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Influence of Meteorological Factors and Plant Age on Incidence of *Tetranychus cucurbitacearum* (Sayed) (Acari: Tetranychidae) on Two Melon Cultivars

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Abstract: Changes in climatic factors and pests have a substantial impact on agricultural yields because of their close relationship to crop production. Understanding how climate change affects pests is therefore essential for efficient management and adequate food production. In this research, correlation and regression relationships were studied on the effect of climatic variables (temperatures, relative humidity & wind velocity) and plant age on the *T. cucurbitacearum* population of two melon cultivars, watermelon (Sakata) and muskmelon (Mac G5), during two consecutive seasons (2022 & 2023) at El-Beheira Governorate. Throughout the crop-growing period, it was found that the mite population increased consistently. The spider mite population reached its peak on May 6 and May 20, after which the population gradually declined. On the two melon cultivars, the moving and egg stages of *T. cucurbitacearum* exhibited a highly significant positive correlation with both plant age and maximum & minimum temperatures. Additionally, wind velocity positively affected the *T. cucurbitacearum* population to a moderate degree. Throughout the two consecutive seasons, there was a significant negative correlation between the *T. cucurbitacearum* population and relative humidity on the two melon cultivars. Therefore, understanding the weather conditions that influence pest fluctuations is crucial when developing mite management plans.

Key words: *Tetranychus cucurbitacearum***,** temperature, wind velocity, relative humidity, plant age, correlation, regression.

1. Introduction

Melons are one of the most common Cucurbitaceae fruit crops farmed around the world. Melons play an important part in global fruit and vegetable production. A melon's quality is defined by its sweetness, agreeable flavor, and excellent nutritional value **(Zhao *et al*., 2023).** Cucurbitaceae fruits contain high levels of carotenoids and phenolic compounds, as well as outstanding antioxidant activity, making them a valuable source of phytochemicals **(Kubola and Siriamornpun, 2011).** Mites, particularly those in the Tetranychidae family, are prevalent agricultural pests that can result in higher financial losses than any other arthropod pest. *T. cucurbitacearum* (Sayed) is regarded as one of the main pests that target a variety of crops, including vegetables, fruits, and ornamental plants **[Taha *et al.* (2001) and Magouz and Saadoon (2005)].** *T. cucurbitacearum*, the two-spotted spider mite, is the most significant agricultural pest among phytophagous mites due to its extensive host range and the harm it does **(Gallo *et al.*, 2002).**

Weather has a significant impact on mite development and population density. Temperature is one of the most significant abiotic factors among all weather parameters, and it directly affects the levels of pest populations through mite development, survivability, and fertility. Therefore, when creating pest management plans for mites, it is important to take into account weather conditions and the weather needs for pest variations **(Devi and Challa 2019).** The ecology of plant-feeding mites is influenced by biotic and abiotic variables, which cause fluctuations in pest populations **(George 2019).** Abiotic variables that affect mites' developmental time, survival rate, and fecundity rate include temperature, humidity, rainfall, photoperiod, and wind direction **(Turi *et al*., 2012).**

The relationship between prey and host, their immunological responses and rate of development, their fertility, and numerous physiological functions have all been directly and indirectly impacted by the intensity of climate change seen by meteorological science **(Yumamura *et al.* 2006).** The primary element affecting the *T. urticae* population is the variation in the attainable nutritional value, which varies throughout the growing season.This variation is influenced by the biological phenomena of the host plant, namely, "different stages of growth and their nutritional contents" **(Abou–Setta, 2020).**

Objectives: Population fluctuation of *T. cucurbitacearum* on two melon cultivars was investigated. Thereafter, the correlation and regression relations between each of *T. cucurbitacearum* and meteorological factors (temperatures, RH & wind velocity) and the plant age factor in two melon cultivars, watermelon (Sakata) and muskmelon (Mac G5) were studied during two successive seasons (2022 & 2023) at El-Beheira Governorate.

2. Materials and Methodes

This study was performed in an area of 600 m², located in Badr Center, El-Beheira Governorate. The area was divided into two equal plots, with one melon cultivar assigned to each plot, and each plot was further divided into three replicates. Cultivars of watermelon (Sakata) and muskmelon (Mac G5) were grown in an open field over the two successive seasons of 2022 and 2023. In the third week of December of 2021 and 2022, melon cultivars were transplanted beneath plastic low tunnels, and on February 5th of 2022 and 2023, respectively, the plastic was totally removed from the plants. Transplanting of the seedlings is done in a single row in each bed, with a planting distance of 75 cm for watermelon cultivars and 50 cm for muskmelon cultivars. The width of the beds is 2.5 meters for watermelon and 2 meters for muskmelon cultivars. The plastic is typically covered in the afternoon to promote plant growth by warming the air around the plants. Recommended fertilizers are applied via drip irrigation. The first and second seasons ran from 20^{th} January to 4^{th} June in the two successive seasons. The population dynamics of all stages of *T. cucurbitacearum* were recorded and monitored weekly for both melon cultivars during these two successive seasons. Thirty leaves /one melon cultivar were randomly collected each week. Leaf samples were placed directly into labeled perforated polyethylene bags and transported to the laboratory for examination using a stereomicroscope.

Statistical Analysis

The obtained data were subjected to a pearson simple correlation and linear regression analysis using the software package SPSS 20 for Windows.

3. Results and Discussion

3.1. Population fluctuation of *T. cucurbitacearum* stages on the two melon cultivars

The study conducted during the watermelon (Sakata) and muskmelon (Mac G5) crop seasons revealed that spider mites began to appear in the 3rd week of January in both 2022 and 2023 (Figs. 1-4). It was observed that the mite population steadily increased throughout the crop growth period, peaking on May 6th and May 20th, accompanied by a rapid rise in the moving stages of the mites and an increase in egg buildup. After that, there was a gradual decline in the mite population. The data given in Tables (1-2) showed that the examined melon cultivars, watermelon (Sakata) and muskmelon (Mac G5), had small differences in *T. cucurbitacearum* infestations, as reflected by the mean number of moving and egg stages recorded during the 2022 and 2023 seasons. Watermelon (Sakata) had a substantial reaction to *T. cucurbitacearum* infection, with 120.21 ± 14.56 and 130.66 ± 13.68 moving stages per leaf, as well as 114.58 ± 12.51 and 116.37 ± 12.48 egg stages per leaf throughout two seasons, 2022 and 2023, respectively. The muskmelon (Mac G5) variety had 93.79 ± 12.01 and 95.35 ± 12.09 moving stages per leaf, as well as 108.1 ± 10.17 and 111.92 ± 10.28 egg stages per leaf in two seasons.

Previous research has explored the population dynamics of the two-spotted spider mites on melon. **Aiad *et al.* (2014)** documented the population dynamics of *T. urticae* motile stages and eggs over the winter seasons of 2012 and 2013, from mid-January to the last week of April. During the 2012 season, the infestation of muskmelon cultivars Shahd2 and Galia2 with motile stages of *T. urticae* began in mid-January and gradually progressed until it peaked in the early third week of April and the early second week for Ananas France. **Abou-Awad *et al.* (2017)** discovered that the infestation of four melon cultivars by *T. urticae* began in the third week of January under plastic low tunnel conditions, gradually increased, and peaked in the third week of April in watermelon (Sakata and Giza 6) and the first week of May in muskmelon (Gal 3 and Dahaby) in open field conditions over two seasons. **Ibrahim *et al.* (2008)** reported that the peak of infestation of *T. urticae* in 2007 occurred on Sudanian watermelon (37.2 individuals/inch²) on July 28, at Bahar El-Bakar, and on Snake watermelon (32.7 individuals/inch²) on July 21. In 2008, the peak of infestation occurred on Sudanian watermelon (38.4 individuals/inch²) on August 3, and on Snake watermelon (31.2 individuals/inch²).

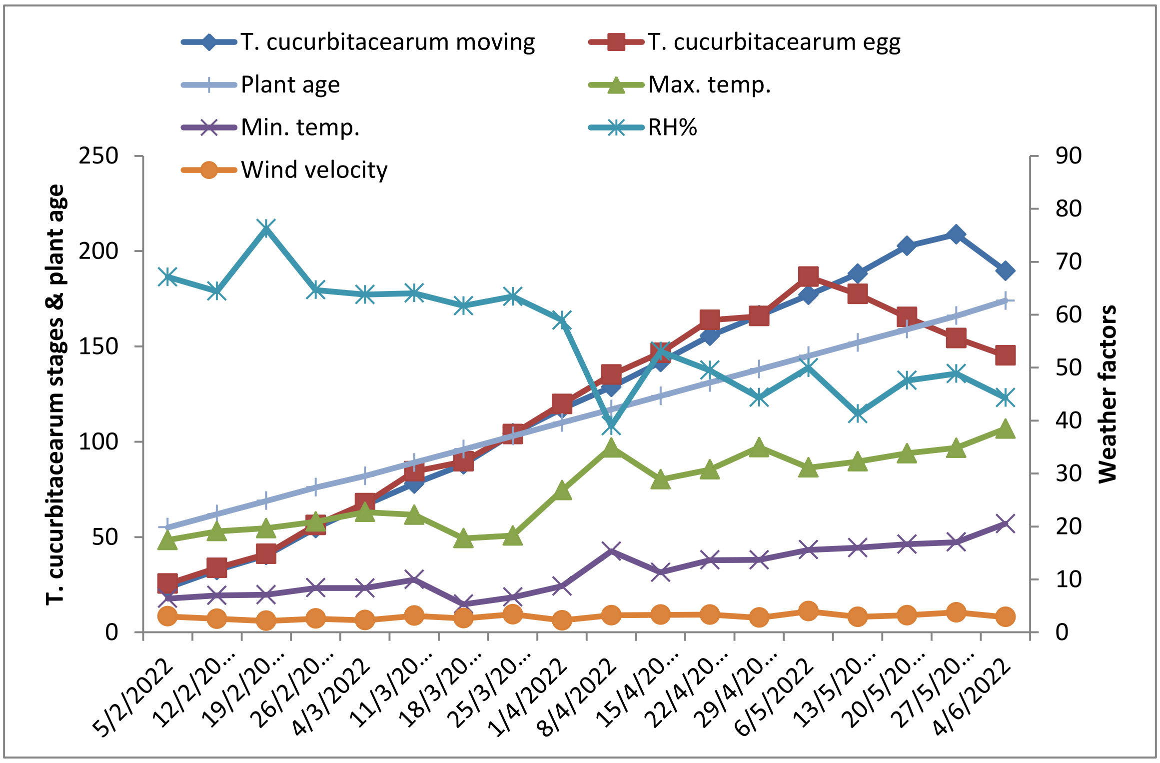

Fig. (1). Population fluctuation of *T. cucurbitacearum* in relation to abiotic factors and plant age during watermelon season 2022

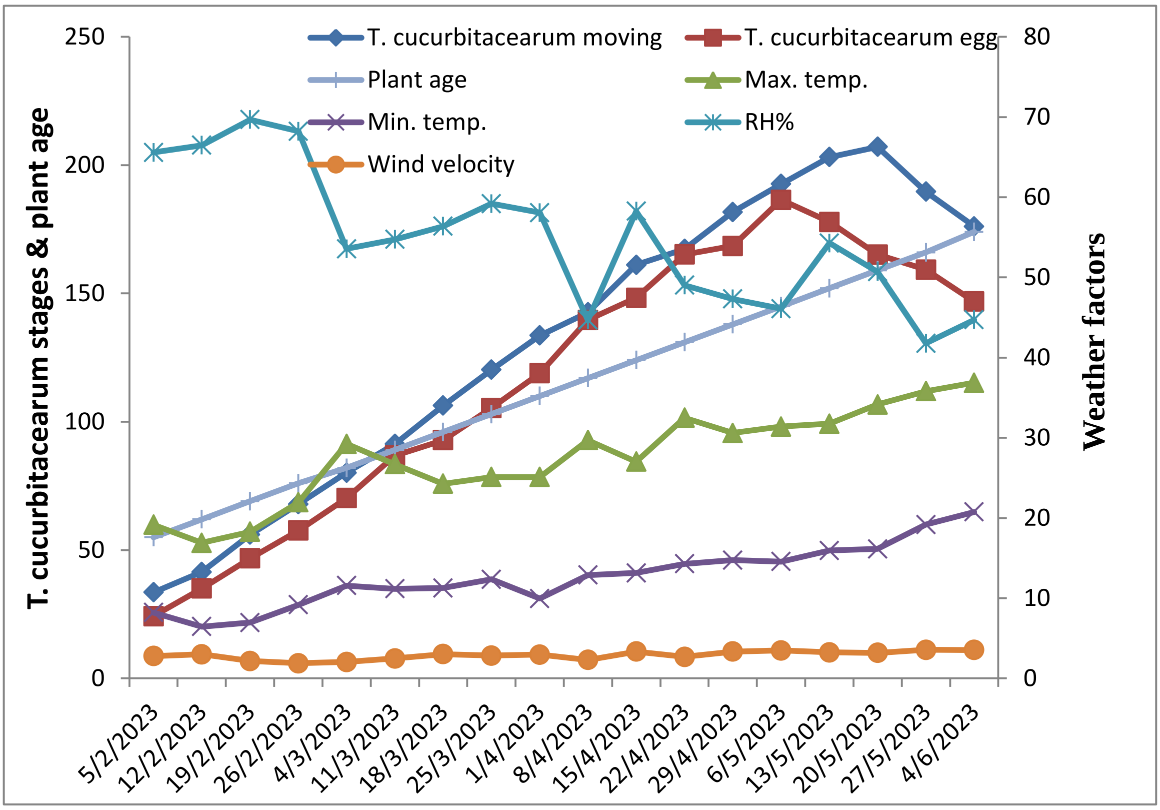

Fig. (2). Population fluctuation of *T. cucurbitacearum* in relation to abiotic factors and plant age during watermelon season 2023

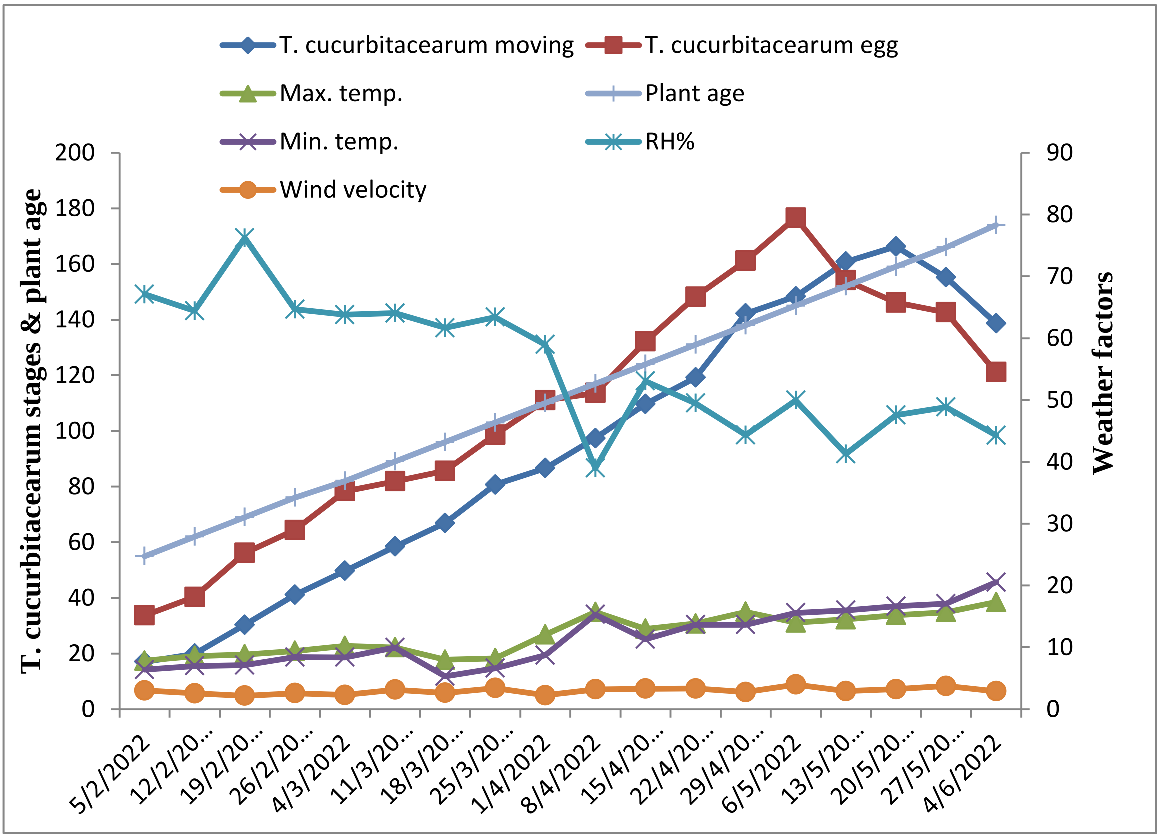

Fig. (3). Population fluctuation of *T. cucurbitacearum* in relation to abiotic factors and plant age during muskmelon season 2022

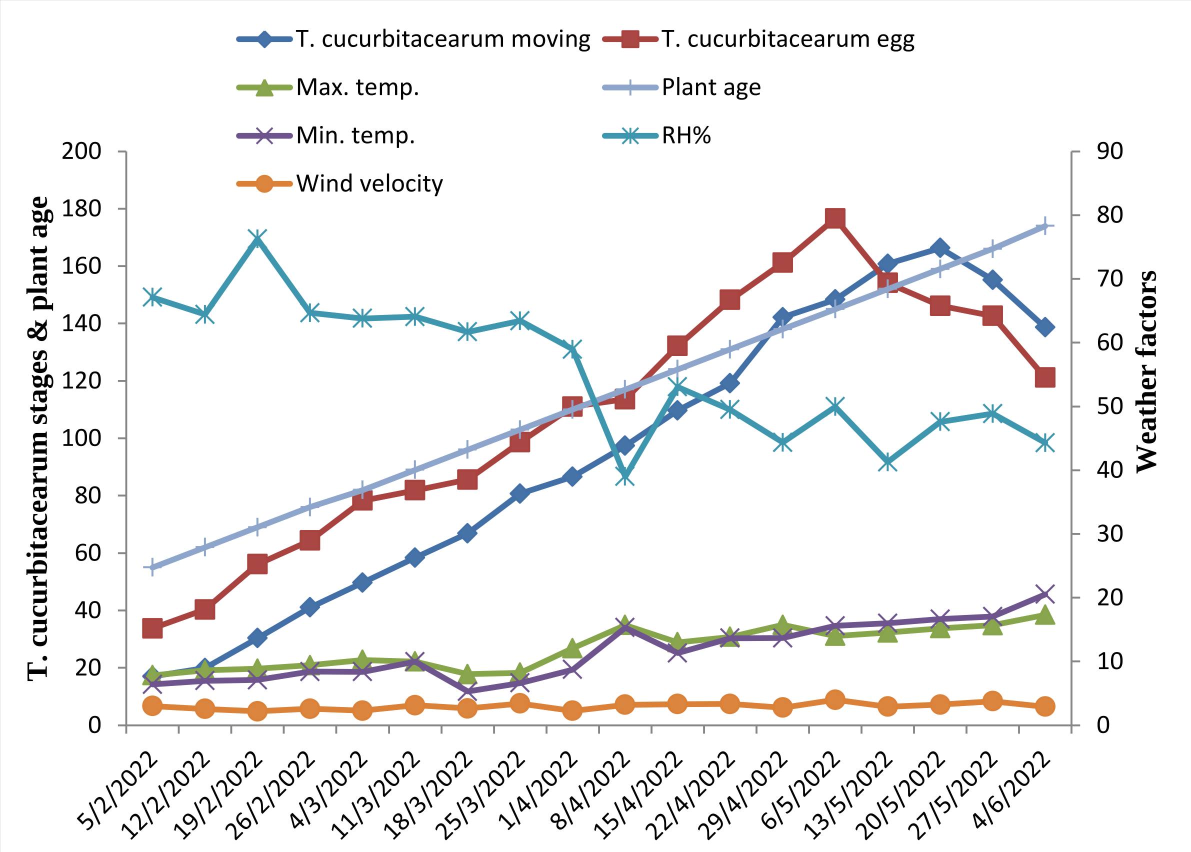

Fig. (4). Population fluctuation of *T. cucurbitacearum* in relation to abiotic factors and plant age during muskmelon season 2023

3.2. Correlation and regression relations between abiotic factors & plant age and *T. cucurbitacearum* on watermelon

In the current study, the mean relative humidity had a highly negative significant correlation (r = -0.861 and -0.8) with moving stages of *T. cucurbitacearum* during watermelon seasons 2022 & 2023, while the averages of maximum and minimum temperature had a highly significant positive correlation with moving stages of *T. cucurbitacearum* (r = 0.892 and 0.883 & 0.883 and 0.868), and wind velocity had a medium significant positive correlation (r = 0.582 and 0.674), respectively. In 2022 and 2023, the *T. cucurbitacearum* population and plant age showed a highly significant positive correlation, with coefficient values of 0.991 and 0.965, respectively (Table1). The same pattern was observed in the mean number of *T. cucurbitacearum* egg stages, and the r value recorded (0.851 and 0.859 & 0.807 and 0.823) with the maximum and minimum temperatures and wind velocity was 0.597 and 0.631; the plant age was 0.926 and 0.928, and the relative humidity was -0.814 and -0.887 in 2022 and 2023, respectively.

Linear regression analysis indicated that in 2022, the mite population moving stages increased by 7.68, 11.9, 1.65, and 71.09 percent for every unit increase in maximum temperature, minimum temperature, plant age, and wind velocity, respectively. These factors contributed to 79.62%, 77.9%, 74.06%, and 33.83% of the variation in the moving stages of *the T. cucurbitacearum* mite population, respectively. Relative humidity had a 98.14% impact on the mite population, with a 1% increase in relative humidity resulting in a 5.04 percent decrease in the mite population. Similar trends were observed in 2023 (Table 1). According to linear regression analysis, for every unit increase in maximum temperature, minimum temperature, plant age, and wind velocity in 2022, the mean numbers of egg stages rose by 6.29, 9.35, 1.32, and 62.71 percent, respectively. These variables were responsible for 72.34%, 65.1%, 85.77%, and 35.65% of the variation in the *T. cucurbitacearum* mite population's egg stages, respectively. The mite population egg stages were 75.68% impacted by relative humidity, and a 1% increase in relative humidity led to a -4.38% decrease in the mean numbers of egg stages. In 2023, comparable patterns were noted (Table 1).

3.3. Correlation and regression relations between abiotic factors & plant age and *T. cucurbitacearum* on muskmelon

Correlation and regression analysis for the 2022 & 2023 muskmelon seasons showed that the averages of maximum and minimum temperatures had a highly significant positive correlation with moving stages of *T. cucurbitacearum* (r = 0.875 and 0.891 & 0.864 and 0.879); the plant age showed a highly significant positive correlation, with coefficient values of 0.974 and 0.966, respectively, as shown in Table 2. Wind velocity had a medium, significantly positive correlation (r = 0.575 and 0.699), while mean relative humidity had a highly negative significant correlation (r = -0.860 and -0.813) in muskmelon seasons 2022 and 2023, respectively. The mean number of *T. cucurbitacearum* egg stages showed the same pattern during the two successive seasons.

According to linear regression analysis, for every unit increase in maximum temperature, minimum temperature, plant age, and wind velocity in 2022, the mite population moving stages rose by 6.2, 9.6, 1.34, and 57.93 percent, respectively. These variables were responsible for 67.57%, 74.57%, 94.92%, and 33.05% of the variation in the *T. cucurbitacearum* mite population's moving stages, respectively. The mite population was 73.99% impacted by relative humidity, and a 1% increase in relative humidity led to a -4.16% drop in the mite population. In 2023, comparable patterns were noted (Table 2).

The mean number of *T. cucurbitacearum* egg stages on muskmelon increased by 4.92, 7.21, 1.04, and 49.86 percent for each unit increase in the maximum temperature, minimum temperature, plant age, and wind velocity in 2022, respectively. These numbers were impacted by relative humidity by 66.96%; a 1% increase in relative humidity led to a –3.35 percent reduction in the mite population. In 2023, similar patterns were noted with slightly different results (Table 2).

The simultaneous impact of certain meteorological variables and plant age on mite pest census revealed that temperature, relative humidity, and plant age were the most important factors influencing *T. cucurbitacearum* population densities. On two melon cultivars, maximum and minimum temperatures, as well as plant age, showed a highly significant positive correlation with *T. cucurbitacearum* movement and egg stages. Wind velocity exhibited a moderate but considerable favorable influence on the *T. cucurbitacearum* population. However, relative humidity has a strongly negative significant correlation with *T. cucurbitacearum* population on two different melon cultivars during two consecutive seasons.

These findings are consistent with **Gotoh *et al.* (2010),** who found that the mite population was positively correlated with maximum temperature (r = 0.841**), minimum temperature (r = 0.805**), and wind velocity (r = 0.728**), while it was negatively correlated with morning R.H. (r = -0.717**) and evening R.H. (r = -0.643*). **El-Halawany and Abou-Seta (2013)** found that the dynamics of the phytophagous mite population densities appeared to follow the plant phenology (especially the leaves). According to **Kumar *et al.* (2018),** *T. ludeni*, a phytophagous mite, has a positive correlation with temperature (r=0.563* in 2010 and r=0.581* in 2011). The relative humidity exhibits a negative correlation (r = -0.467* in 2010 and 0.491* in 2011). **Abou-Zaid *et al.* (2019)** found that temperature (maximum, minimum, and mean) had a highly significant positive effect on the population of *T. urticae* infesting the four squash types over the 2015 and 2016 seasons. The amount of variable explained variation (E.V.%) could be attributed to the combined influence of the investigated climatic conditions on the *T. urticae* population on the four squash types, which was reported at more than 80% throughout the two consecutive seasons.

According to **Kamel *et al.* (2019),** substantial positive correlations were found between the population of *T. urticae* (adult, immature, and egg) and the maximum temperature (r=0.895, 0.866, and 0.895) & (r=0.776, 0.798, and 0.802) on sweet pea in the seasons 2016–2017 and 2017–2018, respectively. Comparatively, during the same seasons, the pea cultivar data were (r=0.928, 0.921, and

0.928) (r=0.715, 0.634, and 0.625), respectively. Conversely, a strong negative correlation was found with relative humidity (R.H.). According to the fractional regression analysis, two seasons have a considerable favorable impact on the population when it comes to maximum and minimum temperatures, but relative humidity has a large negative impact. **Sathua and Singh (2023)** stated that the coefficient of correlation (r) value at p=0.05 revealed a significant and strong positive association between *T. urticae* and the minimum, maximum, and average temperatures. Throughout the crop season, *T. urticae* exhibited a negative connection with relative humidity, which ranged from 63.0 to 85.5%, meaning that the mite population on the crop variety decreased as RH increased.

The present results are in partial agreement with **El-Doksh (2006),** who found a significant and positive correlation between the mite population and the maximum, minimum, and relative humidity of the Giza 111 soybean variety in season 2003. In contrast, mite populations and the maximum temperature and relative humidity on the Giza 21 soybean variety showed negative and statistically significant correlations. According to **Mandal *et al*. (2006),** red spider mite activity was found to have a non-significant negative correlation with maximum temperature and a positive correlation with minimum temperature. **Veerendra *et al.* (2015)** reported that maximum temperature and *T. urticae* showed a positive significant correlation (r = 0.804), but minimum temperature (r = 0.021) had no significant influence. *T. urticae* and both morning and evening relative humidity showed a significantly negative correlation (r = -0.970 and -0.952, respectively). **Kalmosh and Mohamed** (**2020**) found that temperature and *T. cucurbitacearum* population were significantly correlated in both seasons in two governorates, with Sharkia Governorate showing a particularly strong correlation in the second season. During the first season at Beheira and the two growing seasons at Sharkia, there was a highly significant correlation between the population of *T. cucurbitacearum* and relative humidity; however, during the second season at Beheira, there was no significant correlation. **Anber *et al*. (2020)** recorded that maximum and minimum temperatures had an insignificant positive effect on the number of *T. urticae*-infested soybean varieties during the two consecutive seasons. When compared to meteorological conditions, the effects of plant age and phenology on the *T. urticae* population were more significant. According to **Elkholy and Walash (2021),** temperature had a significantly positive correlation (r = 0.91) with *T. urticae* population dynamics on the three tomato cultivars during the summer, while relative humidity had a non-significantly negative correlation. The mite population dynamics were more affected by changes in the nutritional content of the host plant than by variations in the weather. **Patidar *et al.* 2023,** who revealed that there was no significant correlation between *T. urticae* and minimum temperature; however, there was a significant positive correlation with maximum temperature (r = 0.416* and 0.455* in 2020 and 2021, respectively). According to linear regression analysis, for every unit increase in the maximum temperature and daylight hours in 2020, the mite population grew by 0.39 and 1.33 percent, respectively. 17% of the fluctuation in the mite population was caused by the maximum temperature. **Gamit *et al.* (2024)** discovered a positive correlation between mite density on the okra crop and the maximum temperature (r = 0.045) and minimum temperature (r = 0.613). There were both significant and non-significant negative correlations between two-spotted spider mites and morning relative humidity (r = -0.660*) and evening relative humidity (r = -0.126).

However, the results are not in accordance with the reports of **Kumar *et al.* (2003),** who observed a non-significant positive association between the French marigold's mite population and relative humidity. According to **Mandal *et al.* (2006),** there was a significant positive correlation between mite activity and relative humidity in the morning and afternoon. According to **Khan *et al.* (2008),** red spider mites were significantly and negatively impacted by temperature (r = -0.510). There was no correlation between the mite population and rainfall or relative humidity. According to **Ahmed *et al.* (2012**), there was a highly significant positive correlation (r = 0.92) between the infestation of red spider mite and relative humidity. **Majeed *et al.* (2016) and Fahim & El-Saiedy (2021)** reported a negative correlation between spider mite populations and temperature. **Kumar *et al.* (2018)** found that wind velocity was non-significant with *T. ludeni* (r = 0.246 in 2010 and -0.120 in 2011). **Gamit *et al.* (2024)** discovered a non-significant positive correlation (r = 0.068) between wind speed and okra mite.

Table (1). Correlation and regression relations between *Tetranychus cucurbitacearum* and both abiotic parameters and plant age on watermelon sakata during two successive seasons 2022 and 2023

Factors		Mean±SE	Correlation Coefficient r ^{sig}	Explained Variance %	Regression Y=a+Bx	F ^{sig}
	***T. cucurbitacearum* moving stages**	**1st season**				
Max. temp.		**120.21 ± 14.56**	0.892***	79.62	Y= -86.67+7.68 X	62.51***
Min. temp.			0.883***	77.90	Y= -16.99 +11.90 X	56.38***
RH%			(-)0.861***	74.06	Y= 401.1 -5.04 X	45.69***
Wind velocity			0.582**	33.83	Y= -90.96 +71.09 X	8.18**
Plant age			0.991***	98.14	Y=- 67.12 + 1.65 X	845.84***
		2nd season				
Max. temp.		**130.66 ± 13.68**	0.883***	77.93	Y= - 107.7 + 8.64X	56.51***
Min. temp.			0.868***	75.26	Y= - 33.68+ 12.93X	48.68***
RH%			(-) 0.8 ***	63.95	Y=427.2 - 5.4 X	28.38***
Wind velocity			0.674**	45.45	Y=- 84.33 + 74.69 X	13.33**
Plant age			0.965***	93.07	Y= - 40.74 + 1.51 X	214.90***
	***T. cucurbitacearum* egg stages**	**1st season**				
Max. temp.		**114.58 ± 12.51**	0.851***	72.34	Y= - 54.87+ 6.29 X	41.85***
Min. temp.			0.807***	65.100	Y= 6.82 + 9.35 X	29.83***
RH%			(-)0.87**	75.680	Y= 358.54 - 4.38 X	49.80***
Wind velocity			0.597**	35.650	Y= - 71.69 + 62.71X	8.86**
Plant age			0.926***	85.770	Y= - 35.89 + 1.32 X	96.40***
		2nd season				
Max. temp.		**116.37 ± 12.48**	0.859***	73.85	Y= - 95.23+ 7.67X	45.19***
Min. temp.			0.823***	67.66	Y= - 25.74 + 11.19 X	33.47***
RH%			(-)0.814***	66.23	Y= 391.59 - 5.01 X	31.38***
Wind velocity			0.631**	39.88	Y= - 67.3 + 63.81 X	10.61**
Plant age			0.928***	86.11	Y= - 33.99 + 1.32 X	99.21***

* means low significant ** means moderate significant *** means highly significant

Table (2). Correlation and regression relations between *Tetranychus cucurbitacearum* and both abiotic parameters and plant age on muskmelon Mac G_5 during two successive seasons 2022 and 2023

Factors		Mean±SE	Correlation r Coefficient sig	Explained Variance %	Regression Y=a+Bx	sig F
	T. cucurbitacearum moving stages	**1st season**				
Max. temp.		93.79 ± 12.01	0.875***	67.57	Y= -73.47+ 6.2 X	52.29***
Min. temp.			0.864***	74.57	Y= - 16.87 + 9.6 X	46.92***
RH%			(-)0.86***	73.99	Y= 325.21- 4.16 X	45.51***
Wind velocity			0.575**	33.05	Y= - 78.28 + 57.93 X	7.9*
Plant age			0.974***	94.92	Y= - 58.09 + 1.34 X	299.13***
		2nd season				
Max. temp.		95.35 ± 12.09	0.891***	79.43	Y= - 117.25 + 7.71 X	61.80***
Min. temp.			0.879***	77.28	Y= - 51.77 + 11.58 X	54.41***
RH%			(-)0.813***	66.07	Y= 361.6 - 4.847 X	31.16***
Wind velocity			0.699**	44.72	Y= - 93.07 + 65.46 X	12.95**
Plant age			0.966***	93.34	Y= - 56.30 + 1.33 X	224.19***
	T. cucurbitacearum egg stages	**1st season**				
Max. temp.		108.1 ± 10.17	0.819***	67.03	Y= - 24.39 + 4.92 X	32.53***
Min. temp.			0.766***	85.700	Y= 24.97 + 7.21 X	22.74***
RH%			(-)0.818***	66.960	Y= 294.5 - 3.35 X	32.43***
Wind velocity			0.584**	34.160	Y= - 39.99 + 49.86 X	8.31*
Plant age			0.896***	80.300	Y= - 10.17 + 1.04 X	65.22***
		2nd season				
Max. temp.		111.92 ± 10.28	0.827***	68.40	Y= - 55.77 + 6.08 X	34.64***
Min. temp.			0.776***	60.26	Y= 1.49 + 8.69 X	24.27***
RH%			(-)0.787***	61.86	Y= 330.9 - 3.99 X	25.95***
Wind velocity			0.592**	35.07	Y= - 29.9 + 49.27 X	8.64*
Plant age			0.887***	78.65	Y= - 6.39 + 1.04 X	58.93***

* means low significant ** means moderate significant *** means highly significant

4. Conclusion

On two melon cultivars, maximum and minimum temperatures, along with plant age, exhibited a highly significant positive association with the moving and egg stages of *T. cucurbitacearum.* Additionally, wind velocity demonstrated a moderately significant positive effect on the population of *T. cucurbitacearum*. However, relative humidity exhibits a strong negative and significant relationship with the population of *T. cucurbitacearum* across two different melon cultivars during two consecutive seasons.

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