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Seasonal activity of the citrus leafminer, *Phyllocnistis citrella* Stainton in navel orange orchards during autumn season

Ahmed H. El-Afify[1], R.M. Shreef[2], N.M. Ghanim[1] and M.A. Hendawy[2]
[1] *Plant Protection Research Institute, ARC, Dokki, Giza, Egypt*
[2] *Plant Prot. Dept., Fac. Agric., Zagazig Univ., Egypt*

Abstract: *Nursery and young plantations as well as new flushes of citrus orchards in Egypt and worldwide are seriously affected by the citrus leafminer (CLM), Phyllocnistis citrella Stainton (Lepidoptera: Gracillariidae). To obtain a successful integrated CLM management, ecological studies are of great important. So, the present work aimed to study the activity of CLM during autumn season on navel orange trees and determine the effects of certain weather factors on its population. The obtained results showed that the seasonal activity of CLM during autumn season exhibited four and three peaks of abundance during of 2016 and 2017. The general means of CLM larvae all over autumn season of 2016 and 2017 were 9.6 and 7.5 larvae per 25 leaves. On another hand, the mean of infestation percentages during the first season (47.6%) was higher than that during the second one (38.0%); while, the mean of CLM mortality percentages during 2016 (34.6%) was lower than 2017 (54.6%). There was an extrusive relationship between CLM larval population and its infestation percentages in navel orange leaves. The changes in CLM population were significantly positive correlated with temperature degrees and insignificantly negative correlated with relative humidities. Maximum temperature degrees was the highest effective factor on CLM population in comparison with the other tested factors.*

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I. Introduction

In Egypt, the area of citrus has been rapidly increased specially in newly reclaimed lands. Many insect pests were recorded attacking citrus trees; some of these pests cause serious damage and cause economic loss in the crop **[1, 2, 3, 4]**. The citrus leafminer (CLM), *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) is among the serious pests attacking citrus trees in Egypt and worldwide. Whereas, it is one of the most serious pests of nursery and young plantations as well as new flushes of citrus orchards causing severe damage to them **[5, 6, 1, 3]**. It is native to subtropical and tropical Asia **[7]** and was detected in Egypt during summer 1994 attacking many citrus orchards and nurseries **[8, 9, 10, 1, 3]**. It attacks more than half of the new leaves produced on citrus trees **[11]**. According to **[12]**, female of CLM deposits its eggs singly on the adaxial and abaxial sides of young leaves. The hatched larvae feed in the mesophyll beneath the leaf epidermis and producing a chlorotic leaf patch **[12, 13]**. The total generation time of CLM fluctuating between 13 and 52 days depending on temperature degree with eleven generations annually **[12, 14]**.

The damage is directly related to the ratio of the young leaves and the total canopy of the young trees **[15]**. So, citrus nurseries are most susceptible to CLM damage because of continuous production of seedlings and young trees flush **[16]**. According to **[17**, **15]**, CLM attacks succulent stems and fruits in some citrus varieties which become deformed, yield poor fruits and reduces the marketability of the infested fruit. According to **[18]**, other insects pests such as aphids and mealybugs often continue feeding on the damaged leaves after the CLM have finished feeding. The severity of citrus canker, *Xanthomonas citri* Dowson and other fungus pathogens such as *Alternaria* can be augmented on damaged leaf plants by CLM **[19**, **20**, **21, 22]**.

According to **[1**, **3]**, CLM exhibited its highest activity during autumn season. In addition, the growing flushes which will carry the crop of the next year are represented during autumn season; so, the main control of CLM in the Egyptian fields occurred during this season. To obtain a success integrated pest management, different methods used to control insect population must be integrated by a strategy addressed towards greater protection of the cultures with respect to ecological, toxicological and economic principles **[23]**. Ecological studies about the target pest are of great important for building-up an efficient integrated pest management. So, the present work aimed to study the activity of CLM during autumn season on navel orange trees and determine the effects of certain weather factors on its population.

II. Materials And Methods

The present experiments were conducted in a citrus orchard located at Inshas region, Sharkia governorate. An area of about 10 feddans (1 feddan = 4200 m^2) cultivated with navel orange and infested with CLM was selected for the present study.

Samples were collected from the beginning of August till the end of November of 2016 and 2017. Five trees of navel orange were chosen at random from the orchard as replicates. 25 new leaf flushes were collected weekly from each tree. These leaves were collected from different cardinal directions (north, south, east and west) in addition to center of the tree with a rate of five leaves per direction. The collected leaves were kept inside the paper bags, pulled up well tied and taken to laboratory for examination. Numbers of CLM larvae were counted and recorded as living and dead; then the mortality percentages were calculated. In addition, leaves of navel orange were recorded as infested and un-infested leaves; then infestation percentages were also calculated.

Among the available meteorological data, the daily maximum, minimum and mean temperature degrees in addition to daily maximum, minimum and mean relative humidity were obtained from the Agrometeorological Station at Sharkia region during the months from August till November of 2016 and 2017. The daily records of each weather factor were grouped into weekly means according to the sampling dates. The mean weekly numbers of CLM larvae were correlated with each weather factor and the simple regression in addition to explained variance were analyzed by using **[24]**.

III. Results

Data represented in Fig. (1) showed that larval population of CLM exhibited four and three peaks of abundance during autumn season of 2016 and 2017. These peaks were recorded in the 15th of August, 12th of September, 10th of October and 14th of November 2016 with means of 12.0, 13.0, 11.8 and 9.2 larvae per 25 leaves, respectively. While, during 2017, the peaks were recorded in the 22nd of August (8.6 larvae/25 leaves), 3rd of October (10.2) and 7th of November (8.0).

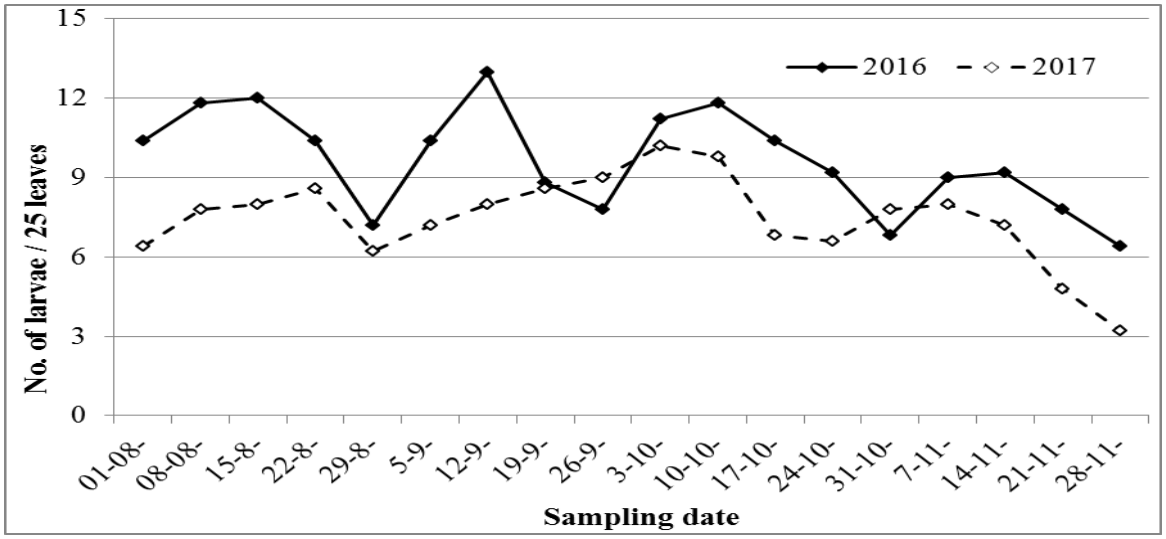

Fig. (1). Seasonal activity of CLM larvae on navel orange orchard during autumn season of 2016 and 2017 at Inshas region, Sharkia governorate.

With respect to infestation percentages, CLM showed four peaks of activity during autumn season of 2016; these peaks were recorded as 52.0, 60.0, 56.0 and 48.0% in the 22nd of August, 12th of September, 3rd of October and 21st of November, respectively. While, during autumn season of 2017, CLM showed three peaks of activity recorded as 42.0, 50.0 and 42.0% in the 15th of August, 10th of October and 31st of October, respectively (Fig., 2).

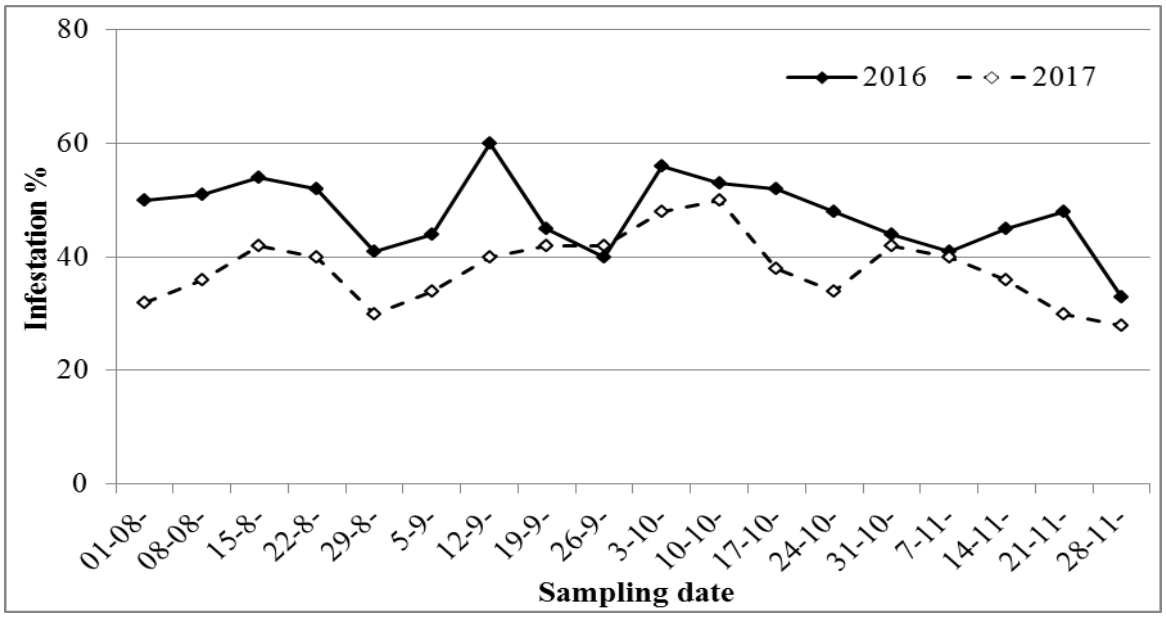

Fig. (2). Infestation percentages cuased by CLM larvae in navel orange leaves during autumn season of 2016 and 2017 at Inshas region, Sharkia governorate.

Mortality percentages caused by different mortality factors in CLM population is illustrated in Fig. (3). Mortality percentages exhibited five peaks during autumn 2016 recorded in the 1st of August, (34.0%), 22nd of August (38.5%), 19th of September (44.0%), 24th of October (41.6%) and 14th of November (41.0%). With respect to autumn season of 2017, there were three peaks of mortality percentages recorded as 57.6% (in the 22nd of August), 69.1% (in the 10th of October) and 63.4% (in the 14th of November).

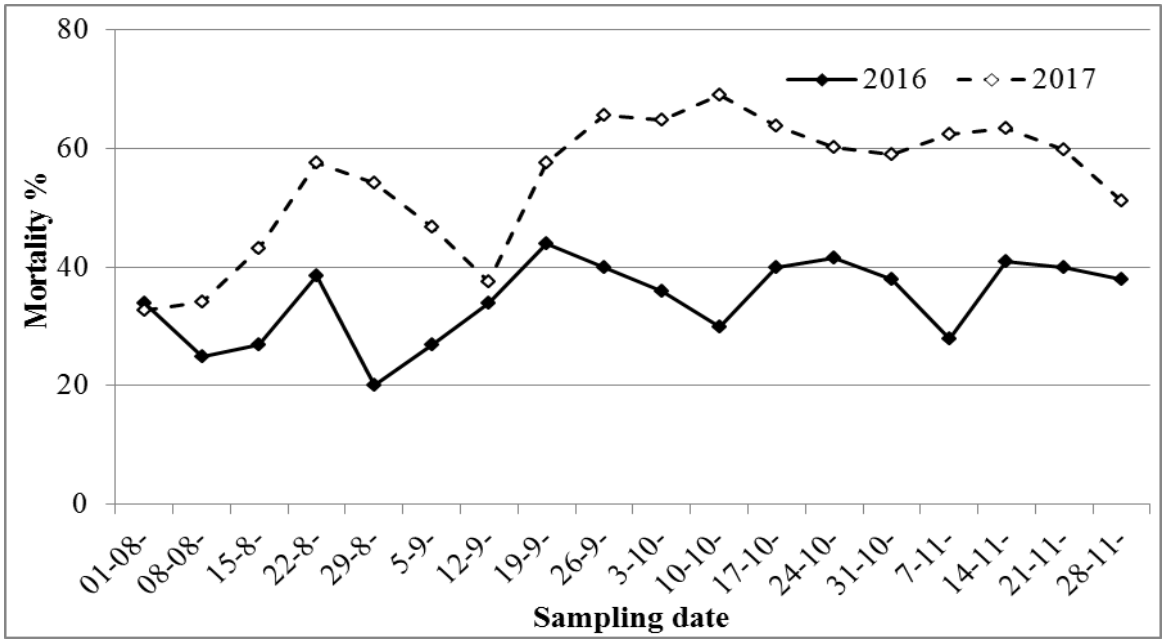

Fig. (3). Mortality percentages of CLM larval population in navel orange orchard during autumn season of 2016 and 2017 at Inshas region, Sharkia governorate.

Data illustrated in Fig. (4) showed that the general means of CLM larvae all over autumn season of 2016 and 2017 were 9.6 and 7.5 larvae per 25 leaves. Also, the general mean of infestation percentages during the first season (47.6%) was higher than that during the second season (38.0%). While, the general mean of mortality percentages during 2016 (34.6%) was lower than 2017 (54.6%).

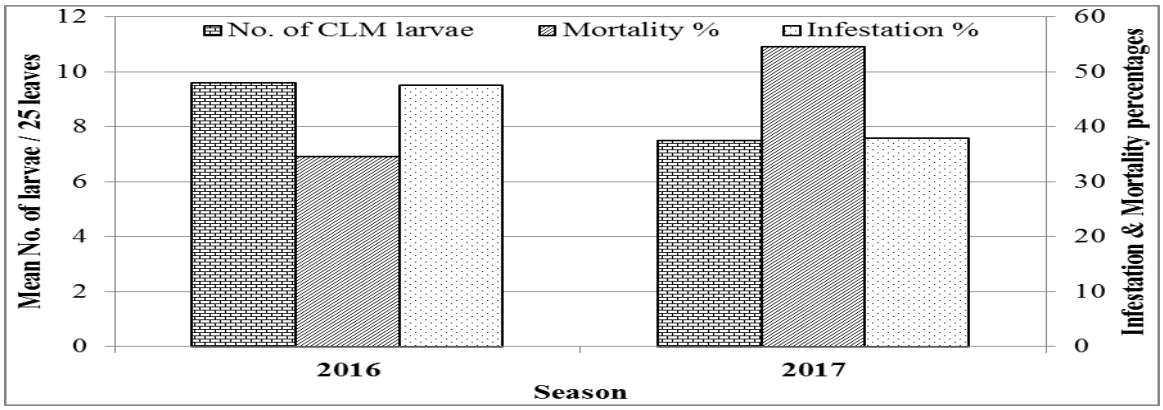

Fig. (4). General means of CLM larval population and its infestation percentages in navel orange orchard in addition to mortality percentages of CLM larvae during autumn season of 2016 and 2017 at Inshas region, Sharkia governorate.

The mathematical relationships between CLM larval population and its infestation percentages in navel orange orchard are represented in Fig. (5). As it shown in this figure, there was an extrusive relationship between them, whereas each increase in CLM populaton by one larva per 25 leaves increased its infestation percentage by 2.96 (R^2 = 0.75) and 3.29% (R^2 = 0.84) during 2016 and 2017 seasons. Also, statistical analysis explained that there was a highly significant positive correlation between CLM larval population and its infestation percentages; where the correlation coefficient value was 0.86** and 0.91** during the first and second seasons.

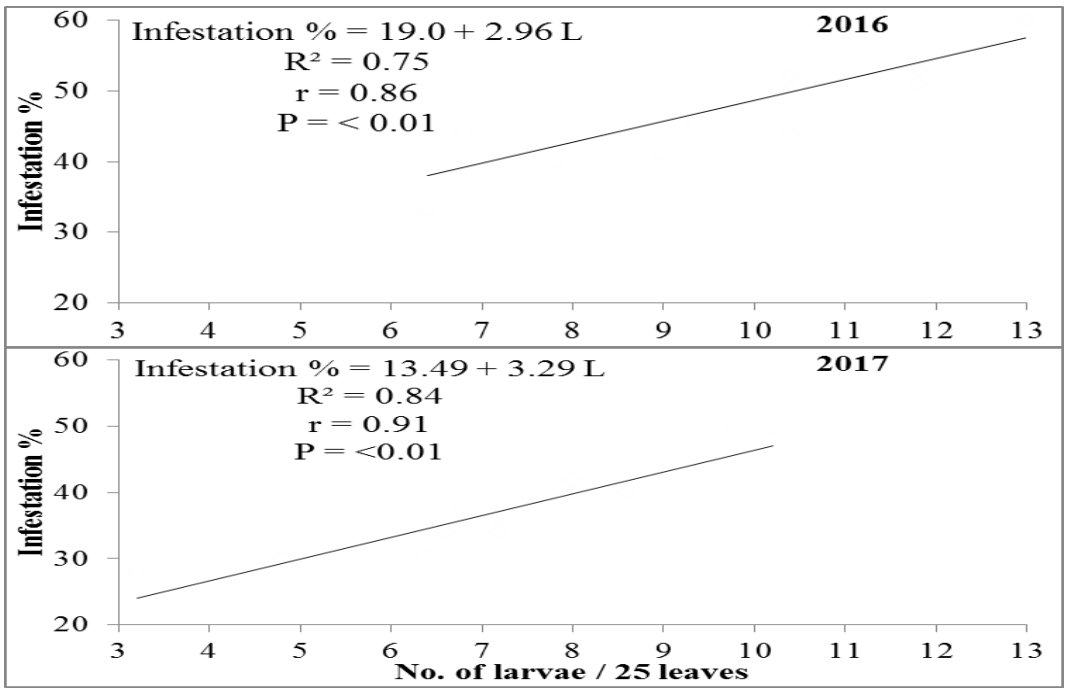

Fig. (5). The relationship between CLM larval population (L) and its infestation percentages in navel orange orchard during autumn season of 2016 and 2017 at Inshas region, Sharkia governorate.

Data compiled in Table (1) indicate that the changes in CLM population were positively correlated with maximum, minimum and mean temperature degrees during autumn seasons of 2016 and 2017 on navel orange orchards; whereas, the calculated r-values were 0.50*, 0.48* and 0.47*, respectively during the fisrt season and wre 0.61**, 0.55* and 0.56* during the second season. On contrary, the correlation coefficient values between CLM population and relative humidity (maximum, minimum and mean) were insignificant (r-values were 0.02, -0.40 and -0.25, respectively durin the first season and were -0.01, -0.23 and -0.13 during the second season).

The simple regression indicated that each increase in maximum, minimum and mean temperature degrees by one degree duing the first season increased CLM population by 0.21, 0.35 and 0.25 larvae per 25

leaves, respectively; while, during the second season these increases were 0.62, 0.44 and 0.48, respectively. Also, each increase in maximum relative humidity by one percent during the first season increased CLM population by 0.01 larvae per 25 larvae and decreased it by 0.02 larvae during the second season. With respect to minimum and mean relative humidity, each increase of them by one percent decreased the pest population by 0.09 and 0.07 larvae per 25 leaves during the first season and decreased it by 0.12 and 0.09 larvae during the second season (Table, 1).

Maximum temperature degrees contributed with a higher effect on CLM population in comparison with the other tested factors during autumn season; whereas the determination coefficient values (R^2) of maximum, minimum and mean temperature degrees during 2016 were 25.1, 22.7 and 22.5%, respectively and were 38.0, 30.1 and 31.5% during 2016. With respect to minimum and mean relative humidity, the determination coefficient values (R^2) were 15.9 and 5.6% (during the first season) and were 5.5 and 1.9% (during the second season). Maximum relative humidity had no effect of CLM population during the first season; while, during the second one R^2-value was 0.1%. All of the tested factors (temperature degrees and relative humidities) contributed with 51.9 and 60.3% of the total factors affecting on CLM population changes during the first and second autumn seasons (Table, 1).

Table (1). Effect of temperature degrees and relative humidity on CLM population in navel orange orchards during autumn seasons of 2016 and 2017 at Inshas region, Sharkia governorate.

Factor	*Correlation and simple regression*				*E.V. in Multi regression*
	r	**b**	**P**	**R^2**	
2016					
Max. T.	0.50	0.21	0.034	25.1	51.9
Min. T.	0.48	0.35	0.046	22.7	
Mean T.	0.47	0.25	0.047	22.5	
Max. RH	0.02	0.01	0.950	0.0	
Min. RH	-0.40	-0.09	0.101	15.9	
Mean RH	-0.25	-0.07	0.309	5.6	
2017					
Max. T.	0.61	0.62	0.009	38.0	60.3
Min. T.	0.55	0.44	0.024	30.1	
Mean T.	0.56	0.48	0.022	31.5	
Max. RH	-0.01	-0.02	0.968	0.1	
Min. RH	-0.23	-0.12	0.279	5.5	
Mean RH	-0.13	-0.09	0.506	1.9	

IV. Discussion

The obtained results showed that CLM exhibited three to four peaks during autumn season. Its highest activity was recorded during the first season in the 15th of August, 12th of September, 10th of October and 14th of November; while during the second season, these peaks were recorded in the 22nd of August, 3rd of October and 7th of November. These results are approximately in agreement with those obtained by **[3]** who reported that the highest activities of CLM on navel orange trees was recorded in the 11th of September and 9th of October 2000 and recorded in the and 24th of September and 22nd of October 2001. Also, **[25]** found that the highest activity of CLM on six varieties of citrus in Qalubia governorate was recorded at the end of August and mid of September. At the same governorate, **[26]** found that the highest activities of CLM on sour orange trees were recorded at the end of July. The variation between the present results and others may be attributed to the variation of host plant species/varieties.

On another hand, the mathematical relationships between CLM larval population and its infestation percentages in navel orange leaves were in extrusive relationships, whereas every increase in CLM populaton resulted significant increases in the infestation percentage of navel orange leaves. Similar results were obtained by **[4, 27]**, they reported that the increase of fruit flies' populations in citrus orchards resulted significant increases in their infestation percentages.

Statistical analysis revealed that the changes in CLM population were positively correlated with temperature degrees during autumn season on navel orange orchards with a significant values. On contrary, the correlation coefficient values between CLM population and relative humidity were generally insignificant negative. These results are supported by those obtained by **[26]**, who found that CLM population exhibited positive responses to the increase of temperature degrees and exhibited negative responses to the increase of relative humidity at Qalubia governorate. Also, **[9]** (in Egypt) and **[28]** (in India) mentioned that weather factors particularly played important roles in the development of CLM population and showed positive correlations with the increase of temperature degrees.

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