

## Ecological studies on *Tetranychus urticae*, *Aphis gossypii* and associated spiders on cotton plants at Qalubiya and Beni-Suef governorates in Egypt

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### ABSTRACT

The population density of the two spotted spider mite, *Tetranychus urticae* Koch, the aphid, *Aphis gossypii* Glover and associated spiders was monitored throughout the two seasons 2019 and 2020 at Qaha, Qalubiya and Wasta, Beni-Suef governorates, Egypt. Obtained results revealed that *T. urticae* increased from mid-May to reach a peak in mid-August. *A. gossypii* was recorded with moderate number in mid-May and gradually increased to June. Associated spiders were recorded to peak in mid-July. The highest frequency of collected spider species were *Thanatus albini* (Audouin), *Cheiracanthium inclusum* (O.P.Cambridge), *Dictyna innocens* (O.P.Cambridge), *Mermessus denticulatus* (Banks), *Pulchellodromus glaucinus* (Simon), *Ballus piger* (O.P.Cambridge) and *Synema diana* (Audouin). The combined effect of weather factors on population dynamics of both *T. urticae* and *A. gossypii* were insignificant over the two seasons and locations in most cases. It had less significant effect once considered pests' population dynamics than plant age. Plant age as third degree of polynomial (emulating host plant developmental stages) had much more significant effect. Influence of weather factors and plant age combined effect explained variance was 96.05, 94.52, 88.53, 83.49% for *T. urticae* and *A. gossypii* in the first and second season, respectively at Qaha location during the two seasons. Similar results were obtained for Wasta location. The combined explained variance was 78.85, 87.05, 84.88 and 92.49 for *T. urticae* and *A. gossypii* in the first and second season, respectively. Correlation results between spiders' counts, *T. urticae* and *A. gossypii* over the two seasons and locations was inconsistent.

**Keywords:** two spotted spider mite, aphid, true spiders, weather factors, plant age, population dynamics.

### INTRODUCTION

Cotton, *Gossypium* spp., (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 cotton aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae) is a polyphagous sap sucking aphid pest of cotton throughout the world causing a significant problem due to the honeydew contamination of the open boll lint (El-Gohary 2010). Its importance as a cotton pest has increased throughout the cotton producing regions of the world (Leclant and Deguine 1994). In Egypt, *A. gossypii* considered as one of the most serious pests and its damage affects the yield of cotton seeds as well as the fiber quality,

beside the transmission of the viral diseases (Abou-Elhagag 1998).

The two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) is one of the most important pests in many cropping systems worldwide. Its host plants (nearly 1150 plant species) comprise vegetables, fruits, crops, and a wide range of ornamentals. *T. urticae* infests cotton fields nearly every year in Egypt and can be considered an important cause of lost revenue to cotton producers. This may be due to high reproductive potential and short generation time. The feeding damage of spider mites, concentrated primarily on the lower surface of the leaves. Under heavy infestation, severe defoliation occurs and leaves become entirely gray, curl, turn brown, and drop off. This decreases the photosynthetic capacity of plants (Taha et al. 1990).

Spiders are fellows of phylum Arthropoda, the large group of animals with jointed limbs and a hard outer skeleton. They belong to class Arachnida. Arachnids are an important but generally poorly studied group of arthropods that play a significant role in the regulation of insect and other invertebrate populations in most ecosystems (Russell-Smith 1999).

This study was conducted on *T. urticae* and *A. gossypii* population dynamics and associated spiders in cotton fields at Qalubiya and Beni-Suef governorates under weather conditions and plant growth developmental stages as plant age.

## MATERIALS AND METHODS

The present study was carried out in cotton fields at two locations. The first was at Qaha location, Qalubiya governorate and the second at Wasta location, Beni-Suef governorate. Population density of associated spiders on cotton crops during two successive seasons 2019 and 2020, in the two locations was determined.

Samples of 50 leaves from 10 plants were randomly collected biweekly during two hours from 10 am to 12am from mid-Apr. to early-Sept. from the three plant levels (upper, middle and lower parts) from five sites of the field. The number of adult stages of *T. urticae* and *A. gossypii* found on leaf samples periodically picked at random from experimental location were counted.

Spider individuals were randomly collected from 10 cotton plants. Plants were shaken five times and fallen spiders were received on silky traps. Specimens were individually picked up in small plastic vials and transferred to the laboratory for counting and identification. Individuals were kept in 70% ethyl alcohol in glass vials for identification. The collected spiders were identified up to the species with the help of available literature (Kaston 1978; World Spider Catalog 2021).

The maximum, minimum temperatures, and relative humidity were obtained from the online database underground<sup>®</sup> (The Weather Company, GA, USA) throughout the investigation period

### Statistical analysis:

Simple correlations and partial regression 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 have to be discussed according to plant physiological growth changes (stages) over the growing season (for annual crops) and over the year for perennials. The effect of weather factors (i.e., maximum and minimum temperatures and RH%) were evaluated as simple correlations and partial regressions. Plant age which emulates plant growth stages was considered as third degree of polynomial. The combined effect of weather factors and plant age was presented as  $Y = a \pm b_1 \text{ Temp\_max} \pm b_2 \text{ Temp\_min} \pm b_3 \text{ RH} \pm b_4 \text{ Age} \pm b_5 \text{ Age}^2 \pm b_6 \text{ Age}^3$ . Obtained data were analyzed using Procs Corr, and Reg in SAS (Anonymous 2003).

## RESULTS AND DISCUSSION

### Identification of spiders:

Spiders associated with cotton plants were recorded at Qaha and Wasta locations was identified as 34 species belonging to nine families. These families were: Araneidae, Cheiracanthiidae, Dictynidae, Lycosidae, Philodromidae, Salticidae, Theridiidae and Thomisidae. Philodromidae and Thomisidae. Results indicated that the highest percentage frequency of occurrence of the collected spider species were *Thanatus albini* (Audouin, 1825), *Cheiracanthium inclusum* (O.P. Cambridge, 1874), *Dictyna innocens* (O.P. Cambridge, 1872), *Mermessus denticulatus* (Banks, 1898), *Pulchellodromus glaucinus* (Simon, 1870), *Ballus piger* (O.P. Cambridge, 1846) and *Synema diana* (Audouin, 1825). These results in are consistent with the previous observation by Abo-Zaed (2008) and El-Gohary (2010).

### Population dynamics of *T. urticae*, *A. gossypii* and associated spiders

Obtained results are illustrated in Figures (1 and 2). Results illustrated in Figure (1) clearly showed that the population of the two-spotted spider mite, *T. urticae* was recorded with few numbers in mid-May after that the population gradually increased to reach its peak in mid-Aug. as 80.3 and 95.1 individuals/10 leaves at maximum and minimum temperatures of 36.38 & 25.77 and 36.00 & 25.43°C, and 51.85 & 53.93 % RH in the first season and second seasons, respectively. After that the population gradually decreased until the end of the season. The total mean number of the two spotted spider mite in

the first season was higher than in the second season recording 507.3 and 498.0 individuals, respectively.

Results illustrated in Figure (1) indicated that the aphid, *A. gossypii* on cotton plants was recorded with moderate number in mid-May, after that the population gradually increased to peak in early to mid-Aug. as 71.8 and 75.5 individuals/10 leaves at maximum and minimum temperatures of 36.38 & 25.77 and 36.00 & 25.43°C, and 51.85 & 53.93 % RH in the first season and second seasons, respectively. After that the population gradually decreased until the end of the season. The total mean number of *A. gossypii* in the second season was higher than in the first season recording 449.1 and 486.1 individuals, respectively.

Obtained results illustrated in Figure (1) revealed that the associated spiders were recorded with fewer numbers in mid-May during two seasons. They gradually increased to peak in mid-Jul. as 69 individuals/10 plants, at maximum and minimum temperatures of 35.0 and 23.56°C, and 47.61% RH during first season 2019. In the second season 2020 it had one peak in late-Jul. as 52 individuals/10 plants at maximum and minimum temperatures of 34.24 and 23.84°C, and 58.10% RH. The total mean number of spider was higher in the first season 390 individuals than in the second season as 349 individuals.

These results are consistent with findings by Taha et al. 1990; Abdallah and Kelany 2003; Abo-Zaed 2008; Hendawy et al. 2011 and Ibrahim and Megahed 2017.

### **Relation between associated spiders and consider two pests on cotton plants:**

Obtained correlation values between spider counts and *T. urticae* and *A. gossypii* at Qaha location revealed  $r$  values of 0.711 and 0.554 with  $P$  values of 0.0213 and 0.0964, respectively, for 2019 season. For 2020 season relative values were 0.730 and 0.725 with  $P$  values of 0.0166 and 0.0178, respectively. This means significant positive relation with *T. urticae*, while insignificant positive relation with *A. gossypii* for 2019 season data, while significant positive relation with both pests for 2020 seasons' data.

Obtained correlation values between spider counts and *T. urticae* and *A. gossypii* at Wsta location revealed  $r$  values of -0.203 and -0.191

with  $P$  values of 0.5729 and 0.5974, respectively, for 2019 season. For 2020 season relative values were -0.198 and -0.492 with  $P$  values as 0.5838 and 0.1489 respectively. This means in significant negative relation with both *T. urticae*, and *A. gossypii* over the seasons and both pests.

These results indicated inconsistent relation between spider counts and *T. urticae* and *A. gossypii* over the two seasons and locations.

These results are in agreement with those conducted by Hendawy et al. 2011, Anbar et al. 2020; Desoky et al. 2021.

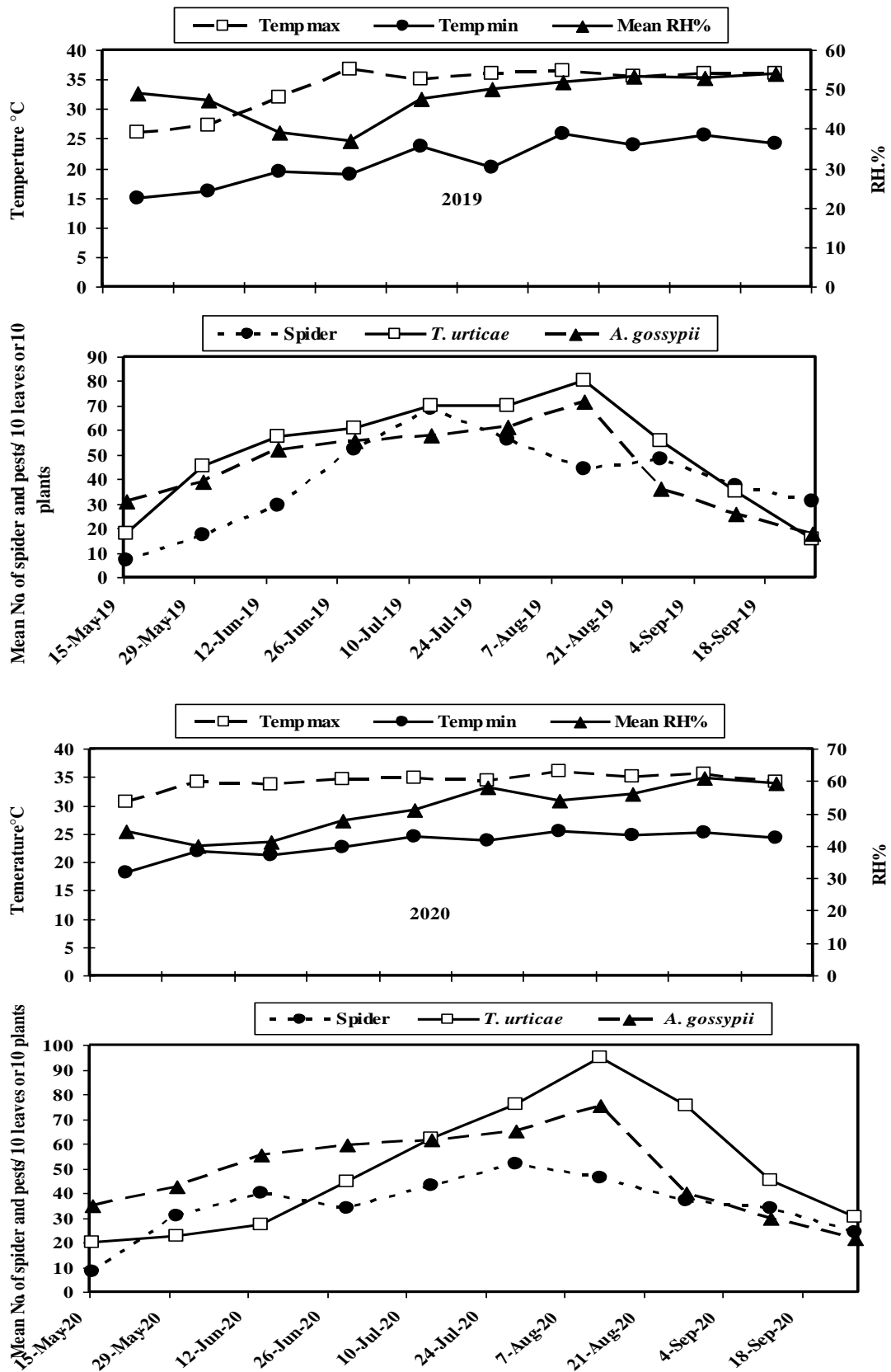
### **Effect of weather and plant age factors on population dynamics of considered cotton pests:**

The effect of climatic and plant age factors on the population dynamics of considered cotton pests are presented in Tables (1 to 4).

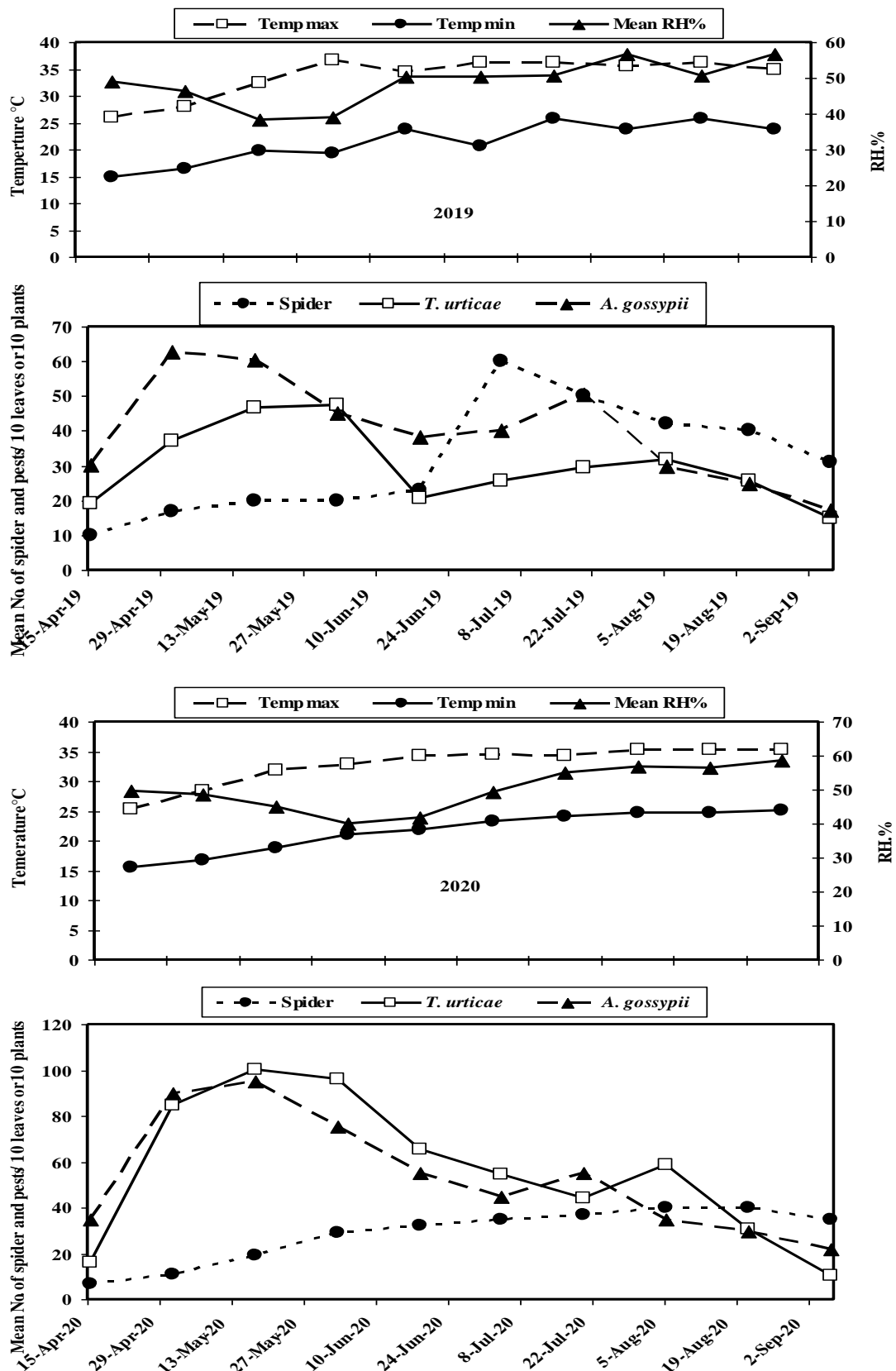
Results revealed that population dynamics of *T. urticae* populations on cotton at Qaha during 2019–2020 seasons were not affected significantly by weather factors separately or in combination. Plant age as third polynomial degree revealed EV as 94.28 and 92.43%, while in combination with weather factors revealed EV was 96.05 and 94.52, over the two seasons, respectively (Table 1).

Results revealed that population dynamics of *A. gossypii* populations on cotton at Qaha during 2019–2020 seasons were not affected significantly by weather factors separately or in combination. Plant age as third polynomial degree revealed EV as 83.23 and 83.00%, while in combination with weather factors revealed EV was 88.53 and 83.49, over the two seasons, respectively (Table 2).

Results revealed that population dynamics of *T. urticae* populations on cotton at Wsta during 2019–2020 seasons were affected significantly by weather factors. Relative humidity was significant only during 2019 season as single factor. In combination weather factors were significant indicated EV as 70.65 and 75.85% during both seasons, respectively. Plant age as third polynomial degree revealed EV as 44.46 and 78.85%, while in combination with weather factors revealed EV as 78.85 and 78.05, over the two seasons, respectively (Table 3).



**Figure 1.** Population dynamics of pests and spiders on cotton plants during 2019-2020 seasons at Qaha location. *T. urticae* and *A. gossypii* (individuals/10 leaves). Spiders (individuals/10 plants).



**Figure 2.** Population dynamics of pests and spiders on cotton plants during 2019-2020 seasons at Wasta location. *T. urticae* and *A. gossypii* (individuals/10 leaves). Spiders (individuals/10 plants).

**Table 1.** Simple and multiple regression values for factors affected *T. urticae* populations on cotton at Qaha during 2019–2020 seasons.

Factor	Level	Simple correlation		Multiple regression				
		r	P	b	P	F	P	EV %
<b>2019 season</b>								
Weather	Temp max	0.44	0.2017	1.87	0.6426	0.94	0.4773	32.0
	Temp min	0.25	0.4792	1.14	0.8076			
	RH%	-0.28	0.4296	-1.62	0.3961			
Plant age	Age-Age <sup>3</sup>	-	-	-	-	32.99	0.0004	94.28
Combined		-	-	-	-	12.16	0.0327	96.05
<b>2020 season</b>								
Weather	Temp max	0.65	0.412	-3.31	0.9022	2.02	0.2120	50.31
	Temp min	0.70	0.0221	10.42	0.6462			
	RH%	0.54	0.1005	-0.08	0.9723			
Plant age	Age-Age <sup>3</sup>	-	-	-	-	24.43	0.0009	92.43
Combined		-	-	-	-	8.62	0.0526	94.52

**Table 2.** Simple and multiple regression values for factors affected *A. gossypii* populations on cotton at Qaha during 2019–2020 seasons.

Factor	Level	Simple correlation		Multiple regression				
		R	P	b	P	F	P	EV %
<b>2019 season</b>								
Weather	Temp max	0.27	0.4396	1.42	0.6642	0.73	0.5687	26.84
	Temp min	0.04	0.8957	0.05	0.9829			
	RH%	-0.39	0.2548	-1.32	0.3935			
Plant age	Age-Age <sup>3</sup>	-	-	-	-	9.93	0.0096	83.23
Combined		-	-	-	-	3.86	0.1475	88.53
<b>2020 season</b>								
Weather	Temp max	0.30	0.3952	4.21	0.8492	0.67	0.6027	24.99
	Temp min	0.18	0.6139	1.93	0.9166			
	RH%	-0.17	0.6362	-1.24	0.5644			
Plant age	Age-Age <sup>3</sup>	-	-	-	-	9.99	0.0086	83.00
Combined		-	-	-	-	2.53	0.2388	83.49

**Table 3.** Simple and multiple regression values for factors affected *T. urticae* populations on cotton at Wasta during 2019–2020.

Factor	Level	Simple correlation		Multiple regression				
		r	P	b	P	F	P	EV %
<b>2019 season</b>								
Weather	Temp max	0.07	0.8272	0.89	0.4970	4.81	0.0488	70.65
	Temp min	-0.26	0.4531	-0.33	0.8198			
	RH%	-0.81	0.0045	-1.42	0.0314			
Plant age	Age-Age <sup>3</sup>	-	-	-	-	1.60	0.2851	44.46
Combined		-	-	-	-	1.88	0.3238	78.85
<b>2020 season</b>								
Weather	Temp max	-0.04	0.8998	22.15	0.0542	6.19	0.0288	75.58
	Temp min	-0.30	0.3866	-22.90	0.6731			
	RH%	-0.71	0.0195	-0.64	0.7258			
Plant age	Age-Age <sup>3</sup>	-	-	-	-	7.15	0.0209	78.15
Combined		-	-	-	-	3.36	0.1736	87.05

**Table 4.** Simple and multiple regression values for factors affected *A. gossypii* populations on cotton at Wasta during 2019–2020.

Factor	Level	Simple correlation			Multiple regression			
		r	P	b	P	F	P	EV %
<b>2019 season</b>								
Weather	Temp max	-0.23	0.5081	-1.30	0.5584	2.32	0.1744	53.76
	Temp min	-0.38	0.2711	1.09	0.6633			
	RH%	-0.71	0.0209	-1.90	0.0700			
Plant age	Age-Age <sup>3</sup>	-	-	-	-	3.60	0.0853	64.27
Combined		-	-	-	-	2.81	0.2131	84.88
<b>2020 season</b>								
Weather	Temp max	-0.33	0.3506	17.91	0.0577	5.94	0.0314	74.83
	Temp min	-0.55	0.0933	-21.3	0.0452			
	RH%	-0.68	0.0291	0.40	0.7882			
Plant age	Age-Age <sup>3</sup>	-	-	-	-	6.95	0.0223	77.64
Combined		-	-	-	-	6.16	0.0821	92.49

The obtained results revealed that population dynamics of *A. gossypii* on cotton at Wasta during 2020 season were affected significantly by weather factors. Relative humidity was significant during 2019 and 2020 seasons as single factor. In combination weather factors were significant indicated EV as 53.76 and 74.83% over the two seasons, respectively. Plant age as third polynomial degree revealed EV as 64.27 and 77.64%, while in combination with weather factors revealed EV was 84.88 and 92.49, over the two seasons, respectively (Table 4).

In general, weather factors were less significantly affected population dynamics considered pests than plant age. The dynamics of mites have to be discussed according to plant physiological growth changes (stages) over the growing season (for annual crops) and over the year for perennials (Abou-Setta 2020),

Such finding coincides with that obtained by Taha et al. 1990; Abdallah and Kelany 2003; Abo-Zaed 2008; Hendawy et al. 2011; Anbar et al. 2020; Desoky et al. 2021.

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