultani and Parchment), pesticides free, were investigated for densities of phytophagous mites and their associated predators. Cultivars were randomly chosen and marked for incidence of 30 leaves. Samples were collected fortnightly from both cultivars. Leave samples were kept in a paper bag tightly closed, and transferred to the laboratory for examination. The numbers of different mite species (motile stages) was recorded using a stereo-microscope of 20–100 times magnification force.

Statistical analysis

For elucidating the effect of weather factors and plant age (i.e., plant phenology to emulate plant nutritional value density), simple correlation coefficients and partial regressions were used to obtain the amount of variability in the pest activity which could be attributed to the percentages of explained variance (EV%) as the combined effect of the climatic factors. According to Abou-Setta (2020), the dynamics of mites on perennials have to be discussed according to plant physiological growth changes

(stages) over the year. So, the period from flowering to crop harvest (March to August) was discussed separately from post-harvest to leaves fall at the end of the year. The effect of weather factors (e.g., maximum and minimum temperatures and RH %) were evaluated as simple correlations and partial regressions. Plant age was considered as multiple third degree of polynomial regressions. The whole model was presented as: $Y = a + b_1 \text{Temp_max} + b_2 \text{Temp_min} + b_3 \text{RH} + b_4 \text{Age} + b_5 \text{Age}^2 + b_6 \text{Age}^3$. Obtained data were analyzed using Procs Corr, Reg, and ANOVA in SAS (Anonymous 2003).

RESULTS AND DISCUSSION

Population densities of *T. urticae* on Sultani fig cultivar during 2020–2021

Results showed that *T. urticae* was active throughout spring-summer of first year. It appeared in the beginning of the first year in mid-March, 2020 with few numbers to reach the first peak at the end of June with mean number of 243 individuals/30 leaves at maximum and minimum temperature (38.1 and 23.1°C) and 34.6 % RH. The population decreased from late June to mid-August during the two years (Figure 1). Afterwards, the population gradually increased and recorded the second peak at the mid-November with mean number of 800 individuals/30 leaves at maximum and minimum temperature (28.5 and 16.5°C) and 54.4% RH. During year 2021, similar behaviour was observed (Figure 2). The first peak occurred at mid-June (236 individuals/30 leaves) at maximum and minimum temperature (36.3 and 21.5°C) and 31.8% RH. The second peak occurred at end of October (743 individuals/30 leaves) at maximum and minimum temperature (32.3 and 18.4°C) and 45.5% RH. It completely disappeared in winter season (from the end of December till early March) due to leaves falling.

Population density of *T. urticae* on Parchment fig cultivar during 2020–2021

The mite densities on fig ‘Parchment’ had led to two peaks at late of June and end of November with mean number of 462 and 286 individuals/30 leaves at maximum and minimum temperature (38.1 & 25.1 and 23.1 & 13.5°C) and (34.6 & 55.4% RH), respectively in 2020 (Figure 1). In the year 2021, this species recorded two peaks at

the end of June and mid-November with relative values of 485 and 309 individuals/30 leaves at maximum and minimum temperature (37.4 & 31.9 and 22.9 & 17.3°C) and (30.2 & 46.4 % RH), respectively (Figure 2). This finding is in agreement with that reported by Sweelam et al. (2021) and Esmael et al. (2018).

Population density of *R. ficifoliae* on Sultani and Parchment fig cultivars during 2020–2021

On ‘Sultani’ fig, *R. ficifoliae* individuals were recorded with scarce numbers in mid-March, then gradually increased from the end of March till reached high numbers in mid-June. Afterwards, the population varied in number till recorded the second peak in mid-November with total number of 320 and 200 individuals/30 leaves at maximum and minimum temperature (37.4 & 28.5 and 22.4 & 16.5°C) and (35.7 & 54.4% RH), respectively at the first year. During the second year, *R. ficifoliae* recorded high numbers at the end of June and November with total numbers of 260 and 306 individuals/30 leaves at maximum and minimum temperature (30.2 & 37.4 and 22.9 & 15.7°C) and (30.2 & 49.1% RH), respectively. This result agrees with what obtained by Abou-Awad et al. (2000) who found *R. ficifoliae* had three annual abundance peaks, two of which were recorded in early July 1990 and late July 1991.

On ‘Parchment’ fig, density of *R. ficifoliae* was increased gradually from mid-March to reach the highest number in mid-June and second one in mid-November, with a total numbers (290 and 230 individuals/30 leaves) at maximum and minimum temperature (37.4 & 28.5 and 22.4 & 16.5°C) and (35.7 & 55.5% RH) in 2020. During 2021, the *R. ficifoliae* had two peaks in the end of June and end of November with total numbers of 307 and 247 individuals/30 leaves at maximum and minimum temperature (37.4 & 30.2 and 22.9 & 15.7°C) and (30.2 & 49.1% RH), respectively. Then the number of individuals gradually decreased till the end of December.

Population density of *E. scutalis* on Sultani fig cultivar during 2020–2021

On ‘Sultani’, *E. scutalis* individuals were found with scarce numbers in mid-March till reach the first peak at the end of June (80 individuals/30 leaves) at maximum and minimum temperature (38.1 & 23.1) and 347.6% RH, respectively.

Then, the population increased and reached its second peak in mid-November with total number (59 individuals/30 leaves) at maximum and minimum temperature (28.5 & 16.5°C) and 54.5% RH, respectively in 2020. In 2021, *E. scutalis* was recorded with higher numbers (60 and 40 individuals/30 leaves) in end of June and mid-November at maximum and minimum temperature (37.4 & 31.9 and 22.9 & 17.3°C) and (30.2 & 46.4% RH), respectively (Figures 1 and 2).

On ‘Parchment’, *E. scutalis* has two peaks recorded in the first year in end of June and mid-November with mean number (60 and 48 individuals/30 leaves) at maximum and minimum temperatures (38.1 & 28.5 and 23.1 & 16.5°C) and (54.4% RH), respectively. In the second year, the population gradually increased and reached its first peak in mid-July (54 individuals/30 leaves) at maximum and minimum temperature (38.5 and 24.3°C) and 29% RH, respectively. The second peak was recorded in mid-November with 41 individuals/30 leaves (Figures 1 and 2). This result is in parallel with that of Ata et al. (2016) and Desoky et al. (2021).

Effect of weather factors and plant age on *R. ficifoliae* population on Sultani and Parchment cultivars during 2020–2021

On ‘Sultani’ fig, significant positive correlation values are recorded for maximum and minimum temperature ranged from 0.73 to 0.77 and 0.67 to 0.80 with P-values between 0.0065 to 0.0053 and 0.0160 to 0.0031 from March to August respectively in both years. However, insignificant correlation for maximum and minimum temperature from August to December in two years was recorded. On ‘Parchment’ fig, *R. ficifoliae*, exhibited highly significant correlation with maximum and minimum temperature during March to August with P-values (0.0001 & 0.0009) and (0.0004 & 0.0009), respectively in both years. *Rhyncaphytoptus ficifoliae* was recorded negative correlated with the relative humidity in the first year on both fig cultivars (Tables 1 and 2), which is in agreement with Abou-Awad et al. (2000).

The explained variance (EV%) of weather factor ranged from 66.43 to 87.69 on ‘Sultani’ fig and 70.59 to 95.10 on ‘Parchment’ during both years.

The single effect of applying the third-degree polynomial model using plant age revealed the explained variance (ranged from 76.25–91.55) and the P-value (ranged from 0.0070–0.0004) on ‘Sultani’ fig, and from (88.97–93.80) with P-value from (0.0079–<0.0001) on ‘Parchment’ in both years. The combined effect of weather factors and plant age were more significant than plant age as it ranged from 94.67 to 98.39 on ‘Sultani’ and from 95.74 to 99.96 on ‘Parchment’ fig (Tables 1 and 2). These results indicted the plant age effects on population of eriophyid mite than weather factor due to the change in the nutritional value of the host plant.

Effect of weather factors and plant age on *T. urticae* population on Sultani and Parchment fig cultivars

On ‘Sultani’ fig, highly significant positive correlation values were recorded for maximum and minimum temperature (0.88–0.90) and (0.87–0.92) from March to August with P-values between (0.0002–0.0001) and (0.0003–0.0001) for the two years, respectively. However, insignificant negative correlation values from August to December were recorded -0.18 to -0.43 and -0.24 to -0.37, with P-values between (0.6120 & 0.2401) and (0.5025 & 0.3240), respectively in both years. Significant negative correlation between *T. urticae* and relative humidity ranged from -0.83 to -0.85 was observed during March to August, while positive correlation ranged from (0.28 to 0.86) was recorded from August to December during the two years (Table 3 and 4).

Tetranychus urticae on ‘Parchment’ fig recorded significant positive correlation for maximum temperature from March to August in the first year. Whereas, insignificant positive correlation for minimum temperature was recorded from March to August during the two years. These results agree the finding mentioned by Abou-Awad et al. (2000).

The explained variance of plant age ranged from 91.98 to 93.97 during the two years on ‘Parchment’ fig. The combined effect of weather factors and plant age was more significant than plant age alone as it ranged from 92.85 to 99.08 on ‘Sultani’ fig and from 96.91 to 99.09 on

‘Parchment’ fig (Tables 3 and 4). This finding indicates that plant age affected on population of *T. urticae* than weather factor due to the change in the nutritional value of the host plant.

Effect of tested cultivars on the relationships between *R. ficifoliae*, *T. urticae* and *E. scutalis* predatory mite during 2020–2021

Statistical analysis proved insignificant positive correlations between *R. ficifoliae* population and the predatory mite, *E. scutalis* (0.45 and 0.59) for the two years on ‘Sultani’ fig. While on ‘Parchment’ fig, significant positive correlation (0.89 and 0.87) for both years was noticed. Insignificant positive correlation between population of *T. urticae* and *E. scutalis* (0.45 and 0.25) on ‘Sultani’ fig was observed. However, significant positive correlation (0.76 and 0.65) was recorded on ‘Parchment’ fig.

CONCLUSION

It can be concluded that *T. urticae* has two similar peaks on both fig cultivars per year in Akhmim district, Sohag governorate; meanwhile, *R. ficifoliae*, and *E. scutalis* have two peaks. The population densities of mite species are affected by the ambient climatic conditions (i.e., temperature and relative humidity), however, plant age has more significant effect than weather factors. Ecological data are required to determine the peak of phytophagous mites and their associated predators in order to understand the best time that predators can play in biological pest control.

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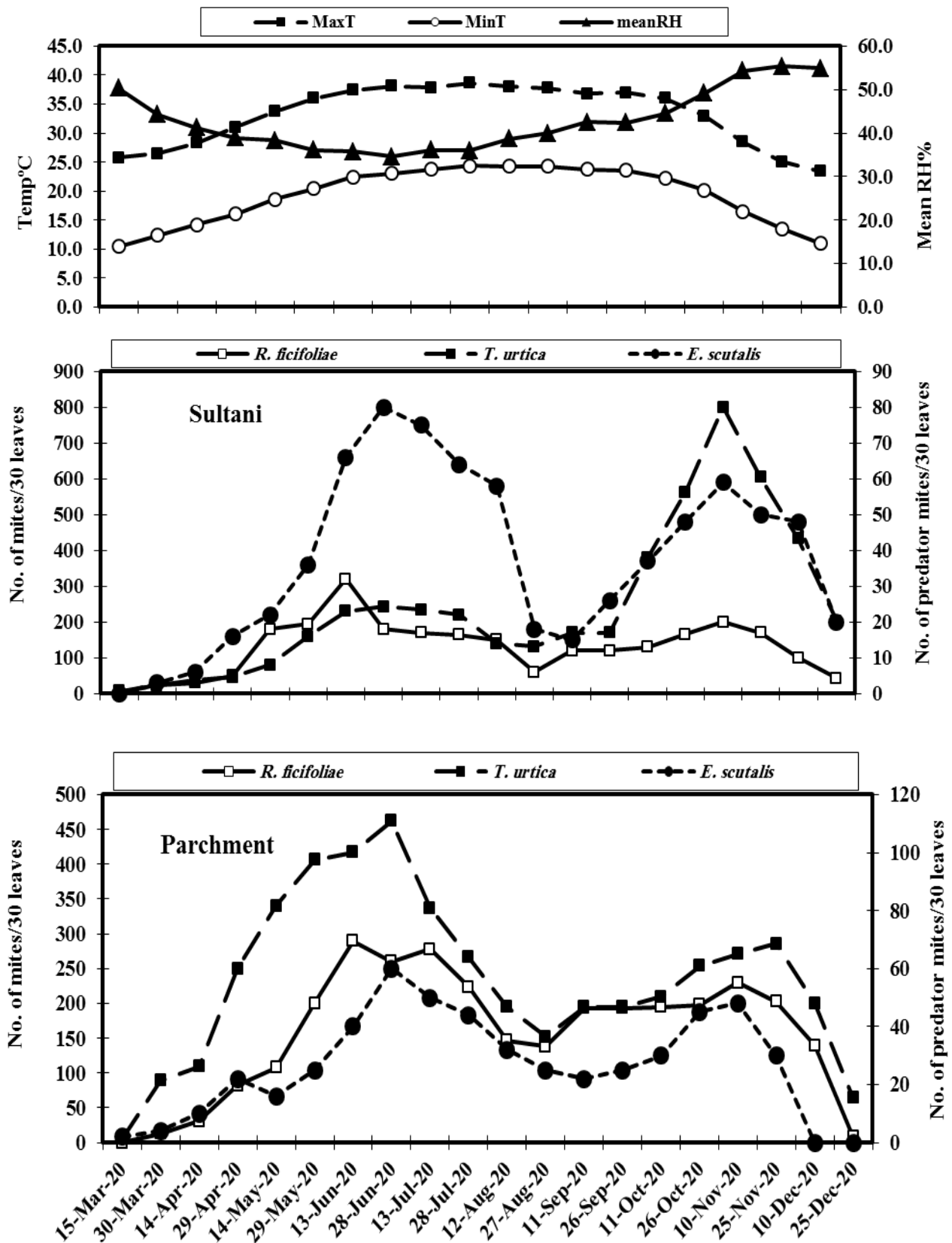


Figure 1. Population densities of phytophagous and predacious mites on Sultani and Parchment fig cultivars in Akhmim district, Sohag governorate during 2020.

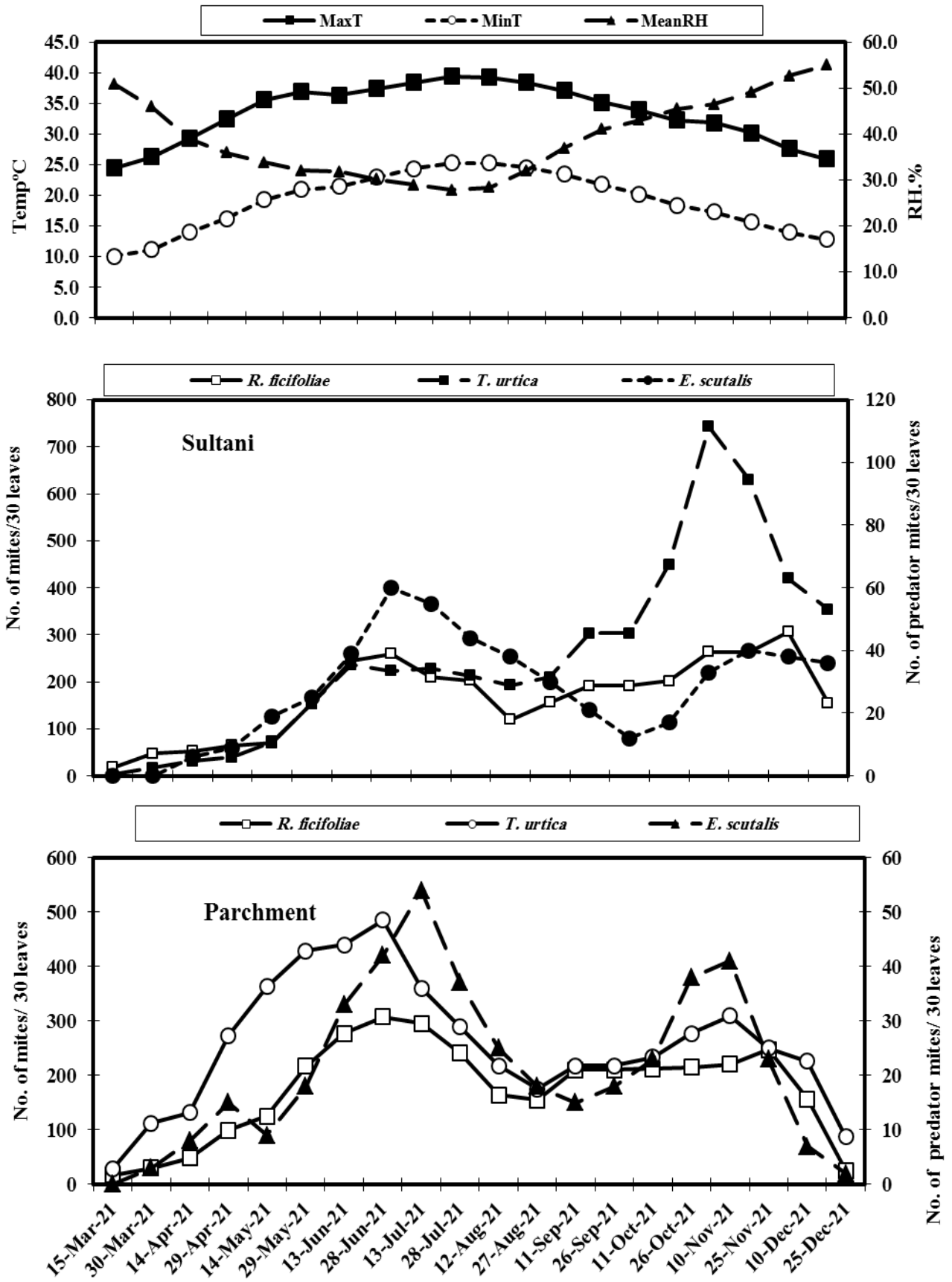


Figure 2. Population densities of phytophagous and predacious mites on Sultani and Parchment fig cultivars in Akhmim district, Sohag governorate during 2021.

Table 1. Simple correlation coefficient and multiple regression values for effect of weather factors and plant age on *Rhyncaphytoptus ficifoliae* population on Sultani fig cultivar in Akhmim district, Sohag governorate during 2020–2021.

Season	Factor	Level	Simple correlation		Multiple regression				
			R	P	b	P	F	P	EV %
2020 (Mar. to Aug.)	Weather	Temp max	0.73	0.0065	66.30	0.0690	7.61	0.0099	74.06
		Temp min	0.67	0.0160	-55.48	0.0852			
		RH	-0.76	0.0035	-5.61	0.4805			
	Plant age	Age-Age ³	-	-	-	-	8.56	0.0070	76.25
	Combined	-	-	-	-	22.70	0.0018	96.46	
2020 (Aug. to Dec.)	Weather	Temp max	0.008	0.9828	35.62	0.2850	6.21	0.0386	78.85
		Temp min	0.087	0.8228	41.13	0.2413			
		RH	0.73	0.0233	4.26	0.1943			
	Plant age	Age-Age ³	-	-	-	-	14.24	0.0070	89.52
	Combined	-	-	-	-	20.43	0.0474	98.39	
2021 (Mar. to Aug.)	Weather	Temp max	0.77	0.0053	-23.8	0.5304	4.62	0.0439	66.43
		Temp min	0.80	0.0031	28.1	0.2748			
		RH	-0.76	0.0063	-5.21	0.7372			
	Plant age	Age-Age ³	-	-	-	-	25.28	0.0004	91.55
	Combined	-	-	-	-	32.33	0.0024	97.98	
2021 (Aug. to Dec.)	Weather	Temp max	-0.08	0.8236	165.6	0.0007	14.25	0.0039	87.69
		Temp min	0.003	0.9918	-112.3	0.0040			
		RH	0.04	0.8974	28.28	0.0071			
	Plant age	Age-Age ³	-	-	-	-	14.17	0.0039	87.63
	Combined	-	-	-	-	8.88	0.0505	94.67	

Table 2. Simple correlation coefficient and multiple regression values for effect of weather factors and plant age on *Rhyncaphytoptus ficifoliae* population on Parchment fig cultivar in Akhmim district, Sohag governorate during 2020–2021.

Season	Factor	Level	Simple correlation		Multiple regression				
			R	P	b	P	F	P	EV %
2020 (Mar. to Aug.)	Weather	Temp max	0.889	0.0001	47.83	0.0976	16.80	0.0008	86.30
		Temp min	0.852	0.0004	-32.58	0.1912			
		RH	-0.856	0.0004	-5.44	0.4006			
	Plant age	Age-Age ³	-	-	-	-	32.19	<0.0001	92.35
	Combined	-	-	-	-	18.71	0.0028	95.74	
2020 (Aug. to Dec.)	Weather	Temp max	0.442	0.234	-16.99	0.4019	32.37	0.0011	95.10
		Temp min	0.512	0.158	27.79	0.2096			
		RH	0.541	0.132	7.514	0.0082			
	Plant age	Age-Age ³	-	-	-	-	22.90	0.0024	93.22
	Combined	-	-	-	-	768.63	0.0013	99.96	
2021 (Mar. to Aug.)	Weather	Temp max	0.826	0.0009	-13.18	0.7387	6.40	0.0161	70.59
		Temp min	0.827	0.0009	15.72	0.5604			
		RH	-0.828	0.0009	-9.69	0.5020			
	Plant age	Age-Age ³	-	-	-	-	40.35	<0.0001	93.80
	Combined	-	-	-	-	51.89	0.0002	98.42	
2021 (Aug. to Dec.)	Weather	Temp max	0.480	0.1906	51.26	0.0418	13.12	0.0083	88.73
		Temp min	0.408	0.2753	-35.3	0.0866			
		RH	-0.378	0.3148	3.34	0.7360			
	Plant age	Age-Age ³	-	-	-	-	13.45	0.0079	88.97
	Combined	-	-	-	-	71.72	0.0138	99.54	

Table 3. Simple correlation coefficient and multiple regression values for effect of weather factors and plant age on *Tetranychus urticae* population on Sultani fig cultivar in Akhmim district, Sohag governorate during 2020–2021.

Season	Factor	Level	Simple correlation		Multiple regression				
			R	P	b	P	F	P	EV %
2020 (Mar. to Aug.)	Weather	Temp max	0.90	0.0001	29.11	0.2551	14.08	0.0015	84.08
		Temp min	0.87	0.0002	-14.88	0.5036			
		RH	-0.83	0.0008	-3.27	0.5822			
	Plant age	Age-Age ³	-	-	-	-	38.06	0.0001	93.45
		Combined	-	-	-	-	43.21	0.0004	98.11
2020 (Aug. to Dec.)	Weather	Temp max	-0.43	0.2401	-78.26	0.6146	5.28	0.0524	75.99
		Temp min	-0.37	0.3240	80.3	0.6188			
		RH	0.86	0.0027	23.56	0.1519			
	Plant age	Age-Age ³	-	-	-	-	17.68	0.0043	91.39
		Combined	-	-	-	-	5.02	0.1755	93.77
2021 (Mar. to Aug.)	Weather	Temp max	0.88	0.0003	-22.5	0.3664	17.85	0.0012	88.44
		Temp min	0.92	0.0001	37.4	0.0444			
		RH	-0.85	0.0008	0.35	0.9719			
	Plant age	Age-Age ³	-	-	-	-	54.77	0.0001	95.91
		Combined	-	-	-	-	72.03	0.0005	99.08
2021 (Aug. to Dec.)	Weather	Temp max	-0.18	0.6120	303.6	0.0365	3.04	0.1141	60.35
		Temp min	-0.24	0.5025	-200.7	0.1092			
		RH	0.28	0.4168	60.0	0.0963			
	Plant age	Age-Age ³	-	-	-	-	8.91	0.0125	81.66
		Combined	-	-	-	-	6.50	0.0766	92.85

Table 4. Simple correlation coefficient and multiple regression values for effect of weather factors and plant age on *Tetranychus urticae* population on Parchment fig cultivar in Akhmim district, Sohag governorate during 2020–2021.

Season	Factor	Level	Simple correlation		Multiple regression				
			R	P	b	P	F	P	EV %
2020 (Mar. to Aug.)	Weather	Temp max	0.71	0.0095	102.22	0.0009	59.06	<0.0001	95.68
		Temp min	0.63	0.0266	-97.46	0.0006			
		RH	-0.88	0.0001	-23.97	0.0011			
	Plant age	Age-Age ³	-	-	-	-	30.58	<0.0001	91.98
		Combined	-	-	-	-	28.56	0.0010	97.17
2020 (Aug. to Dec.)	Weather	Temp max	0.06	0.8747	-30.73	0.1661	31.89	0.0011	95.03
		Temp min	0.14	0.7116	38.55	0.108			
		RH	0.80	0.0085	7.95	0.0071			
	Plant age	Age-Age ³	-	-	-	-	25.95	0.0018	93.97
		Combined	-	-	-	-	36.13	0.0272	99.09
2021 (Mar. to Aug.)	Weather	Temp max	0.68	0.0139	71.82	0.2482	5.13	0.0287	65.79
		Temp min	0.61	0.0329	-65.86	0.1305			
		RH	-0.72	0.0077	-12.16	0.5756			
	Plant age	Age-Age ³	-	-	-	-	30.58	<0.0001	91.98
		Combined	-	-	-	-	50.22	0.0003	98.37
2021 (Aug. to Dec.)	Weather	Temp max	0.21	0.5823	135.68	0.0045	8.21	0.0224	83.12
		Temp min	0.12	0.7438	-76.45	0.0250			
		RH	-0.11	0.7686	32.95	0.0337			
	Plant age	Age-Age ³	-	-	-	-	22.25	0.0025	93.03
		Combined	-	-	-	-	10.44	0.0899	96.91

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