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Impact of Sowing Dates and Certain Climatic Factors on the Population Dynamics of Key Insect Pests of Maize Plants

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ABSTRACT

The effects of four sowing dates (early of April, May, June and July) and three major climatic factors (means of maximum & minimum temperatures and percentage of relative humidity) on the seasonal abundance of three stem borers (*Sesamia cretica* Led., *Chilo agamemnon* (Bles.), *Ostrinia nubilalis* Hbn represented by larval content and *Rhopalosiphum maidis* Fitch represented by total numbers of nymphs and adults) throughout two successive growing seasons 2014 and 2015 were investigated. The highest numbers of *S. cretica* larvae were found within April plantation with a peak on the 3rd week of May during both seasons; while maize plants sown on June and July were almost free of infestation. Maize plants sown on June and July were more liable to be attacked by *C. agamemnon* as compared to April and May sowing dates. Maize plants sown in April and May in both seasons were almost free from the infestation with *O. nubilalis* larvae. The highest numbers of *R. maidis* population was occurred for maize sown on July followed by those sown on June in both seasons. For June plantation, two peaks of abundance occurred on the last week of July and the 1st week of September, whereas only one peak was occurred on July plantation during the 1st week of September. The lowest numbers occurred on maize plants sown on May, while plants sown on April were free from aphid infestation. We concluded that sowing maize plants during May and June escapes from severe infestation with stem borers and aphids, however April plantation is almost free from infestation but its yield is very low. The effect of mean maximum and minimum temperatures during May plantation was significant negative on the changes in the population of *S. cretica*. Mean maximum temperature had a negative effect; while mean minimum temperature had a positive significant effect on the population dynamics of *C. agamemnon* during May plantation. The mean maximum temperature during May and June plantations on *O. nubilalis* larvae was significant; while the effect of mean minimum temperature was insignificant during both seasons of study. Means of minimum temperature during May and June plantations were positively significant on the changes of *R. maidis* population and the same trend was observed for R.H.%. It could be concluded that mean maximum and minimum temperatures are affecting the infestation with stem borers and mean minimum temperature and R.H% are the most factors affecting *R. maidis* population.

Keywords: *Sesamia cretica*, *Chilo agamemnon*, *Ostrinia nubilalis*, *Rhopalosiphum maidis,* maize, sowing dates, population dynamics, weather factors

INTRODUCTION

Maize is considered as one of the most important field food crop in Egypt and allover the world. Maize grains are used for human consumption, as feed for poultry birds and livestock, for extraction of edible oil and also for starch and glucose industries. The countries with large maize growing areas include Argentina, Brazil, China, Hungary, India, Indonesia, Italy, Mexico, Philippines, South Africa, Rumania and United States (Biradar *et al.*, 2011). This crop is usually attacked by several injurious insect pests namely greater sugarcane borer, *Sesamia cretica* Lederer, the lesser sugarcane borer, *Chilo agamemnon* (Bleszynski), the European corn borer, *Ostrinia nubilalis* Hübner and corn leaf aphid, *Rhopalosiphum maidis* Fitch during maize growing season which cause reliable damages and yield losses. Many researchers have investigated the population dynamics of these pests on different sowing dates and different fertilization regimes (El-Saadany, 1965 ; Tawfik *et al*., 1974; Metwally, 1976; Hudon and LeRoux, 1986; Abdallah, 1990; Abdel-Rahim *et al*., 1991; Ismail *et al*., 1993; Mesbah *et al.*, (2002);Velasco *et al*., 2007 and Mousa, Heba, 2012;). Also, the effect of weather factors on its population dynamics was investigated (Panwar and Sarup, 1980; Abdallah, 1990; Kuroli and Nemeth, 1991; Farag *et al*., 1992; Cagan *et al*., 2000; El-Gepaly, 2007; Zulfiqar *et al*., 2010 and Meti *et al.*, 2014).

The aims of the present work to re-evaluate the most suitable time for sowing maize plants to avoid heavy infestations with stem borers and aphids and to investigate the effect of the changes in certain weather factors on the population dynamics of these pests.

MATERIALS AND METHODS

To study the effect of sowing dates on the levels of infestation with the main pest of maize, seeds (single hybrid) were sown on four successive dates one month apart from April to July during two growing seasons 2014 and 2015 at the Experimental Farm of the Agricultural Research Station attached to Faculty of Agriculture, Ain Shams University at Shalakan, Qalyubyia Governorate. The experimental field area was about one feddan divided into 20 equal plots, each of 4 x 50 meters. Five plots were selected for each sowing date. No chemical control applications were used. Maize seeds were sown on the beginning of April, May, June and July in both seasons. Maize plants were sampled weekly for examination, starting two weeks after seedling appearance from the soil. Weekly samples of 50 plants were taken at random from each sowing date up to harvest. The relation between sowing dates of maize and the corresponding population densities of *Sesamia cretica* Lederer, *Chilo agamemnon* (Bleszynski) and *Ostrinia nubilalis* Hübner were represented by larval contents, while *Rhopalosiphum maidis* Fitch was represented by counts of nymphs and adults. Analysis of variance between sowing dates (treatments) was applied and separation between means was adopted by L.S.D.

The corresponding meteorological factors prevailed at the time of the experiment means of maximum day temperature, minimum night temperature

(˚C) and percentage of relative humidity were obtained from the Central Laboratory for Agricultural Climate (CLAC), ARC, MoA. The effects of weekly means of these weather factors on the population densities of the studied pests of maize was estimated through the partial regression factors using the Excel program. Counts of the insect pests were taken as independent variable (y) and records of the weekly means of these weather factors were taken one week earlier as dependent variables (X1, X2 and X3, respectively). The correlation coefficients and the C-multiplier formula were applied to calculate the combined effect of these three factors on the population dynamics were expressed as percentage of explained variance. The significance of the chosen factors was expressed by the "F" values.

RESULTS AND DISCUSSION

1. Impact of sowing dates on larval content of three maize stem borers and aphids

Sesamia cretica

Data in Table (1) show the fluctuations in the population density of *S. cretica* larvae inhabiting maize plants sown on four different sowing dates during two successive seasons (2014 & 2015). For 2014 season, the maximum population of the pest occurred within April plantation with a peak of 20 larvae/50 plants on the 3rd week of May. The plantation of May also harbored a relatively high numbers of larvae with a peak on the 4th week of May being 15 larvae/50 plants. Maize plants sown on June and July were almost free of infestation. Results of statistical analysis showed significant differences between means of these four sowing dates (F = 6.22, L.S.D. = 1.1).

For 2015 season, the population of larvae was higher than that of 2014 season. The peak of larval population occurred one week earlier during April plantation and in the same 4th week of May during May plantation. The two peaks were 21 and 18 larvae/50 maize plants, respectively. Plantations of June and July had very low population of *S. cretica* larvae. Again, there were significant differences between means of larval content of these sowing dates (F = 5.3, L.S.D. = 1.4). It could be concluded that maize plants sown at the beginning of April are liable to heavily attacked by *S. cretica*.

Table 1. Weekly counts of *Sesamia cretica* larvae/50 maize plants sown on four different dates during two successive seasons at Shalakan, Qalyubyia Governorate

Sampling Date		2014 season					2015 season				
		Sowing Date				Total	Sowing Date				Total
Month	Week	April	May	June	July		April	May	June	July	
April	2nd	---	---	---	---	---	---	---	---	---	---
	3rd	6	---	---	---	6	0	---	---	---	0
	4th	7	---	---	---	7	8	---	---	---	8
May	1st	11	---	---	---	11	16	---	---	---	16
	2nd	15	5	---	---	20	21	6	---	---	27
	3rd	20	9	---	---	29	17	10	---	---	27
	4th	13	15	---	---	28	15	18	---	---	33
	5th	6	9	---	---	15	7	10	---	---	17
June	1st	3	3	---	---	6	6	7	---	---	13
	2nd	1	2	2	---	5	3	5	3	---	11
	3rd	0	0	4	---	4	2	4	5	---	11
	4th	0	1	4	---	5	1	1	2	---	4
July	1st	1	0	2	---	3	1	1	1	---	3
	2nd	0	1	4	0	5	0	1	3	2	6
	3rd	---	0	1	2	3	---	1	2	2	5
	4th	---	0	1	3	4	---	1	1	4	6
	5th	---	1	0	1	2	---	1	2	1	5
August	1st	---	0	0	2	2	---	0	0	1	1
	2nd	---	---	0	1	1	---	0	0	2	2
	3rd	---	---	---	0	0	---	---	0	0	0
	4th	---	---	---	0	0	---	---	---	0	0
Total		83	46	18	9	156	97	66	19	12	195
Mean		6.4	3.3	1.8	1.1		7.5	4.4	1.7	1.5	
"F" = 6.22		L.S.D. = 1.1					"F" = 5.3	L.S.D. = 1.4			

These results are in harmony with that obtained by El-Saadany (1965); Abul-Nasr and El-Nahal (1968), Metwally (1976) and Farag *et al.* (1991) who stated that maize sown at Mid-May was subjected to the least infestation by *S. cretica* while those sown during April harbored the highest infestation level in different localities of Egypt. Cordero *et al.* (1998) reported that although small larvae of *S. nonagrioides* were abundant on young maize plants but levels of infestation were very low. Mannaa (1999) found that maize sown in May 1st suffered more infestation with *S. cretica* than those sown in mid- or late- season in Assiut. Also, Moyal *et al.* (2002) in Egypt found high densities of *S. cretica* larvae in maize plants sown in the beginning of April for two weeks then larvae disappeared from maize plants till the end of the season. Velasco *et al.* (2007) reported that the numbers of *S. nonagrioides* larvae collected from maize plants in June and July were very low in northwestern Spain.

Chilo agamemnon

Data presented in Table (2) show the effects of planting dates on the infestation levels with *C. agamemnon* in maize fields. For 2014 season, it seems that maize plants sown as late as June and July were more liable to be attacked by *C. agamemnon* as compared to April and May sowing. The total numbers of *C. agamemnon* larvae observed on maize plants were 22, 19, 31 and 57 larvae/50 plants sown on April, May, June and July, respectively. This pest had only one peak in the 1st week of August during July plantation; being

17 larvae/50 plants. The analysis of variance proved the significant differences between the means of larval content within the four sowing dates. The "F" value was 4.1 and L.S.D. = 3.2 which separated the means into 3 groups; April & May, June and July in separate groups.

Table 2. Weekly counts of *Chilo agamemnon* larvae/50 maize plants sown on four different dates during two successive seasons at Shalakan, Qalyubyia Governorate

Sampling Date		2014 season					2015 season				
		Sowing Date				Total	Sowing Date				Total
Month	Week	April	May	June	July		April	May	June	July	
April	2nd	---	---	---	---	---	---	---	---	---	---
	3rd	---	---	---	---	---	---	---	---	---	---
	4th	0	---	---	---	0	0	---	---	---	0
May	1st	0	---	---	---	0	0	---	---	---	0
	2nd	0	---	---	---	0	0	---	---	---	0
	3rd	0	0	---	---	0	0	0	---	---	0
	4th	0	0	---	---	0	1	0	---	---	1
	5th	1	0	---	---	1	2	1	---	---	3
June	1st	3	1	---	---	4	1	0	---	---	1
	2nd	1	1	---	---	2	4	0	---	---	4
	3rd	2	2	2	---	6	1	1	0	---	2
	4th	5	1	1	---	7	0	2	2	---	4
July	1st	2	2	1	---	5	2	1	2	---	5
	2nd	2	2	0	---	4	3	3	1	---	7
	3rd	1	4	2	5	12	1	1	3	9	14
	4th	3	2	9	9	23	1	0	14	20	35
	5th	1	2	7	11	21	1	2	8	22	33
August	1st	1	1	5	17	24	1	1	6	7	15
	2nd	0	1	2	9	12	1	1	5	11	18
	3rd	0	0	1	4	5	0	0	1	3	4
	4th	---	---	1	2	3	---	---	0	2	2
Total		22	19	31	57	129	19	13	42	74	148
Mean		1.2	1.3	2.8	8.1		1.1	0.9	3.8	10.6	
"F" = 6.1		L.S.D. = 3.2					"F" = 6.3 L.S.D. = 5.3				

For 2015 season, the same trend was also observed and maize plants sown on April and May harbored the lowest populations of *C. agamemnon* larvae; being 19 and 23 larvae/50 plants, while plants sown on June and July harbored 42 and 74 larvae/50 plants, respectively. This pest had two peaks in the 4th week of July during June plantation and the 4th week of July during July plantation represented by 14 and 22 larvae/50 plants, respectively. Again, the analysis of variance was significant (F = 6.3 and L.S.D. = 5.3).

Metwally (1976) reported that early plantation of maize during April was completely free of *C. agamemnon* infestation. El-Rawy (1999) mentioned that infestation with *C. agamemnon* larvae to maize plants appears 5-7 weeks after *S. cretica* but it continues to the end of the season. Mesbah *et al.* (2002) in Alexandria and Farmanullah *et al*. (2010) in Pakistan reported that, the late-sown maize recorded higher infestation of *C. agamemnon* compared to the early-sown plants.

Ostrinia nubilalis

Results in Table (3) reveal that plants sown in April and May in both seasons (2014 and 2015) were almost free from the infestation with *O. nubilalis* larvae. On plants sown in the beginning of June, population of larvae began to increase gradually from the 3rd week of June till it reached the only peak of abundance during the 4th week of July in 2014 (9 larvae/50 plants) and the 2nd week of July in 2015 (10 larvae/50 plants) and. On plants sown in July, *O. nubilalis* larvae were slightly higher than those sown on June. The pest also had one peak of abundance in each season occurred during the last week of July, 2015 (17 larvae/50 plants) and the first week of August 2014 (15 larvae/50 plants). Analysis of variance of the data obtained during the first season showed significant differences between the mean number of *O. nubilalis* larvae inhabited maize plants, "F" value was 4.9 and L.S.D. was 0.7 for 2014 and "F" value was 4.8 and L.S.D. was 1.8 for 2015.

These findings are in agreement with those found by Tawfik *et al*. (1974) who mentioned that in early plantations of maize in Egypt (not later than May) infestation with *O. nubilalis*, *S. cretica* and *C. agamemnon* were quite lower than that of late plantation. Hudon and LeRoux (1986) in Canada mentioned that adults of *O. nubilalis* began to emerge from mid-June to early July. Oviposition and larval hatching took place mainly in July, in synchrony with the phenological development (whorl stage) of maize. Maize plants sown during May were entirely free from European corn borer (Abdel-Rahim *et al*. 1991). Simsek and Gullu (1992) in Turkey, reported that population of *O. nubilalis* on maize plants was low until the second week of July. Segeren *et al.* (1997) recorded 26 percent incidence of maize stem borer at 30 days of emergence and mentioned that early sowing decreased the intensity of stem borers under southern Mozambique conditions. Hammad (2006) in Egypt; Litsinger *et al.*, (2007) in Philippines; Velasco *et al.* (2007) in northwestern Spain; Blandino *et al.* (2008) in north of Italy and Obopile and Hammond (2013) in USA had results of the same trend in their work.

Table 3. Weekly counts of *Ostrinia nubilalis* larvae/50 maize plants sown on four different dates during two successive seasons at Shalakan, Qalyubyia Governorate

Sampling Date		2014 season					2015 season				
		Sowing Date				Total	Sowing Date				Total
Month	Week	April	May	June	July		April	May	June	July	
April	2nd	---	---	---	---	---	---	---	---	---	---
	3rd	---	---	---	---	---	---	---	---	---	---
	4th	0	---	---	---	0	0	---	---	---	0
May	1st	0	---	---	---	0	0	---	---	---	0
	2nd	0	---	---	---	0	0	---	---	---	0
	3rd	0	0	---	---	0	0	0	---	---	0
	4th	0	0	---	---	0	0	0	---	---	0
	5th	0	0	---	---	0	1	0	---	---	1
June	1st	2	0	---	---	2	2	0	---	---	2
	2nd	4	1	0	---	5	1	1	0	---	2
	3rd	3	1	2	---	6	3	1	3	---	7
	4th	1	2	3	---	6	1	2	3	---	6
July	1st	3	0	1	---	4	3	1	6	---	10
	2nd	0	3	5	1	9	1	0	10	2	13
	3rd	0	1	3	4	8	0	0	7	3	10
	4th	0	1	9	3	13	0	1	4	4	9
	5th	0	1	6	9	16	---	0	5	17	22
August	1st	---	0	4	15	19	---	1	7	9	17
	2nd	---	0	1	6	7	---	0	3	5	8
	3rd	---	0	2	6	8	---	0	1	3	4
	4th	---	---	2	2	4	---	---	1	3	4
Total		13	10	38	46	107	12	7	50	46	115
Mean		0.9	0.7	3.2	5.8		0.9	0.5	4.2	5.8	

"F" = 4.9 L.S.D. = 0.7 **"F" = 4.8 L.S.D. = 1.8**

Rhopalosiphum maidis

Data in Table (4) show the weekly fluctuations in the population density of *R. maidis* on maize plants during two successive growing seasons 2014 and 2015. During 2014 season, the highest numbers of aphid populations occurred for maize sown on July (4290 individuals/50 plants) followed by those sown on June (3086 individuals/50plants). For June plantation, two peaks of abundance were found on the last week of July and the 1st week of September, whereas only one peak was occurred on July plantation during the 1st week of September. The lowest numbers were found on maize plants sown on May (315 individuals/50 plants), while plants sown on April were free from aphid infestation. The same trend was observed during 2015 season where plants sown on July harbored the highest numbers (5385 individuals/50 plants) followed by those sown in June and May being; 3685 and 470 individuals/50 plants). On the other hand, one peak of abundance occurred during June plantation in the 4th week of August and two peaks on plants sown during July during the 2nd and 4th weeks of August.

Table 4. Weekly counts of *Rhopalosiphum maidis* larvae/50 maize plants sown on four different dates during two successive seasons at Shalakan, Qalyubyia Governorate

Sampling Date		2014 season					2015 season				
		Sowing Date				Total	Sowing Date				Total
Month	Week	April	May	June	July		April	May	June	July	
April	2nd	---	---	---	---	---	---	---	---	---	---
	3rd	0	---	---	---	0	0	---	---	---	0
	4th	0	---	---	---	0	0	---	---	---	0
May	1st	0	---	---	---	0	0	---	---	---	0
	2nd	0	0	---	---	0	0	0	---	---	0
	3rd	0	0	---	---	0	0	0	---	---	0
	4th	0	0	---	---	0	0	0	---	---	0
	5th	0	0	---	---	0	0	0	---	---	0
June	1st	0	1	---	---	1	0	0	---	---	0
	2nd	0	5	13	---	18	0	9	0	---	9
	3rd	0	3	25	---	28	0	16	36	---	52
	4th	0	7	97	---	104	0	22	65	---	87
July	1st	---	7	112	---	119	---	25	75	---	100
	2nd	---	10	234	23	267	---	18	135	48	201
	3rd	---	20	311	65	396	---	44	279	166	489
	4th	---	39	307	98	444	---	71	299	399	769
	5th	---	45	498	130	673	---	90	170	656	916
August	1st	---	78	366	147	591	---	109	398	312	819
	2nd	---	100	206	220	526	---	66	192	978	1236
	3rd	---	---	388	338	726	---	---	400	604	1004
	4th	---	---	186	876	1062	---	---	612	766	1378
Sept.	1st	---	---	210	955	1165	---	---	364	512	876
	2nd	---	---	133	814	947	---	---	445	499	944
	3rd	---	---	---	501	501	---	---	215	235	450
	4th	---	---	----	123	123	---	---	---	210	210
Total		0	315	3086	4290	7691	0	470	3685	5385	9540
Mean		0	21.0	220.4	357.5		0	31.3	245.7	359.0	

"F" = 7.3 L.S.D. = 98.1 **"F" = 5.8 L.S.D. = 107.5**

Analysis of variance for the data of both seasons indicated the presence of significant differences between the investigated sowing dates in harboring *R. maidis* on maize plants, ("F" value was 7.3 & L.S.D. was 98.1 for the first season) and ("F" value was 5.8 & L.S.D. was 107.5 for the second season).

These results are in harmony with those obtained by Guiberteau *et al.* (1990) in Spain, who stated that maize plants sown during the period from 15th March to 1st May were found to be free from aphid infestation until harvest time. Abdel-Rahim *et al*. (1992) stated that cultivars sown on the first of May had fairly nil infestation with *R. maidis* and maximum percentage of infestation occurred plants sown on the first of July. Farag *et al*. (1992) mentioned that the infestation with *R. maidis* began by the end of July at Kafr El-Sheikh Governorate. The highest percentage of infestation was on August, 10. Ismail *et al.* (1993) reported that the infestation with *R. maidis* on maize plants at Qalyubyia Governorate continued for 9, 8 and 6 weeks on plants sown on May 15, June 15 and July 15 respectively. Sahito *et al*. (2012) in Pakistan found that *R. maidis* began to infest maize plants 75 days after sowing, maximum infestation was during the end of the third month from sowing in July.

2. Impact of certain climatic factors on population densities of maize key insect pests

Sesamia cretica

Results of statistical analysis summarized in Table (5) show that the effect of mean maximum temperature during May plantation 2014 was negatively significant. This could be attributed to the negative effect of high temperature on the mating process between males and females in the field which cause females to lay less number of eggs and accordingly little number of larvae. The effect of mean minimum temperature was positive on the larval content of *S. cretica*. The corresponding 'r' values for these factors were -0.822 and 0.852, respectively. The combined effect of these factors was significant (E.V. = 79%) and the "F" value was also highly significant (12.68**). The same trend was observed in May plantation, 2015 season (Table 6) since the same two factors had the same significant effects on the larval content of of *S. cretica* (Values of 'r' were -0.833 and 0.833). In addition, the effect of mean minimum temperature during June plantation was negative significant (r = -0.781). The combined effect of the three tested weather factors was highly significant for both plantations (E.V. = 80 and 71%, respectively).

Table 5. Results of statistical analysis for the relationship between certain climatic factors (one week earlier) and the population of *S. cretica* on maize plants sown on four different dates during 2014 season

Sowing Date	Tested Variable	Simple Correlation		Partial Regression				
		" r "	Prob.	" b "	s.e.	" t "	Prob.	
April	Max. Temp.	-0.303	0.292	---	2.26	0.509	0.622	E.V. = 27%
	Min. Temp.	-0.361	0.205	---	2.37	0.221	0.829	"F" Value
	R.H. %	-0.413	0.142	---	0.57	1.343	0.209	1.26
May	Max. Temp.	-0.822	0.000	-1.98	0.67	1.723	0.116	E.V. = 79%
	Min. Temp.	0.852	0.000	1.89	0.79	1.123	0.288	"F" Value
	R.H. %	-0.507	0.065	---	0.21	0.519	0.615	12.68**
June	Max. Temp.	-0.105	0.772	---	0.67	0.339	0.746	E.V. = 43%
	Min. Temp.	-0.580	0.079	---	0.65	1.013	0.350	"F" Value
	R.H. %	-0.572	0.084	---	0.21	0.811	0.448	1.48
July	Max. Temp.	-0.586	0.127	---	0.59	0.907	0.416	E.V. = 44%
	Min. Temp.	-0.531	0.176	---	0.71	0.823	0.460	"F" Value
	R.H. %	-0.271	0.516	---	0.37	0.010	0.992	1.04

Table 6. Results of statistical analysis for the relationship between certain climatic factors (one week earlier) and the population of *S. cretica* on maize plants sown on four different dates during 2015 season

Sowing Date	Tested Variable	Simple Correlation		Partial Regression				
		" r "	Prob.	" b "	s.e.	" t "	Prob.	
April	Max. Temp.	-0.276	0.361	---	1.53	0.329	0.750	E.V. = 14%
	Min. Temp.	-0.362	0.224	---	1.76	0.761	0.466	"F" Value
	R.H. %	-0.216	0.478	---	0.61	0.196	0.849	0.51
May	Max. Temp.	-0.833	0.000	-1.97	0.50	2.301	0.032	E.V. = 80%
	Min. Temp.	0.833	0.000	2.04	0.53	2.031	0.047	"F" Value
	R.H. %	-0.411	0.128	---	0.17	0.570	0.581	14.41**
June	Max. Temp.	-0.256	0.447	---	0.33	0.453	0.664	E.V. = 71%
	Min. Temp.	-0.781	0.005	-1.18	0.35	3.861	0.006	"F" Value
	R.H. %	-0.095	0.780	---	0.07	1.443	0.192	5.50**
July	Max. Temp.	0.418	0.303	---	0.71	1.138	0.319	E.V. = 47%
	Min. Temp.	-0.539	0.168	---	0.71	1.256	0.276	"F" Value
	R.H. %	-0.135	0.750	---	0.12	0.492	0.649	1.16

Farag *et al*. (1992) found an insignificant negative correlation between either daily mean temperature or daily mean relative humidity on *S. cretica* infestation rates. They added that the combined effect for both weather factors insignificantly affected its infestation. Mousa-Heba (2012) reported that maximum temperature and R.H.% had insignificant effects on the population of *S. cretica* larvae; while minimum temperature had a positive significant effect.

Chilo agamemnon

Results of statistical analysis of data in Table (7) show that mean maximum temperature had a significant negative effect ; while mean minimum temperature had positive significant effect on the larval content of *C. agamemnon* during May plantation. The values of 'r' were -0.735 and 0.635, respectively. The combined effect of these factors showed that the percentage of explained variance was 64% and the "F" value was 5.91. During June

plantation, mean maximum temperature showed negative significant effect and the 'r' value was -0.655. The combined effect of the three factors was slightly significant on the larval content of *C. agamemnon*. The E.V. was 59% and "F" value was 3.39.

Surprisingly, in 2015 season, the only significant effect was due to mean minimum temperature during July plantation since the 'r' value was -0.800. The combined effect of the three tested factors was highly significant (84%) and the corresponding "F" value was 5.10 (Table 8).

Table 7. Results of statistical analysis for the relationship between certain climatic factors (one week earlier) and the population of *C. agamemnon* on maize plants sown on four different dates during 2014 season

Sowing Date	Tested Variable	Simple Correlation		Partial Regression				
		" r "	Prob.	" b "	s.e.	" t "	Prob.	
April	Max. Temp.	0.400	0.100	---	0.38	0.213	0.835	E.V. = 17%
	Min. Temp.	0.369	0.132	---	0.41	0.407	0.690	"F" Value
	R.H. %	0.060	0.812	---	0.11	0.482	0.638	0.98
May	Max. Temp.	-0.735	0.003	-0.41	0.22	2.478	0.033	E.V. = 64%
	Min. Temp.	0.635	0.015	0.33	0.25	1.049	0.319	"F" Value
	R.H. %	0.507	0.064	---	0.06	1.653	0.129	5.91**
June	Max. Temp.	-0.655	0.029	0.07	0.86	3.150	0.016	E.V. = 59%
	Min. Temp.	0.103	0.764	---	1.21	1.295	0.237	"F" Value
	R.H. %	0.111	0.745	---	0.28	0.043	0.967	3.39*
July	Max. Temp.	-0.525	0.227	---	2.02	0.214	0.844	E.V. = 27%
	Min. Temp.	-0.188	0.687	---	2.75	0.316	0.772	"F" Value
	R.H. %	-0.842	0.017	---	1.26	2.209	0.114	2.63

Table 8. Results of statistical analysis for the relationship between certain climatic factors (one week earlier) and the population of *C. agamemnon* on maize plants sown on four different dates during 2015 season

Sowing Date	Tested Variable	Simple Correlation		Partial Regression				
		" r "	Prob.	" b "	s.e.	" t "	Prob.	
April	Max. Temp.	0.391	0.109	---	0.19	1.752	0.102	E.V. = 22%
	Min. Temp.	0.209	0.405	---	0.20	0.986	0.341	"F" Value
	R.H. %	0.110	0.665	---	0.07	0.046	0.964	1.28
May	Max. Temp.	0.373	0.171	---	0.18	0.934	0.370	E.V. = 16%
	Min. Temp.	0.289	0.296	---	0.23	0.248	0.809	"F" Value
	R.H. %	0.262	0.346	---	0.07	0.547	0.595	0.71
June	Max. Temp.	0.319	0.338	---	1.83	1.137	0.293	E.V. = 18%
	Min. Temp.	0.097	0.776	---	1.95	0.199	0.846	"F" Value
	R.H. %	-0.088	0.797	---	0.41	0.747	0.480	0.51
July	Max. Temp.	0.179	0.701	---	3.54	1.786	0.172	E.V. = 84%
	Min. Temp.	-0.800	0.031	-8.93	2.79	3.396	0.043	"F" Value
	R.H. %	-0.387	0.391	---	0.42	0.831	0.467	5.10*

Panwar and Sarup (1980) reported that very high and low temperature (*i.e.* greater than 35°C and less than 20°C, respectively) affected the development of *C. partellus* in maize crop adversely. Mousa-Heba (2012) reported that maximum temperature had a negative and significant effect on the population of *C. agamemnon* larvae; while R.H.% had no effect. Meti *et al.* (2014) in India showed that percent of damage caused by stem borers was highly significant and positively correlated with minimum temperature.

Ostrinia nubilalis

Results of statistical analysis shown in Table (9) reveal that mean maximum temperature had positive significant effect on the larval content of *O. nubilalis* during May plantation (r = 0.811). The combined effect of the three tested factors showed significant effect during this plantation. The E.V. value was 51% and the "F" value was 4.46. The same trend was observed during the same plantation in 2015. The 'r' value was 0.643 and E.V. was 51% and "F" value was 4.87 (Table 10); while in June plantation, mean percentage of relative humidity had positive significant effect on the larval content of *O. nubilalis* throughout both seasons. The 'r' values were 0.632 and 0.517 for 2014 and 2015 seasons, respectively. The combined effect of these three factors showed significant differences during 2014 (E.V. = 55% and "F" = 3.31); while during 2015 their effect was insignificant.

Table 9. Results of statistical analysis for the relationship between certain climatic factors (one week earlier) and the population of *O. nubilalis* on maize plants sown on four different dates during 2014 season

Sowing Date	Tested Variable	Simple Correlation		Partial Regression				
		" r "	Prob.	" b "	s.e.	" t "	Prob.	
April	Max. Temp.	0.403	0.136	---	0.39	0.936	0.369	E.V. = 23%
	Min. Temp.	0.226	0.419	---	0.41	0.230	0.822	"F" Value
	R.H. %	-0.182	0.517	---	0.11	0.539	0.600	1.13
May	Max. Temp.	0.811	0.039	1.14	0.28	0.546	0.596	E.V. = 51%
	Min. Temp.	0.212	0.448	---	0.32	0.442	0.667	"F" Value
	R.H. %	0.292	0.292	---	0.08	0.879	0.398	4.46*
June	Max. Temp.	-0.449	0.143	---	0.77	2.808	0.023	E.V. = 55%
	Min. Temp.	0.206	0.521	---	0.81	1.257	0.244	"F" Value
	R.H. %	0.632	0.039	0.87	0.24	0.849	0.421	3.31*
July	Max. Temp.	-0.035	0.934	---	2.15	0.526	0.627	E.V. = 34%
	Min. Temp.	0.283	0.497	---	2.59	0.740	0.500	"F" Value
	R.H. %	-0.610	0.108	---	1.34	1.916	0.128	1.54

Table 10. Results of statistical analysis for the relationship between certain climatic factors (one week earlier) and the population of *O. nubilalis* on maize plants sown on four different dates during 2015 season

Sowing Date	Tested Variable	Simple Correlation		Partial Regression				
		" r "	Prob.	" b "	s.e.	" t "	Prob.	
April	Max. Temp.	0.233	0.422	---	0.21	0.709	0.495	E.V. = 26%
	Min. Temp.	0.365	0.200	---	0.26	1.607	0.139	"F" Value
	R.H. %	0.012	0.967	---	0.09	1.171	0.269	1.26
May	Max. Temp.	0.643	0.054	1.88	0.13	0.484	0.638	E.V. = 51%
	Min. Temp.	0.227	0.417	---	0.17	0.136	0.894	"F" Value
	R.H. %	0.260	0.349	---	0.05	0.620	0.548	4.87*
June	Max. Temp.	0.122	0.706	---	0.98	0.133	0.897	E.V. = 23%
	Min. Temp.	0.046	0.888	---	1.03	0.728	0.487	"F" Value
	R.H. %	0.517	0.049	0.96	0.25	1.477	0.178	0.779
July	Max. Temp.	-0.414	0.308	---	3.00	0.927	0.407	E.V. = 36%
	Min. Temp.	-0.373	0.363	---	3.02	0.919	0.410	"F" Value
	R.H. %	-0.336	0.416	---	0.49	0.330	0.758	0.731

Cagan *et al.* (2000) in Poland, found that high temperature prevailed in July favored the development of the second generation of *O. nubilalis*. Mousa-Heba (2012) in Egypt found that the effect of mean maximum temperature on the population of *O. nubilalis* larvae was positive significant in 2008 and significant in 2009. Mean minimum temperature has no significant effect on both years. On the other hand, the effect of R.H.% was negative significant in one year and insignificant in the other.

Rhopalosiphum maidis

Results of statistical analysis shown in Tables (11 & 12) reveal that mean minimum temperature during May plantation had positive significant effect on the total numbers of *R. maidis* during both seasons. The calculated 'r' values were 0.718 and 0.758 for 2014 and 2015 seasons, respectively. The combined effect of the three weather factors on the population of *R. maidis* was significant during both seasons. The E.V. values were 58 and 60% and the corresponding "F" values were 3.28 and 5.43 for both seasons, respectively. On June plantation during both plantation, means of minimum temperature and relative humidity had positive effect on the population of *R. maidis*. The 'r' values were 0.667 and 0.868 for mean temperature and 0.620 and 0.595 for R.H.% during 2014 and 2015, respectively. Also, the combined effect of the tested factors was significant on the population during June plantation throughout both seasons. The explained variance values were 56 and 77% and the corresponding "F" values were 4.24 and 11.98 for both seasons, respectively.

Table 11. Results of statistical analysis for the relationship between certain climatic factors (one week earlier) and the population of *R. maidis* on maize plants sown on four different dates during 2014 season

Sowing Date	Tested Variable	Simple Correlation		Partial Regression				
		" r "	Prob.	" b "	s.e.	" t "	Prob.	
April	Max. Temp.	---	---	---	---	---	---	---
	Min. Temp.	---	---	---	---	---	---	---
	R.H. %	---	---	---	---	---	---	---
May	Max. Temp.	0.087	0.800	---	10.94	1.006	0.347	E.V. = 58%
	Min. Temp.	0.718	0.013	19.86	10.49	2.122	0.051	"F" Value
	R.H. %	0.564	0.071	---	2.41	0.154	0.882	3.28*
June	Max. Temp.	0.158	0.590	---	41.50	1.253	0.239	E.V. = 56%
	Min. Temp.	0.667	0.009	86.82	43.65	1.981	0.076	"F" Value
	R.H. %	0.620	0.018	26.90	12.75	0.926	0.376	4.24*
July	Max. Temp.	0.307	0.331	---	150.11	0.075	0.942	E.V. = 17%
	Min. Temp.	0.361	0.249	---	205.65	0.742	0.479	"F" Value
	R.H. %	0.187	0.561	---	77.85	0.541	0.603	0.53

Table 12. Results of statistical analysis for the relationship between certain climatic factors (one week earlier) and the population of *R. maidis* on maize plants sown on four different dates during 2015 season

Sowing Date	Tested Variable	Simple Correlation		Partial Regression				
		" r "	Prob.	" b "	s.e.	" t "	Prob.	
April	Max. Temp.	---	---	---	---	---	---	---
	Min. Temp.	---	---	---	---	---	---	---
	R.H. %	---	---	---	---	---	---	---
May	Max. Temp.	0.476	0.073	---	4.98	0.759	0.464	E.V. = 60%
	Min. Temp.	0.758	0.001	13.09	5.26	2.982	0.012	"F" Value
	R.H. %	0.347	0.205	---	1.69	0.196	0.848	5.43**
June	Max. Temp.	0.301	0.275	---	27.04	0.112	0.913	E.V. = 77%
	Min. Temp.	0.868	0.000	144.28	31.38	4.157	0.002	"F" Value
	R.H. %	0.595	0.019	23.39	7.09	0.731	0.480	11.98**
July	Max. Temp.	0.110	0.733	---	72.48	0.473	0.649	E.V. = 59%
	Min. Temp.	0.472	0.121	---	104.44	2.855	0.021	"F" Value
	R.H. %	-0.341	0.278	---	13.88	2.660	0.029	3.81*

Farag *et al*. (1992) reported that both daily mean temperature and daily mean relative humidity exerted a highly significant positive effect on the infestation by *R. maidis*. The combined effect of both weather factors was positive but relative humidity affected aphid population more than mean temperature. Kuroli and Nemeth (1991) in Hungary mentioned that aphids prefer temperature prevailed during the second half of June and high R.H. was suitable for aphid reproduction. Bartam and Cagan (2005) revealed that warmer temperatures positively influenced the population development of cereal aphids including *R. maidis*. El-Gepaly (2007) reported that the combined effect of minimum & maximum temperature and R.H.% positively affected the abundance of *R. maidis*. Sahito *et al*. (2012) in Pakistan found that correlation of *R. maidis* with temperature was positive. On the contrary, Zulfiqar *et al*. (2010) found a negative relationship between the population of maize aphid and both temperature and relative humidity.

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تأثير مواعيد الزراعة وبعض العوامل الجوية على ديناميكية مجاميع الآفات الحشرية الرئيسية لنباتات الذرة

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تم دراسة تأثير مواعيد الزراعة (أوائل ابريل، مايو، يونيو ويوليو) وبعض العوامل الجوية الرئيسية (درجتي الحرارة العظمى والصغرى والنسبة المئوية للرطوبة النسبية) على التواجد الموسمي لآفات الذرة الرئيسية وهى دودة القصب الكبيرة *Sesamia cretica*، دودة القصب الصغيرة *Chilo agamemnon*، دودة الذرة الأوروبية *Ostrinia nubilalis* معبراً عنها بعدد اليرقات وحشرة منّ الذرة *Rhopalosiphum maidis* لموسمين زراعين متتاليين (2014 و2015). سجلت أكبر أعداد من يرقات دودة القصب في زراعات شهر أبريل وكانت ذروة تواجدها في الأسبوع الثالث من مايو في كلا الموسمين بينما النباتات المنزرعة في مايو ويونيو خالية تقريباً من الإصابة. سجلت أعلى إصابة بدودة القصب الصغيرة في زراعات يونيو ويوليو مقارنة بتلك المنزرعة في ابريل ومايو. كانت نباتات الذرة المنزرعة في ابريل ومايو خالية تقريباً من الإصابة بدودة الذرة الأوروبية في كلا الموسمين. كان أكبر تعداد لحشرة منّ الذرة على النباتات المنزرعة في يوليو تليها تلك المنزرعة في يونيو في كلا الموسمين. في عروة يونيو كانت هناك قمتين للتواجد لهذه الحشرة خلال الأسبوع الأخير من يوليو والأسبوع الأول من سبتمبر بينما في زراعات يوليو كانت هناك قمة واحدة للتواجد في الأسبوع الأول من سبتمبر وكان أقل تعداد للحشرة في عروة شهر مايو بينما النباتات المنزرعة في شهر ابريل كانت خالية تماماً من حشرة منّ الذرة. كان لدرجات الحرارة العظمى والصغرى السائدة في عروة شهر مايو تأثير معنوي وسالب على تعداد يرقات دودة القصب الكبيرة وكان تأثير درجة الحرارة العظمى سالباً ودرجة الحرارة الصغرى موجباً على تعداد يرقات دودة القصب الصغيرة التي تصيب نباتات الذرة المنزرعة في شهر مايو. كان تأثير درجة الحرارة العظمى على يرقات دودة الذرة الأوروبية المنزرعة في مايو ويونيو معنوياً بينما كان تأثير درجة الحرارة الصغرى غير معنوياً خلال موسمي الدراسة. كان لدرجة الحرارة الصغرى والنسبة المئوية للرطوبة النسبية تأثير موجب ومعنوي على تعداد حشرات المنّ في عروتي مايو ويونيو في كلا موسمي الدراسة.