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Effects of certain environmental factors on population fluctuations of *Bemisia tabaci* (Hemiptera: Aleyrodidae) in squash fields at Assiut Governorate

Khttab, H.M.[2]; Ibrahim, I.L.[1]; Abd El-Ghaffar, M.M.[1] and Zedan, O.A.[2]
[1]Plant Protection Dept., Fac. Agric., AL-Azhar Univ., Cairo.
[2]Plant Protection Dept., Fac. Agric., AL-Azhar Univ., Assuit.

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Abstract

Field experiments were conducted at the farm of Agriculture Faculty, AL-Azhar University at Assuit Governorate throughout two successive seasons 2019 and 2020 in order to survey the insects associated with squash crop (*Cucurbita pepo* L.). Also, to throw light on the population fluctuation of *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) which is considered as a most dangerous insect pest on that plant. Results indicated the existence of 10 insect species related to 8 families of 5 orders. The important insect pests recorded on squash were leafhoppers, *Empousca* spp. (Hemiptera: Cicadellidae), thrips, *Thrips tabaci* ((Linderman)) (Thysanoptera:Thripidae), the melon aphids *Aphis gossypii (*Glover) (Hemiptera: Aphididae), the tomato whitefly, *B. tabaci*, the cucurbit fruit flies, *Dacus ciliates* (Loew) (Diptera: Tephitidae) and cucurbit leaf fly (Leafminer) *Liriomyza bryoniae* (Kaltenbach) (Diptera: Agromyzidae). However the commonly associated natural enemies inhabiting squash fields were, *Coccinella septempunctata* L., *Coccinella undecimpunctata* L., *Scymnus interruptus* (Goeze) (Coleoptera: Coccinellidae) and *Chrysoperla carnea* (Stephens). **(**Neuroptera: Chrysopidae). The effects of certain environmental factors (Maximum temperature, minimum temperature, mean temperature, relative humidity, in addition to associated natural enemies) on the population fluctuation of *B. tabaci* were studied. Results indicated that natural enemy numbers had a significant correlation with the population of *B. tabaci* during the two seasons 2019 and 2020. The previous environmental factors were responsible for about 62.07%, 89.88% in the 15th of March and 15th of April (Summer plantations) and 72%, 67.48% in the 15th of August and 15th of September (Nili plantations) of the variability in the populations of *B. tabaci* during 2019, respectively , In the same trend they were responsible for about 75.23 % , 75.64% in the summer plantations and 78.23%, 85.64% in the nili plantations, respectively, in 2020.

Introduction

Squash (*Cucurbita pepo* L.) is one of the most important economic vegetable crops cultivated in Egypt and many countries of the world. The cultivated area with this crop increased

during the last two decades especially in newly reclaimed regions in both open and protected plantations. Throughout the growing season, the squash plants are suffering from a severe infestation with different phytophagous insect pests such as the aphids, *Aphis gossypii (*Glover) (Hemiptera: Aphididae) and the tomato whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), which considered the most common and dangerous insect pests of squash plants.

In case of heavy infestation, these pests are causing serious damage to plants, leading to a great reduction in the final yield. Cucurbitaceous plants are subjected also to being attacked by several major insect pests which cause severe damage directly or indirectly to the crop production (Hanafy, 2004; Gameel, 2004 and Gallab *et al*., 2011).

Therefore, the purpose of this work aimed to study the effect of certain environmental factors on the population dynamics of *B. tabaci* infesting squash during summer and nili plantations.

Materials and methods

The experiments were conducted on the farm of Faculty of Agriculture, AL-Azhar University at Assiut Governorate throughout two successive summers and nili cultivations during 2019 and 2020. An area of about 1 Kirat was sown with squash seeds (*Cucurbita pepo* L.) variety Eskandarany on the15th of March as are commended date for summer plantation and on 15th of April as a late plantation in nili plantation, the crop was planted on15th of August (As are commended date) and on 15th September (As late date) during 2019 and 2020.

The experimental area was about 168 m^2 divided into 4 equal plots area each (7×6 m^2). Normal agricultural practices were followed except for using chemical control. Sampling started after two weeks from the planting date and continued to the harvesting time.

1. Different methods were used to survey *Bemisia tabaci* and other insects found on squash plants:

1.1. Direct count:

In this method, three plants were selected randomly representing the four plot corners and plot center at weekly intervals. Three leaves from each of the three levels of each plant were chosen and examined. Collected specimens were kept in paper bags and transferred to the laboratory for identification. Specimens of unknown species were kept in glass vials containing 75% ethyl alcohol, for later identification.

1.2. Sweeping net:

Twenty five double sweeps (50 net strokes) in five replicates, were taken weekly from the four corners and the center plot. The collected insects were transferred to the laboratory in paper bags for later identification and counting.

1.3. Yellow sticky traps:

Yellow sticky cardboard measuring 15×20 cm vertically fixed to white stalks was distributed at a rate of 5 traps / plot. Traps were located just or slightly above the tops of the plants and replaced with new ones every week.

2. Environmental factors:

Minimum temperature, maximum temperature, mean temperature and relative humidity were obtained from the meteorological records of Central Laboratory for Agricultural Climate, Agricultural Research Center at Dokki (Presentative Assiut Governorate). Weather factors in addition to number of predatory insects, *Coccinella septempunctata* L., *Coccinella undecimpunctata* L., *Scymnus interruptus* (Goeze) (Coleoptera: Coccinellidae) and *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) were statistically analysed with numbers of

B. tabaci to obtain the effect of environmental factors on the population fluctuation of *B. tabaci.*

3. Statistical analysis:

The statistical analysis (Simple correlation and partial regression) of the obtained data was performed by using SAS program (SAS Institute, 1988).

Results and discussion

1. Insects associated with squash crop:

Table (1) contains a taxonomic list of insect pests and associated natural enemies inhabiting squash fields in Assuit during 2019 and 2020 seasons. Data revealed the presence of 10 insect species related to 8 families belonging to 5 orders. Data also indicate that, 6 insect species of them were pests; the tomato whitefly B. *tabaci*, the cotton aphid *A.gossypii* Glover , leafhoppers, *Empousca* spp. (Hemiptera: Cicadellidae), the cucurbit fruit flies, *Dacus ciliates* (Loew) (Diptera: Tephitidae) and cucurbit leaf fly (Leafminer) *Liriomyza bryoniae* (Kaltenbach) (Diptera: Agromyzidae) and thrips, *Thrips tabaci* (Linderman) (Thysanoptera:Thripidae). The other four species were common predators; *C. carnea* ,*C. septempunctata*, *C.undecimpuctata* and *S. interruptas.* Those insects are recorded as common insects on cucurbit plants in many parts of the world (Kamel *et al*., 2000; Gameel and Sayed, 2008, Younes *et al.*, 2010 and Gameel, 2013). The obtained results are in agreement with those of El-Kareim *et al.* (2015) and Abou El-Saad (2015) who reported that, each of *C. undecimpunctata*, *C. carnea* and S. *corolla were* the most common predator species associated with the cucurbit insect pests.

Table (1): Taxonomic list of insects on squash plants during 2019 and 2020 seasons at Assiut Governorate.

Order	Family	Scientific Name	Status
Hemiptera	Cicadellidae	*Empoasca spp.*	Pest
	Aphididae	*Aphis gossypii (*Glover)	Pest
	Aleyrodidae	*Bemisia tabaci* (Gennadius)	Pest
Diptera	Agromyzidae	*Liriomyza bryoniae* (Kaltenbach)	Pest
	Tephritidae	*Dacus ciliates* (Loew)	Pest
Thysanoptera	Thripidae	*Thrips tabaci* (Linderman)	Pest
Coleoptera	Coccinellidae	*Coccinella septempunctata* L.	Predator
		Coccinella undecimpunctata L.	Predator
		Scymnus interruptus (Goeze)	Predator
Neuroptera	Chrysopidae	*Chrysoperla carnea* (Stephens)	Predator

2. Population fluctuations of *Bemisia tabaci* on squash plants:

2.1. Season 2019:

2.1.1. Summer plantation 15th of March and 15th April:

Data illustrated in Figure (1) show that infestation of *B. tabaci* on squash started after 15 days from sowing date; 31th March by 59 individuals /45 leaves *B. tabaci* population increased gradually weekly to reach its peak (3892 adult /45 leaves) after 58 days after sowing date on12th May. After that the insect population decreased gradually to reach the lowest level (156 adult /45 leaves) at mid of June. Meanwhile, data indicated also that the population of *B. tabaci* was obviously higher on young plants (3-6 weeks) than on older plants of the squash. This result indicated that young fresh plants showed higher biological activities with turgid fully nourished cells than older squash plants and were more suitable for the reproduction of the insect pest. These results were in agreement with Habashi *et al*. (2007) and Griffen (2007).

In the case of late summer plantation, the same Figure indicates that the first occurrence of *B. tabaci* was recorded in 28th April 2019 with a number of 100 individuals. However, the insect population raised week by week to reach its peak in the 2nd June with a weekly number of 4498 individuals. Then, the insect number declined in 9th June, the insect number decreased to record a lowest level (126 individuals / 45 leaves) on 14th June by the end of the late summer plantation 2019.

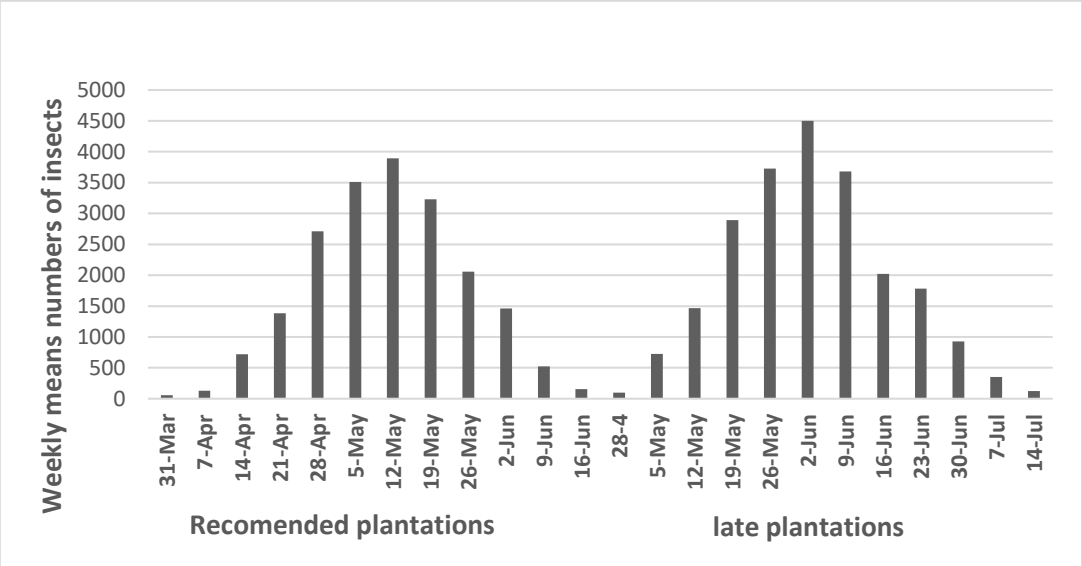

Figure (1): Weekly mean numbers of *Bemisia tabaci* on squash var (Eskandrani) during summer plantations 2019.

2.1.2. Nili plantation 15th August and 15th September:

Data illustrated in Figure (2) showed that infestation of *B. tabaci on* squash started at 15 days after sowing date at the beginning of September (454 adults /45 leaves). It increased to reach its maximum level (2006 adults /45 leaves) 22nd of September. The insect population decreased during the following 2 weeks it increased to reach a higher peak (2348 adults /45 leaves) on 20th October. After that, the insect population decreased gradually to reach a lower level (110 adults /45 leaves) on 17th November after 90 days from the sowing date. Also, as recorded in summer plantations, young and fresh squash leaves are more suitable for *B. tabaci*. These results are in agreement with,Hanafy (2004) and El-Lakwah *et al* (2011) who stated that *B. tabaci* population reached its maximum by the end of October.

In case of late plantation, (15th September plantation), Figure (2) indicates that the first occurrence of *B. tabaci* was recorded on 29th September 2019 with a number of 30 individuals. However, the insect population raised week by week to reach its peak on the 3rd of November with a weekly number of 1632 individuals. Then, the insect number declined on 10th November and decreased gradually till it reaches the lowest level (34 individuals / 45 leaves) on 15th December by the end of the nili season 2019.

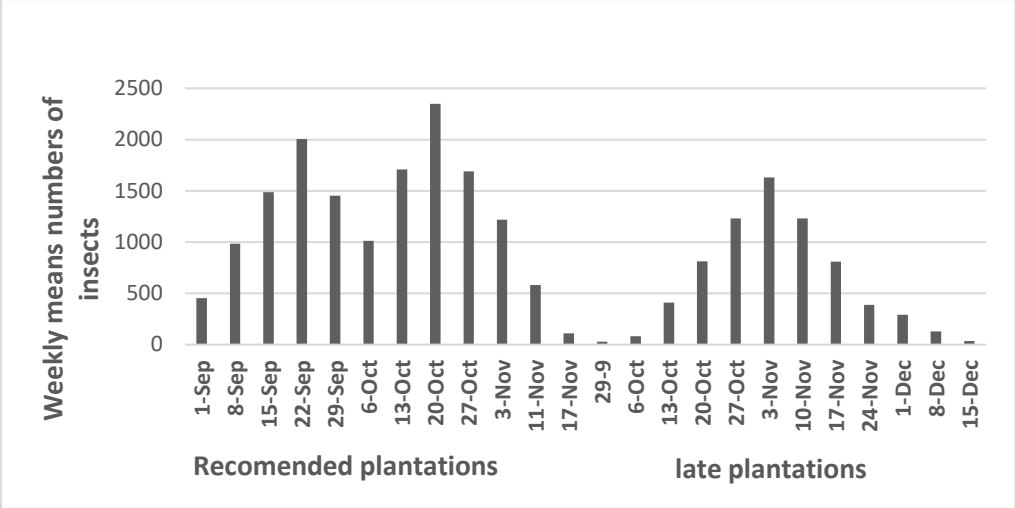

Figure (2): Weekly numbers of *Bemisia tabaci* on squash var (Eskandrani) during nili plantations 2019.

2. Season 2020:

2.1. Summer plantation 15th of March and 15th April:

As shown in Figure (3), the infestation level of *B. tabaci* showed the same trend observed in the previous season. The infestation of *B. tabaci* **on** squash started 15 days after sowing date on 31st March (45 adults /45 leaves). It increased to reach its maximum level (2432 adults /45 leaves) 43 days after sowing on 28th April. After that, the insect population decreased gradually to reach the lowest level (134 adults /45 leaves) on 16th June after 90 days from the sowing date

With respect to 15th April plantation, the insect population started to appear in a low number on 28th April (460 adults / 45 leaves), then it increased in numbers to reach a high level (2070 adults / 45 leaves) on 19th May. After that, the insect population fluctuated to record another peak on 16th June by a number of (2342 adults / 45 leaves) then it declined to reach a lower level (131 adults /45 leaves) on 14th July by the end of the summer plantations.

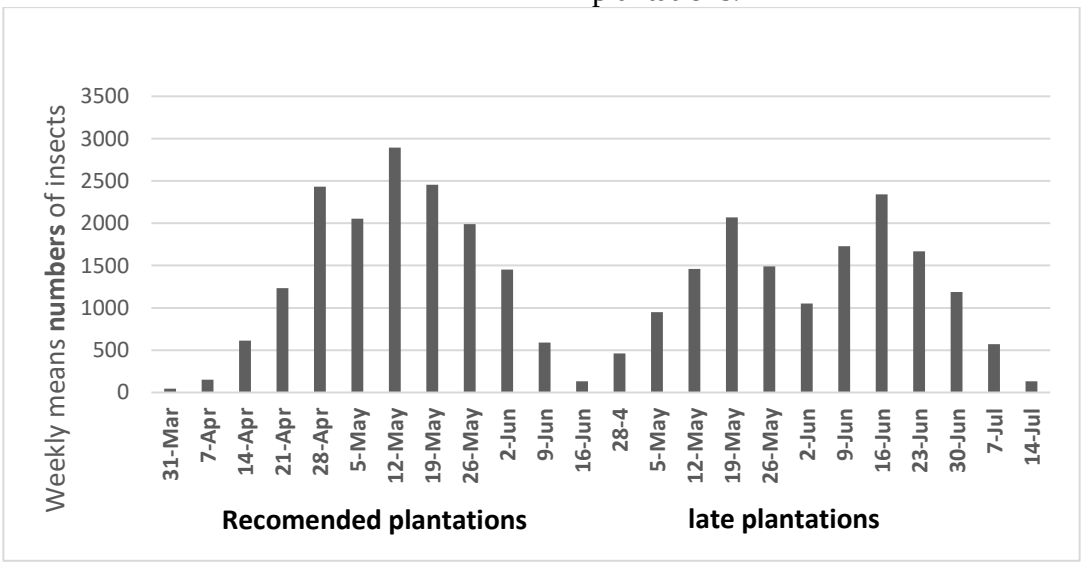

Figure (3): Weekly numbers of *Bemisia tabaci* on squash var (Eskandrani) during summer plantations 2020.

2.2. Nili plantation 15th August and 15th September:

Data illustrated in Figure (4) showed that infestation of *B. tabaci*

started on the plants after 15 days after sowing on 30th Augast (429 adult /45 leaves). It increased to reach its maximum level (2189 adults /45 leaves) at 37 days after, sowing on 22nd septemper. After that, the insect population decreased gradually to reach its lowest level (131 adult /45 leaves) on 17th November after 90 days from the sowing date.

However, 15th September plantation, the same fig. individuals started to appear on the plants in relatively low numbers on 29th September (30 adult / 45 leaves) then it increased to reach its high level (1188 adult / 45 leaves) on 10th November. After that, the insect population decreased gradually to reach a lower level (23 adult /45 leaves) on 15th December by the end of the nili plantation.

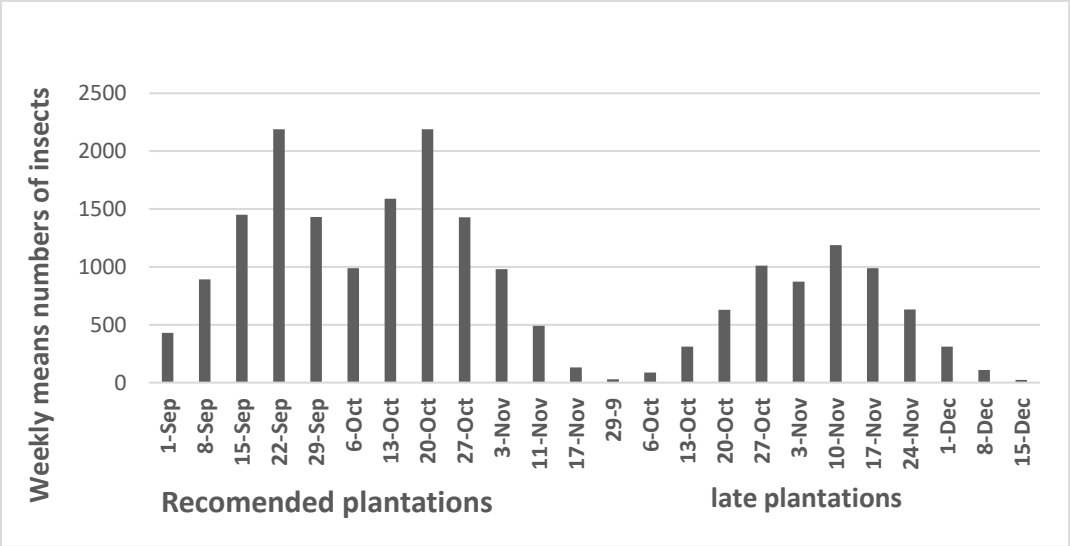

Figure (4): Weekly numbers of *Bemisia tabaci* on squash var (Eskandrani) during nili plantations 2020.

3. Effects of environmental factors on the population fluctuations of *Bemisia tabaci* infesting squash:

An experiment was carried out to verify the influence of certain environmental factors (Temperatures, relative humidity and number of predatory insects on the fluctuations of *B. tabaci* population.

3.1. Season 2019:

3.1.1. Summer plantation (15th March and 15th April) season, 2019:

As shown in Table (2), there is a positive correlation between the *B. tabaci* population and each of maximum, minimum, mean temperatures and the predator numbers, the correlation was significant in the case of predator numbers, but it was insignificant with each of max., min. and mean temperatures during both plantations (15th March and 15th April). The correlation coefficient (r) between *B. tabaci* population and predators population were, 0.769 and 0.905 during recommended and late summer plantations, respectively. However, a simple correlation between *B. tabaci* population and relative humidity was positive and insignificant, during summer plantations (Table 2)

The partial regression analysis proved a significant effect in the case of predator **numbers** during both plantations b= 2.884 ,4.378. The four previously mentioned environmental factors were responsible for about approximately 62.07% and 89.88 % of the variability in *B. tabaci* population on squash during summer plantations of 2019, respectively (Table 2).

Table (2): Simple correlation, partial regression and explained variance values between environmental factors and *Bemisia tabaci* population on squash plants during summer plantation, 2019.

Plantation	Factors	Simple correlation		Partial regression				
		r	p	b	p	F	P	E. v. %
15th March	R.H.	0.046	0.887	0.068	0.991	2.86	0.106	62.07
	Min. Temp.	0.090	0.780	5.189	0.669			
	Max. Temp.	0.234	0.463	6.943	0.560			
	Mean. Temp.	0.755	0.542	0.004	0.806			
	Predators	0.769	0.003	2.884	0.015			
15th April	R.H.	0.037	0.909	2.089	0.635	15.54	0.001	89.88
	Min. Temp.	0.351	0.262	18.882	0.188			
	Max. Temp.	0.117	0.716	28.296	0.102			
	Mean. Temp.	0.678	0.473	0.015	0.119			
	Predators	0.905	0.0001	4.378	0.0007			

r: Simple correlation value. **P: Probability level.**
b: Partial regression coefficient value. **E. v.: Explained variance.**

3.1.2. Nili plantation (15th August and 15th September) season, 2019:

As shown in Table (3), there is a positive relation between the *B. tabaci* population and each of maximum, minimum, mean temperatures and the predator numbers, the correlation was significant in the case of predator numbers, but it was insignificant with max., min., and mean temperatures during both plantations (15th August and 15th September)**.** The correlation coefficient (r) between *B. tabaci* population and predator numbers were ,0.657 and 0.743 during nili plantations, respectively. However, simple correlation between *B. tabaci* population and relative humidity was a positive and insignificant, during nili plantations (Table 3). The partial regression analysis proved a significant effect in case of predator numbers during both plantations b= 2.767 ,4.555. The four previously mentioned environmental factors were responsible for about approximately 72% and 67.48 % of the variability in *B. tabaci* population on squash during nili plantations of 2019, respectively (Table 3).

Table (3): Simple correlation, partial regression and explained variance values between environmental factors and *Bemisia tabaci* population on squash plants during nili plantation, 2019.

Plantation	Factors	Simple correlation		Partial regression				
		R	p	b	p	F	P	E. v. %
15th August	R.H.	0.525	0.079	1.397	0.861	4.50	0.040	72
	Min. Temp.	0.527	0.077	42.595	0.861			
	Max. Temp.	0.413	0.181	18.849	0.411			
	Mean. Temp.	0.068	0.119	3.452	0.336			
	Predators	0.657	0.020	2.767	0.025			
15th September	R.H.	0.636	0.026	10.549	0.250	3.63	0.065	67.48
	Min. Temp.	0.516	0.085	20.738	0.622			
	Max. Temp.	0.507	0.092	6.009	0.850			
	Mean. Temp.	0.332	0.017	4.054	0.068			
	Predators	0.743	0.005	4.555	0.050			

r: Simple correlation value. **b.: Partial regression coefficient value.**
E. v.: Explained variance. **P: Probability level.**

3.2. Season 2020:

3.2.1. Summer plantation (15th March and 15th April):

Simple correlation values given in Table (4) showed, there is a positive relation between the *B. tabaci* population and each of maximum, minimum, mean temperatures and the predator numbers, the correlation was significant in the case of predator numbers, but it was insignificant with each of max., min., and mean temperatures during both plantations (15th March and 15th April). The correlation coefficient (r) between *B. tabaci* population and predator population were ,0.306 and 0.831 during summer plantations, respectively. However, the simple correlation between *B. tabaci* population and relative humidity was positive and insignificant, during summer plantations (Table 4)

The partial regression analysis proved a significant effect in the case of predator numbers during both plantations (b= 6.002 and 9.040). The four previously mentioned environmental factors were responsible for about approximately 75.23% and 75.64 % of the variability in *B. tabaci* population on squash during summer plantations of 2020, respectively (Table 4).

Table (4): Simple correlation, partial regression and explained variance values between environmental factors and *Bemisia tabaci* population on squash plants during summer plantation, 2020.

Plantation	Factors	Simple correlation		Partial regression				
		R	P	B	P	F	p	E. v. %
15th March	R. H.	0.074	0.818	5.974	0.734	0.95	0.488	75.23
	Min. Temp.	0.443	0.148	55.771	0.278			
	Max. Temp.	0.351	0.262	31.853	0.554			
	Mean. Temp	0.325	0.178	21.451	0.687			
	Predators	0.306	0.332	6.002	0.267			
15th April	R. H.	0.379	0.223	3.120	0.919	5.43	0.026	75.64
	Min. Temp.	0.511	0.089	36.938	0.534			
	Max. Temp.	0.396	0.202	10.556	0.864			
	Mean. Temp	0.465	0.165	7.312	0.647			
	Predators	0.831	0.0008	9.040	0.016			

r: Simple correlation value. **P: Probability level.**
b: Partial regression coefficient value. **E. v.: Explained variance.**

3.2.2. Nili plantation (15th August and 15th September):

As shown in Table (5), there is a positive relation between the *B. tabaci* population and each of maximum, minimum, mean temperatures and the predator numbers, the correlation was significant in the case of predator numbers, but it was insignificant with other factors during both plantations (15th August and 15th September). The correlation coefficient (r) between *B. tabaci* population and predator numbers were ,0.206 and 0.731 during nili plantations, respectively. However, a simple correlation between B. *tabaci* population and relative humidity was positive and insignificant, during nili plantations (Table 5).

The partial regression analysis proved a significant effect in the case of predator numbers during both plantations (b= 7.002 and 7.040). The four previously mentioned environmental factors were responsible for about approximately 78.23 and 85.64 % of the variability in *B. tabaci* population on squash during nili plantations of 2020, respectively (Table 5).

Table (5): Simple correlation, partial regression and explained variance values between environmental factors and *Bemisia tabaci* population on squash plants during nili plantation, 2020.

Plantation	Factors	Simple correlation		Partial regression				
		r	p	b	p	F	P	E. v. %
15th August	R.H.	0.064	0.818	6.974	0.734	0.95	0.488	78.23
	Min. Temp.	0.343	0.148	52.771	0.278			
	Max. Temp.	0.251	0.262	28.853	0.554			
	Mean. Temp	0.225	0.178	19.451	0.687			
	Predators	0.206	0.332	7.002	0.267			
15th September	R.H.	0.479	0.223	4.120	0.919	5.43	0.026	85.64
	Min. Temp.	0.611	0.089	34.938	0.534			
	Max. Temp.	0.496	0.202	12.556	0.864			
	Mean. Temp	0.565	0.165	8.312	0.647			
	Predators	0.731	0.0008	7.040	0.016			

r: Simple correlation value. **b.: Partial regression coefficient value.**
E. v.: Explained variance. **P: Probability level.**

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