



Effect of plant phenology and some climatic factors on certain important pests affecting cucumber crops on different ecosystems

Mona. I. Ammar, E. A. M. Mousa and Maha S. El Ghanam

Plant Protection Research Institute (PPRI), Agriculture Research Center (ARC), Dokki 12618, Giza, Egypt.

Received: 15 July 2023

Accepted: 20 August 2023

Published: 30 August 2023

ABSTRACT

Experimental trials were conducted during 2021 and 2022 summer growing season at Sidi salem district, Kafr El-Sheikh Governorate and Brunch Village, El Ayat Center, Giza Governorate Egypt. Monitor included two different ecosystems on cucumber plant. Results revealed that, general weekly mean number of the pests (*Bemisia tabaci* immature and *Tetranychus urticae* movable stage) was higher abundant at Giza Governorate than these recorded at Kafr El-Sheikh Governorate throughout two successive seasons 2021 and 2022. The statistical analysis of the total mean number of pests showed significant difference at <0.0001 for two different locations whereas T value equal (19.55). On the other hand, the population densities of the pests were higher abundant on May (871 and 842 individual / pests) at different ecosystem (Giza and Kafr El-Sheikh), respectively in first season. But in the second season found in April, was higher mean number of pests (872 and 612 individual / pests) at different ecosystem (Giza and Kafr El-Sheikh), respectively. Than these recorded on March lower mean number of pests (402 and 292 individual / pests) at different ecosystem (Giza and Kafr El-Sheikh) in first season and the second season recorded mean number of pests (451 and 322 individual / pests) at different ecosystem (Giza and Kafr El-Sheikh. results showed that significant positive effects to maximum and minimum temperature on the seasonal fluctuations of *Bemisia tabaci* immature and *Tetranychus urticae* movable stage on both seasons (2021 and 2022) Data cleared that, the mean percentage of relative humidity had significant negative effect during two successive seasons. Considering plant phenology as plant age (X) (presented by three degree polynomial equation $Y = a + b_1X + b_2X^2 + b_3X^3$) revealed that the most relation to the variance in population the results showed that significant positive effect in both seasons. The combined effect of maximum , minimum temperature and the mean percentage of relative humidity and age of plant factors as a group (E.V) showed responsible of 93%, 97 %, 86%, 83% 83%,87%,92% and 83% effects on the population dynamics of *Bemisia tabaci* immature and *Tetranychus urticae* movable stage throughout in seasons 2021 and 2022 at different ecosystem. These additional values did not appear to be noteworthy. These findings do not completely exclude the impact of meteorological variables on population dynamics. These variables may exhibit significant effects in a laboratory setting. These elements, when present in the field, initially have an impact on plant development, which makes the plant more appealing to pests. Thus, statistically, the influence of meteorological elements was replaced by plant phenology as plants became older.

Keywords: plant phenology, plant age, maximum temperature, minimum temperature, relative humidity different ecosystem , *Bemisia tabaci* immature and *Tetranychus urticae* movable stage

Introduction

One of the most significant vegetable crops cultivated in Egypt is the cucumber (*Cucumis sativus* L.). The pests that attack cucumber plants, such insects and mites, can reduce output by preventing plant development, delaying blooming, draining juice, damaging leaf surface, and spreading viral illnesses. Many piercing-sucking insect pests, including aphids, whiteflies, and jassides, attack vegetables (El-Khawas, 2005). However, various pests infest Egypt's cucumber plants, making them difficult to grow.

Corresponding Author: Mona. I. Ammar, Plant Protection Research Institute (PPRI), Agriculture Research Center (ARC), Dokki 12618, Giza, Egypt. E-mail: - mona.ammar@arc.sci.eg

Whitefly, *Bemisia tabaci* (Genn) (Hemiptera: Aleyrodidae), a sap-sucking insect pest, is best characterized as a cryptic species complex made up of multiple morphologically similar species. (De Barro *et al.*, 2011) and in several regions of the world, the two-spotted spider mite *Tetranychus urticae* Koch was the most detrimental to cucumber (*Cucumis sativus* L.) crops economically (Saad 2002). These pests are commonly considered as serious pests of various crops both in the open field and greenhouses (Oliverira. 2001, Roll, 2004 and Alston, 2007). These pests make two types of damage, direct damage and indirect damage (Berlinger, 1986). Direct damage that considered by sucking plant sap from the plant foliage. While indirect damage due to the accumulation of honeydew that is considered as a good media for sooty mold growth. Also these insects are considered serious pests due to vectoring of plant viruses, so a small population of these pests is sufficient to cause considerable damage to the importance crops (Francki 1979, Cohen & Berlinger, 1986, Berlinger, 1986, Conte 1998, Jones, 2003, Stansly *et al.* 2004, Baiomy 2008). Temperature, precipitation, and sunshine all have a significant impact on the bio sector of agriculture. The effects of climate change might harm these components. Contrary to natural climate drivers, anthropogenic factors significantly raise the global mean temperature (GMT). (Myhre *et al.*, 2017). It affects precipitation patterns, which might cause floods or a drought. Soil qualities would be impacted by a rise in temperature and a fall in precipitation. (Gelybó *et al.*, 2018). The ability of the soil to store water, soil moisture content, and soil particle size are all impacted by changes in soil temperature. An rise in soil surface temperature slows down water circulation in the soil profile and speeds up evaporation (Onwuka and Mang, 2018). According to one study, decreased organic matter and clay size as a result of elevated soil temperature lower the soil's potential for cation exchange. (CEC) (Certini, 2005). Broad-scale climate changes are closely associated to decreased production of livestock, horticulture, and cultivated crops (Malla, 2008). The aim of this study is to avoid that impact of plant phenology and some weather factors on certain important pests affecting cucumber crops on different ecosystem.

Materials and Methods

Field studies were conducted during 2021 and 2022 summer growing season at Sidi salem district, Kafr El-Sheikh Governorate and Brunch Village, El Ayat Center, Giza Governorate, Egypt.

Monitor included two different ecosystems cucumber plant was sowing in early February and seedlings were transplanted at the end of February 2021 and 2022 for two seasons. The plant was replicated three times in a complete randomized blocks design. The cultivated area of each plot size was about 42 m². All agricultural practices were applied except for pest control. Sampling started on March, 10th and continued until May, 26th. Random samples of ten leaves per plot were picked up weekly. A direct count of pests samples was conducted. Meteorological data of maximum and minimum temperatures, relative humidity, and wind speed for ten meters were obtained and used in data analysis. Considering plant phenology as plant age (X) was presented by a three-degree polynomial equation:

$$(Y = a + b_1 X + b_2 X^2 + b_3 X^3).$$

The statistical analyses of the present data were carried out using SAS program computer including f-test and L.S.D. value (SAS Institute, 1999).

3. Result and Discussion

3.1. Population density of certain pests infesting cucumber (*Cucumis sativus* L.) under different ecosystem.

The results showed that, general weekly mean number of the pests (*Bemisia tabaci* immature s and *Tetranychus urticae* movable stage) was higher abundant at Giza Governorate (4008 individual / 420 leaves) than these recorded (3379 individual/ 420 leaves) at Kafr El-Sheikh Governorate throughout two successive seasons 2021 and 2022. The statistical analysis of the total mean number of pests showed significant difference at <0.0001 for two different locations whereas T value equal (19.55) Fig (1).

On the other hand, the population densities of the pests were higher abundant on May (871 and 842 individual / pests) at different ecosystem (Giza and Kafr El-Sheikh), respectively in first season. But in the second season found in April, was higher mean number of pests (872 and 612 individual / pests) at different ecosystem (Giza and Kafr El-Sheikh), respectively than these recorded on March

lower mean number of pests (402 and 292 individual / pests) at different ecosystem (Giza and Kafr El-Sheikh) in first season and the second season recorded mean number of pests (451 and 322 individual / pests) at different ecosystem (Giza and Kafr El-Sheikh), respectively Fig (2).

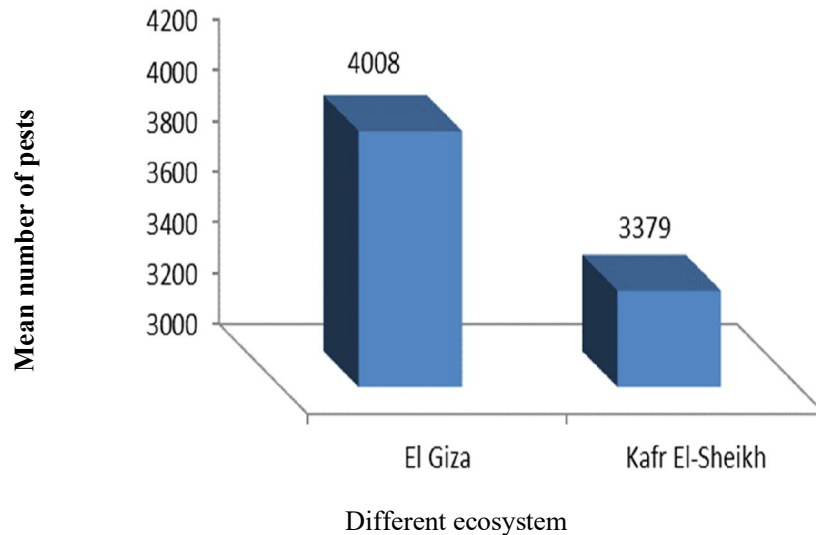


Fig. 1: Seasonal mean number of pests on cucumber plants at different ecosystem (Giza and Kafr El-Sheikh) during two successive seasons 2021 & 2022.

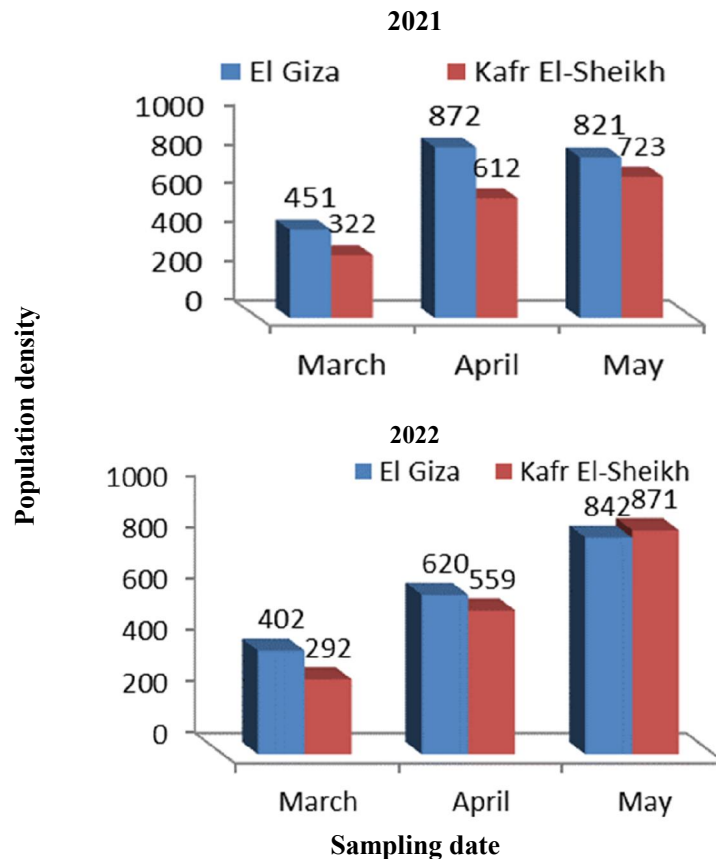


Fig. 2: Seasonal mean number of pests in the 2021 and 2022 seasons.

3.2. Population density of certain pests infesting cucumber (*Cucumis sativus* L.) at Giza Governorate.

3.2.1. *Bemisia tabaci* (Genn.)

Results indicated that in the first season *B. tabaci* appeared on cucumber plants on March, 10th (66 individuals/sample) then increased gradually until reaching its maximum (187 individuals/sample) on April, 21st. These numbers decreased to be 165 and 177 individuals/sample on April, 28th and May, 5th respectively. After that date it reaching its maximum (244 individuals/sample) on May, 19th. (Fig. 3).

In the second season, recorded that, *B. tabaci* appeared on cucumber plants on March, 10th (39 individuals/sample) then increased gradually until reaching its maximum (102 individuals/sample) on April, 14th. These numbers decreased to be 76 and 81 individuals/sample on April, 21st and 28th, respectively. After that date it reaching its maximum (154 individuals/sample) on May, 5th and it decreased to be 98 and 123 individuals/sample on May, 11st and 26th, respectively (Fig. 3).

3.2.2. *Tetranychus urticae* Koch

In the first season 2021, the population had four peaks with mean number 88, 198, 170 and 159 individuals/sample on March, 24th, April, 21st, May, 5th and 26th, respectively (Fig. 4).

As the same in the second season, the population had four peaks with mean number 71, 102, 154 and 131 individuals/sample on March, 24th, April, 14th, May, 5th and 19th, respectively (Fig. 4).

3.3. Population density of certain pests infesting cucumber (*Cucumis sativus* L.) at Kafr El-Sheikh Governorate.

3.3.1. *Bemisia tabaci* (Genn.)

The data indicated that in the first season *B. tabaci* immature appeared on cucumber plants on March, 10th (25 individuals/sample) then increased gradually until reaching its maximum (102 individuals/sample) on May, 5th. These numbers decreased to be 69 and 77 individuals /sample on May, 11st and 26th, respectively. (Fig. 5).

In the second season, recorded that, *B. tabaci* immature appeared on cucumber plants on March, 10th (21 individuals/sample) then increased gradually until reaching its maximum (89 individuals/sample) on April, 7th. These numbers decreased to be 50 and 79 individuals/sample on April, 21st and 28th, respectively. After that date it reaching its maximum (98 individuals/sample) on May, 5th and it decreased to be 74 and 87 individuals/sample on May, 19th and 26th, respectively. (Fig. 5).

3.3.2. *Tetranychus urticae* Koch

Results indicated that in the first season *T. urticae* appeared on cucumber plants on March, 10th (39 individuals/sample) then increased gradually until reaching its maximum (98 individuals/sample) on April, 14th. These numbers decreased to be 69 and 83 individuals/sample on April 28th and May 5th, respectively. After that date it reaching its maximum (102 individuals/sample) on May, 11st and it decreased to be 96 individuals/sample on May, 19th, respectively (Fig. 6).

In the second season, recorded that, *T. urticae* appeared on cucumber plants on March, 10th (33 individuals/sample) then increased gradually until reaching its maximum (104 individuals/sample) on April, 14th. These numbers decreased to be 75 individuals/ sample on April, 28th, respectively. After that date it reaching its maximum (103 individuals/sample) on May, 19th and it decreased to be 89 individuals/sample on May, 26th, respectively (Fig. 6).

These results are in agreements with those obtained Habashi *et al.* (2007), Ghallab *et al.*, (2011), Data revealed that Nemsse cultivar harbored the highest infestation of spider mites and *Bemisia tabaci* in summer plantation. Abozeid *et al.*, (2022) recorded that , the population dynamics of *B. tabaci* immature were lower in the first season was 140.67 individuals/360 leaves but in the second season recorded 253.17 individuals/360 leaves, the activity period of *B. tabaci* immature during first season was expressed by four peaks, The lower peak was 61 immature /30 leaves on 13th of April, the second peak in 27th of April was 134 immature /30 leaves and the higher peaks were 277 and 222 immature /30 leaves, in 1st , 15th of June, respectively. In the second season was expressed by four peaks, the higher peaks were 412 and 416 immature /30 leaves, in 18th of May and 1st of June, then it comes the third peaks in 22th of June and the fourth peak was lower peak was 121 immature /30 leaves on 20th

of April, respectively. Data indicated that the population dynamics of *T. urticae* movable stage were lower in the first season was to 15.92 individuals/360 leaves but in the second season the individuals increased to 17.58 individuals/360 leaves, the activity period of *T. urticae* movable stage during first season was note the rounding of the census during the examination and recorded three peaks were 34, 35 and 39 movable stage /30 leaves on 4th of April, 27th of 1st, 15th of June, respectively. In the second season was expressed by two peaks, the higher peaks was 49 movable stage /30 leaves, in 8th of June, then the lower peak was 14 movable stage /30 leaves on 4th of May, respectively.

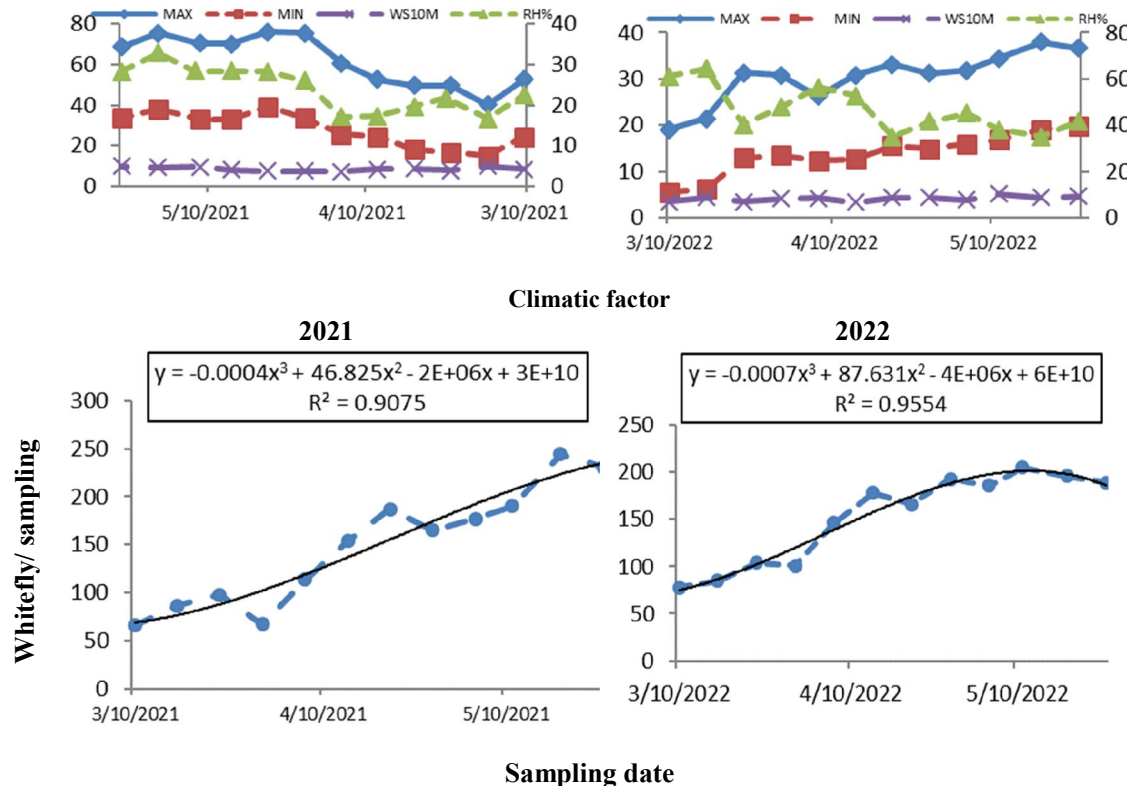


Fig. 3: Seasonal fluctuation of *Bemisia tabaci* (immature s) on cucumber at Giza governorate during 2021 and 2022 seasons.

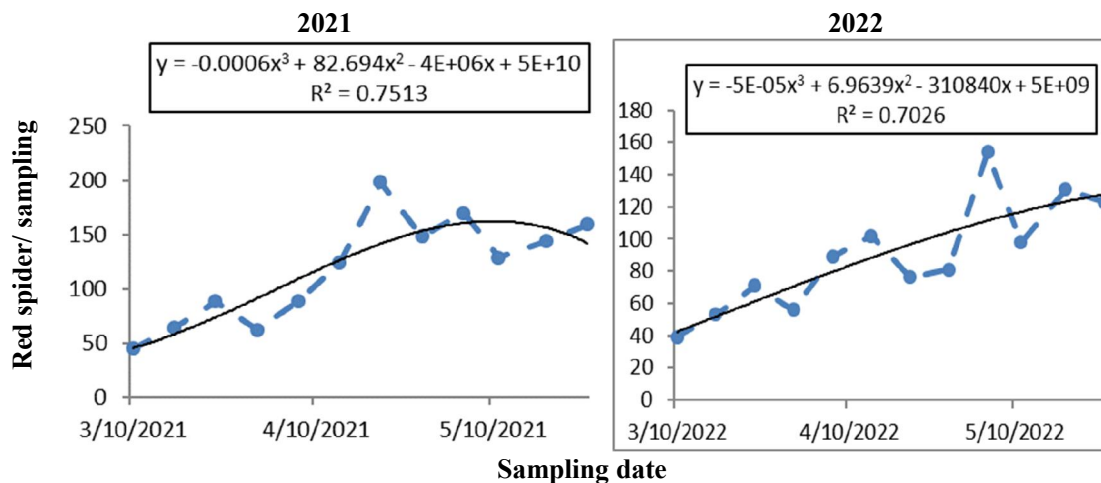


Fig. 4: Seasonal fluctuation of *Tetranychus urticae* (movable stage) on cucumber at Giza governorate during 2021 and 2022 seasons.

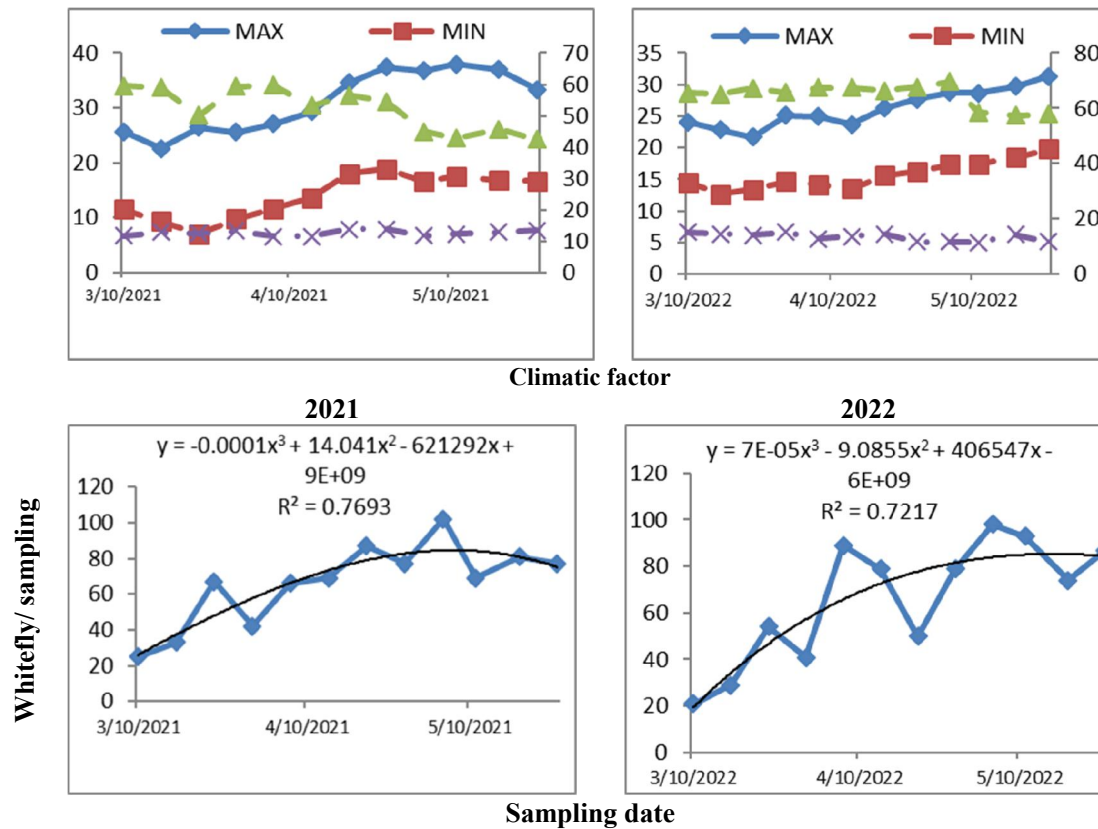


Fig. 5: Seasonal fluctuation of *Bemisia tabaci* (immature s) on cucumber at at Kafr El-Sheikh governorate during 2021 and 2022 seasons.

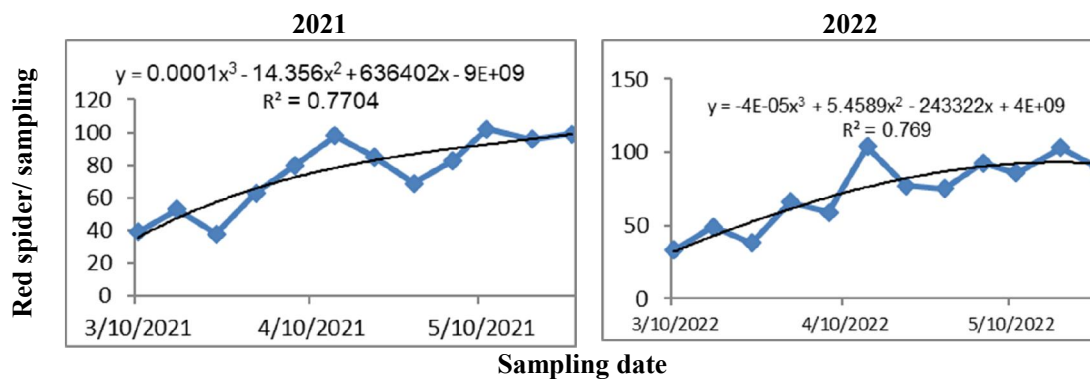


Fig. 6: Seasonal fluctuation of *Tetranychus urticae* (movable stage) on cucumber at Kafr El-Sheikh governorate during 2022 season.

3.4. Impact of phenology (age of plant) and some weather factors on population dynamics of pests infesting cucumber plants in different ecosystem.

Statistical analysis of the obtained data using multiple or partial regression for factors affecting population dynamics of the investigated pests (*Bemisia tabaci* immature and *Tetranychus urticae* movable stage) in relation to certain weekly mean of the weather factors (Maximum temperature, Minimum temperature, and Mean relative humidity (R.H %) and plant phenology (as plant age (X) in different ecosystem (Giza and Kafr El-Sheikh), are presented in Table (1).

3.4.1. Giza governorate

Bemisia tabaci

The results showed that significant positive effects to maximum and minimum temperature on the seasonal fluctuations of *B. tabaci* immature on both seasons (2021 and 2022), whereas “r” values were 0.864, 0.843, 0.785 and 0.836, respectively in both seasons. Data cleared that, the mean percentage of relative humidity had significant negative effect, whereas “r” values were -0.824 and -0.668, respectively during two successive seasons. Considering plant phenology as plant age (X) (presented by three degree polynomial equation $Y = a + b_1 X + b_2 X^2 + b_3 X^3$) revealed that the most relation to the variance in population the results showed that significant positive effect in both seasons, whereas “r” values were 0.949 and 0.925, respectively. The combined effect of maximum, minimum temperature and the mean percentage of relative humidity and age of plant factors as a group (E.V) showed responsible of 93% and 97 % effects on the population dynamics of *B. tabaci* immature throughout in seasons 2021 and 2022, respectively (“F” values were 10.80** and 25.61**) Table, (1).

Tetranychus urticae

The data showed that significant positive effects to maximum and minimum temperature on the seasonal fluctuations of *T. urticae* movable stage on both seasons (2021 and 2022), whereas “r” values were 0.883, 0.798, 0.699 and 0.763, respectively in both seasons. Data cleared that, the mean percentage of relative humidity had significant negative effect, whereas “r” values were -0.873 and -0.488, respectively during two successive seasons. Considering plant phenology as plant age (X) (presented by three degree polynomial equation $Y = a + b_1 X + b_2 X^2 + b_3 X^3$) revealed that the most relation to the variance in population the results showed that significant positive effect in both seasons, whereas “r” values were 0.796 and 0.832, respectively. The combined effect of maximum, minimum temperature and the mean percentage of relative humidity and age of plant factors as a group (E.V) showed responsible of 86% and 83 % effects on the population dynamics of *T. urticae* movable stage throughout in seasons 2021 and 2022, respectively (“F” values were 13.50** and 12.42**) Table, (1)

3.4.2. Kafr El-Sheikh Governorate

Bemisia tabaci

The results showed that significant positive effects to maximum and minimum temperature on the seasonal fluctuations of *B. tabaci* immature on both seasons (2021 and 2022), whereas “r” values were 0.798, 0.672, 0.682 and 0.723, respectively in both seasons. Data cleared that, the mean percentage of relative humidity had significant negative effect, whereas “r” values were -0.635 and -0.591, respectively during two successive seasons. Considering plant phenology as plant age (X) (presented by three degree polynomial equation $Y = a + b_1 X + b_2 X^2 + b_3 X^3$) revealed that the most relation to the variance in population the results showed that significant positive effect in both seasons, whereas “r” values were 0.767 and 0.851, respectively. The combined effect of maximum, minimum temperature and the mean percentage of relative humidity and age of plant factors as a group (E.V) showed responsible of 83% and 87 % effects on the population dynamics of *B. tabaci* immature throughout in seasons 2021 and 2022, respectively (“F” values were 9.33** and 9.96**) Table, (1).

Tetranychus urticae

The data showed that significant positive effects to maximum and minimum temperature on the seasonal fluctuations of *T. urticae* movable stage on both seasons (2021 and 2022), whereas “r” values were 0.682, 0.723, 0.685 and 0.617, respectively in both seasons. Data cleared that, the mean percentage of relative humidity had significant negative effect, whereas “r” values was -0.591 in the first season but in the second season found insignificant negative effect whereas “r” values was -0.349, respectively during two successive seasons. Considering plant phenology as plant age (X) (presented by three degree polynomial equation $Y = a + b_1 X + b_2 X^2 + b_3 X^3$) revealed that the most relation to the variance in population the results showed that significant positive effect in both seasons, whereas “r” values were 0.851 and 0.836, respectively. The combined effect of maximum, minimum temperature and the mean percentage of relative humidity and age of plant factors as a group (E.V) showed responsible of 92% and 83 % effects on the population dynamics of *T. urticae* movable stage throughout in seasons 2021 and 2022, respectively (“F” values were 9.50** and 8.86**) Table, (2).

Table 1: Correlation and partial regression values of the three weather factors and plant phenology as plant age on pests and corresponding percentages of explained variance on cucumber plants at Giza Governorate during 2020&2021 and 2021&2022 seasons.

Pests stage	Variables	2021						2022					
		Correlation		Regression coefficient		E.V %	F value	Correlation		Regression coefficient		E.V %	F value
		R	P	b	P			r	P	b	P		
<i>B. tabaci</i> (Immature)	Max. temp.	0.864	0.0003	4.84	0.64			0.785	0.002	1.43	0.72		
	Min. temp.	0.843	0.0006	2.97-	0.73	76%	8.65**	0.836	0.0007	-7.90	0.32	73%	18.9**
	RH %	-0.824	0.001	0.38-	0.92			-0.668	0.01	-0.36	0.82		
	Age of plant	0.949	<.0001	-	-	17%	2.15*	0.925	<.0001	--	--	24%	6.71*
	Combined effect					93%	10.80**	Combined effect					97%
<i>T. urticae</i> (Movable stage)	Max. temp.	0.883	0.0001	9.33	0.42			0.699	0.01	5.87	0.40		
	Min. temp.	0.798	0.001	-8.72	0.38	70%	8.28**	0.763	0.003	14.02	0.29	69%	6.23*
	RH%	-0.873	0.0002	-0.91	0.83			-0.488	0.10	5.14	0.11		
	Age of plant	0.796	0.001	--	--	16%	5.22*	0.832	0.0008	--	--	14%	6.19*
	Combined effect					86%	13.50**	Combined effect					83%

Max. temp. = Maximum temperature E.V%= Explained Variance Min. temp.= Minimum temperature R.H%= Relative Humidity

Table 2: Correlation and partial regression values of the three weather factors and plant phenology as plant age on pests and corresponding percentages of explained variance on cucumber plants at Kafr El-Sheikh Governorate during 2020&2021 and 2021&2022 seasons.

Pests stage	Variables	2020						2021					
		Correlation		Regression coefficient		E.V	F	Correlation		Regression coefficient		E.V%	F
		R	P	B	P	%	value	r	P	b	P		value
<i>B. tabaci</i> (Immature)	Max. temp.	0.798	0.001	2.18	0.60			0.624	0.03	-1.177	0.91		
	Min. temp.	0.672	0.01	1.14	0.82	66	5.25*	0.578	0.04	-6.326	0.70	72	6.92*
	RH%	-0.635	0.02	-1.56	0.46			-0.168	0.59	2.79	0.32		
	Age of plant	0.767	0.003	----	--	17%	4.08*	0.784	0.002	--	--	15	3.04*
	Combined effect					83%	9.33**	Combined effect				87%	9.96**
<i>T. urticae</i> (Movable stage)	Max. temp.	0.682	0.01	-8.193	0.03			0.685	0.01	4.198	0.62		
	Min. temp.	0.723	0.007	2.86	0.44	63%	5.03*	0.617	0.03	-14.48	0.30	66%	4.87
	RH%	-0.591	0.04	-0.633	0.66			-0.349	0.264	0.29	0.89		
	Age of plant	0.851	0.0004	--	---	29%	4.57*	0.836	0.0007	--	--	17%	3.99*
	Combined effect					92%	9.60**	Combined effect				83%	8.86**

These results do not eliminate the effect of weather factors on the population dynamics. Under lab conditions these factors may reveal a great deal of effect. Under field conditions these factors first affect the plant growth which makes the plant more palatable for infestation. So plant phenology as plant age took over the effect of weather factors mathematically. Climatic factors exert a great influence on the growth, development, distribution, and population dynamics of insect pest (Chang, *et al.* 2008). Effect of maximum and minimum temperatures and relative humidity on population density of the dominant white fly infesting certain vegetable plants (tomato, potato, cabbage, cauliflower, squash and cucumber) were studied under Dakahlia Governorate (Elgindy, 1997). Badran *et al.*, (2018) Maximum and minimum temperature were showed that significant negative effect on the population in first season conversely, in the second season cleared significant positive on *B. tabaci*, population. The relative humidity had significant positive effect on first season however in the second season found insignificant. The combined effect (E.V) of these ecological factors on *B. tabaci* showed that these factors were responsible as a group for 94 % during 2016-2017 and 98 during 2017-2018 effects on the population density of insects throughout both seasons, respectively.

Conclusions

There is a clear difference between the different ecosystems. It was also evident that pests were present at the end of the season in abundance compared to the beginning of the season. results showed that significant positive effects to maximum and minimum temperature on the seasonal fluctuations of *Bemisia tabaci* immature and *Tetranychus urticae* movable stage on both seasons (2021 and 2022) Data cleared that, the mean percentage of relative humidity had significant negative effect during two successive seasons. Considering plant phenology as plant age (X) (presented by three degree polynomial equation $Y = a + b_1 X + b_2 X^2 + b_3 X^3$) revealed that the most relation to the variance in population the results showed that significant positive effect in both seasons. The combined effect of maximum, minimum temperature and the mean percentage of relative humidity and age of plant factors as a group (E.V) showed responsible of 93%, 97 %, 86%, 83%, 83% ,87%, 92% and 83% effects on the population dynamics of *Bemisia tabaci* immature and *Tetranychus urticae* movable stage throughout in seasons 2021 and 2022 at different ecosystem.

References

- Alston, D., 2007. Insect Pests in Greenhouse and Nursery Crops. Utah State University Extension Utah Green Conference January 22: 55 PP.
- Badran, A. B., Ammar, Mona I. and E. A. M. Mousa, 2018. Efficiency of Colored Sticky Traps on the Population of Certain Sap-Sucking Insects on Cucumber Plants in Greenhouses. J. Plant Prot. and Path., Mansoura Univ., 9(7): 411– 415
- Baiomy, Fatina, A.M., 2008. Efficiency of modern methods for controlling some vegetable pests in greenhouses in Egypt and Morocco. PhD. Thesis, Ins. African Res. Studies, Cairo Univ. 154pp.
- Berlinger, M.J., 1986. Host plant Resistance to *Bemisia tabaci*. Agric. Ecosystems Enveiro.17: 69-82.
- Certini, G., 2005. Effects of fire in properties of forest soils: a review. Oecologia 143, 1–10.
doi: 10.1007/s00442-004-1788-8
- Chang, X. N., H.J. Gao, F.J. Chen, and B.P. Zhai, 2008. Effects of environmental moisture and precipitation on insects: A review. Chinese J. Ecol., 27: 619-625.
- Cohen, S. and M.J. Berlinger, 1986. Transmission and cultural control of whitefly-borne viruses. Agric. Ecosystems Enveiro.,17: 89-97.
- Conte, L., 1998. The technique of "banker plants" for biological control of *Aphis gossypii* on cucumber. Informatora Agrario., 54(36): 71-75.
- De Barro, P.J., S.S. Liu, L.M. Boykin, and A.B. Dinsdale, 2011. *Bemisia tabaci*: A statement of species status. Annu. Rev. Entomol., 56, 1–19.
- Devasahayam, S., K.M.A. Koya, and P.P. Reddy, 1998. IPM in spices - challenges for the future. Environmental implications and thrusts, Banalore, India, 157-164.
- Elgindy, M.A.E., 1997. Studies on certain pests infesting some vegetable crops in Dakahlia Governorate, Egypt. M.Sc. Thesis. Fac. of Agric. Zagazig Univ.
- El-Khawas, M. A. M., 2005. Survey of predators associated with major insect pestson okra plants in Qalubia Governorate. J. Agric. Mansoura Unvi., 30:1105- 1116.
- Francki, R.I.B., D.W. Mossop, and T. Hatta, 1979. Cucumber Mosaic Virus. CMI/AAB Descriptions

- of Plant Viruses No. 213.
- Gelybó, G., E. Tóth, C. Farkas, Á. Horel, I. Kása, and Z. Bakacsi, 2018. Potential impacts of climate change on soil properties. *AgroKémiai Talajtan* 67, 121–141. doi: 10.1556/0088.2018. 67.1.9
- Gharaibeh, M. A., N. I. Eltaif and A.A. Albalasmeh, 2011. Reclamation of highly calcareous saline sodic soil using Atriplex halimus and by-product gypsum. *Int. J. Phytoremed.* 13, 873–883. doi: 10.1080/15226514.2011.573821.
- Habashi, Nadia H., Ghallab, Mona M., Rizk, Marguerite A. and E.S. Mansour, 2000). New approaches for controlling sucking pests on cucumber plants, and their impact on the crop yield. *Egyptian J. Biol. Pest Cont.*, 17(2) :131-137.
- Jones, D.R., 2003. Plant viruses transmitted by whiteflies. *Eur. J. Plant Pathol.* 2003, 109, 195–219.
- Malla, G., 2008. Climate change and its impact on nepalese agriculture. *J. Agricul. Environ.*, 9, 62–65. doi: 10.3126/aej.v9i0.2119
- Myhre, G., W. Aas, R. Cherian, W. Collins, G. Faluvegi, and M. Flanner, 2017. Multi-model simulations of aerosol and ozone radiative forcing due to anthropogenic emission changes during the period 1990–2015. *Atmosp. Chem. Phys.* 17, 2709–2720. doi: 10.5194/acp-17-2709-2017
- Oliveira, M. R.V., T. J. Henneberry and P. Anderson, 2001. History, current status, and collaborative research projects for *Bemisia tabaci*. *Crop Protection.*, 20: 709-723.
- Onwuka, B.M. and B. Mang, 2018. Effects of soil temperature on some soil properties and plant growth. *Adv. Plants Agric. Res.* 8, 34–37. doi: 10.15406/apar.2018.08.00288
- Roll, D., 2004. Greenhouse Pest Control Study Guide. Oct 2004 – Ohio Department of Agriculture – Pesticide Regulation – Certification and Training Section, 74 pp.
- Saad, H.M., 2002. Economics of the integrated pest management of certain insect and animal pests on most important vegetable crops production under plastic greenhouse. M.Sc, Thesis, Fac. of Agri., Moshtohor, Zeg. Univ., Benha Branch 203 Pp
- Samia M. Abozeid; Ammar, Mona. I. and A.K. Rahouma, 2022. Impact of Modern Tactics from Integrated Pest Management and Ecosystem against the Pests Infesting Zucchini Plants. *Middle East Journal of Applied Sciences*, 12(2):159-170.
- SAS Institute, 1999: SAS User's guide: Statistics SAS Inst., Cary, N.C.
- Stansly, P. A., P. A. Sanchez, J. M. Rodriguez, F. Canizares, A. Nieto, M. J. Lopez Leyva, M. Fajardo, V. Suarez and A. Urbaneja, 2004. Prospects for biological control of *Bemisia tabaci* (Homoptera, Aleyrodidae) in greenhouse tomatoes of southern Spain. *Crop Protection.* 23:701-712.