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JN Kotak
Department of Entomology, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

MF Acharya
Professor & Head, Department of Entomology, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

KM Devananda
Department of Entomology, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

Corresponding Author:
JN Kotak
Department of Entomology, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

Population dynamics of leaf miner *Liriomyza trifolii* (Burgess) and whitefly *Bemisia tabaci* (Gennadius) on tomato

JN Kotak, MF Acharya and KM Devananda

Abstract
Experiment was undertaken during the year 2016-17 at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh to determine the population dynamics of leaf miner *Liriomyza trifolii* (Burgess) and whitefly *Bemisia tabaci* (Gennadius) on tomato. The results showed that leaf miner (*Liriomyza trifolii*) oriented mined leaves per plant damage peaked (7.20% /plant) during 4th SMW (Standard Meteorological Week) while, it was lowest (0.42%) during 13th SMW. Leaf miner oriented mines per five leaves per plant damage peaked (0.78% /five leaves/plant) during 4th SMW while, it was lowest (0.14%) during 52th SMW. Whitefly (*Bemisia tabaci*) population remained highest (7.67/three leaves) during 4th SMW while, it remained lowest (0.47) during 13th SMW. Relationship between leaf miner oriented mined leaves per plant and weather factors indicated significant negative correlation with temperature (maximum and minimum) (‘r’= -0.590* and -0.522*) and relative humidity (morning and evening) (‘r’= 0.264 and 0.511) indicated positive correlation (non-significant) with the pest abundance. Relationship between leaf miner oriented mines per five leaves per plant and temperature (maximum and minimum) (‘r’= -0.370 and -0.330) indicated non-significant negative correlation. However, relative humidity (morning and evening) (‘r’= 0.017 and 0.315) indicated positive correlation (non-significant) with the pest abundance. Abundance of whitefly population with relative humidity (morning and evening) (‘r’= 0.168 and 0.437) indicated non-significant positive correlation. While, temperature (maximum and minimum) (‘r’= -0.561* and -0.515*) indicated negative but significant correlation with the pest abundance.

Keywords: Tomato crop, *Liriomyza trifolii* (burgess), *Bemisia tabaci* (gennadius), population dynamics

1. Introduction
Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetable crops of the globe due to its immense commercial and nutritive value and wide range of climatic adaptability. The tomato popularly called as “poor man’s orange” is an important solanaceous vegetable fruit originated from tropical America [14]. Tomato is a good source of vitamin ‘A, B’ and excellent source of vitamin ‘C’. It can be eaten as a fresh fruit and as a salad vegetable. It is used for culinary purpose and also used in preparation of pickles, ketchup, sauces and many products. The estimated area under tomato in India is about 6.33 lakh hectares with a production of 124.25 lakh tonnes of fruits. It was grown in an area of 46,397 hectares with the production of 13, 19, 113 tonnes and a productivity of 28.43 tonnes per hectare in Gujarat [1]. The production and quality of tomato fruits are considerably affected by many pests infesting at different stages of crop growth. Amongst various pests reported in India, as many as sixteen of different groups have been observed feeding from germination to the harvesting stage which not only reduce yield but also deteriorate the quality [3]. Among the various insect pest, whitefly (*Bemisia tabaci*) and leaf miner (*Liriomyza trifolii*) are major insect pest causing considerable damage to the crop by attacking the different plant parts of tomato in Gujarat state [2, 12]. So, to avoid the yield losses caused by these destructive pests and encourage cultivation as well as to increase the production and productivity of tomato crop, our efforts were needed to tackle these pests by knowing the peak period of infestation (Population dynamics in relation to the weather parameters) for management point of view.

2. Materials and Methods
The tomato variety (GT-1) was transplanted in an isolated plot with plot size of 20 m x 20 m at a distance of 75 cm x 60 cm to estimate the population of leaf miner and whitefly. All the

recommended agronomical practices were adopted to grow the crop. The experimental plot was divided into twenty equal quadrate and number of leaf miner damage and whitefly (Adults) was recorded from one randomly selected plant from each 1.0 m × 1.0 m quadrate. The crop under the experiment was kept without spraying of insecticides throughout the season. The observations on damage done by leaf miner were recorded from each plant at weekly interval while the observation on population of adult whitefly was recorded from upper, middle and bottom leaves of each plant at weekly interval, starting from germination to the harvest of crop.

2.1 Observations recorded for leaf miner (*Liriomyza trifolii*)

(i) Number of mined leaves/plant

Number of mined leaves per plant was recorded at every week in each quadrate.

(ii) Number of mines/five leaves/plant

Number of mines per five leaves per plant was recorded at every week in each quadrate.

2.2 Observations recorded for whitefly (*Bemisia tabaci*)

(i) Number of whitefly/three leaves per plant

Number of whitefly per three leaves per plant was counted at every week in each quadrate.

The weekly meteorological observations on maximum and minimum temperature, morning and evening relative humidity, wind velocity and sunshine hours during the course of investigation was obtained from the meteorological observatory of Agronomy, Instructional Farm, COA, JAU, Junagadh. Simple correlations between periodical mean values of leaf miner (*Liriomyza trifolii*) and whitefly (*Bemisia tabaci*) with various abiotic parameters were computed.

3. Results and Discussion

3.1 Population dynamics of leaf miner and whitefly on tomato

3.1.1 Leaf miner (*Liriomyza trifolii*)

3.1.1.1 Mined leaves/plant

Leaf miner damaged leaves per plant were noticed from 52^th^ SMW (31^st^ December) to 13^th^ SMW (1^st^ April). It was less during early stage of the crop indicating lower damage (1.45% mined leaves per plant) during 52^th^ SMW (31^st^ December). Thereafter, it increased gradually with advancement in crop phenology indicating peak (7.20%) during 4^th^ SMW followed by another peak (6.30%) during the preceding SMW (21^st^ January). There was no incidence during 51^st^ SMW (23^rd^ December). On the other hand, it remained high (> 5% mined leaves per plant) during 2-4^th^ SMW (14 January - 28 January), which is considered to be its active period (Table 1).

The infestation based on mines/leaf attained the highest peak (10.26 mines/leaf) during 3^rd^ week of January [16]. Higher incidence of serpentine leaf miner (*L. trifolii*) was noticed during 4, 7 and 9^th^ SMWs [17].

In the present investigation, highest mined leaves (7.20%) were noticed during 4^th^ SMW, which is more or less similar as observed by the above mentioned workers. So, the current results are in close agreement with the above reports.

3.1.1.2 Mines/five leaves/plant

The data on leaf miner oriented mines per five leaves per plant (Table 1) revealed that the damage was noticed from 52^th^ SMW (31^st^ December) to 13^th^ SMW (1^st^ April). It was less during early stage of the crop indicating lower damage (0.14% mines per five leaves) during 52^th^ SMW (31^st^ December). Thereafter, it increased gradually with advancement in crop phenology showing peak (0.78%) during 4^th^ SMW followed by another peak (0.68%) during the succeeding SMW (4^th^ February). There was no incidence during 51^st^ SMW (23^rd^ December). On the other hand, it remained high (> 0.6% mines per five leaves) during 3-5^th^ SMW (21 January - 4 February), showing its active period.

The infestation based on mines/leaf attained the highest peak (10.26 mines/leaf) during 3^rd^ week of January [16]. The number of mines/leaf attained the highest peak during 3^rd^ week of January [15]. Higher incidence of serpentine leaf miner (*L. trifolii*) was noticed during 4, 7 and 9^th^ SMWs [17].

In the present investigation, highest number of mines/leaf (0.78%) were noticed during 4^th^ SMW which is in close agreement with the earlier researchers.

3.1.2 Whitefly (*Bemisia tabaci*)

3.1.2.1 Mean adult whitefly/3 leaves

The data presented in Table 1 on abundance of whitefly revealed that it varied from 0.47 to 7.67 per three leaves during 52^th^ SMW (31^st^ December) to 13^th^ SMW (1^st^ April) wherein highest whitefly population (7.67/three leaves) was observed during 4^th^ SMW (28^th^ January) followed by 6.71 whiteflies per three leaves during the subsequent week (4^th^ February). Thereafter, the population declined steadily till 13^th^ SMW (1^st^ April). Lowest whitefly population (0.47) was noticed during 13^th^ SMW (1^st^ April). No whitefly population was noticed during 51^st^ SMW (23^rd^ December).

The incidence of whitefly (*Bemisia tabaci*) attained highest peak during January (2^nd^ SMW) and become lowest in March (12^th^ SMW) [7]. Higher incidence of whitefly was noticed during 11^th^ standard week to 18^th^ standard week that is during 2^nd^ week of March to 3^rd^ week of March with peak population (0.47/leaf) was recorded [13]. Initiation of *B. tabaci* population at 48^th^ SMW. Thereafter, it further increased first slowly up to 1^st^ SMW then steadily up to 5^th^ SMW attained peak at 6^th^ SMW which continued up to about 9^th^ SMW [4]. The peak population of whitefly *B. tabaci* during 7^th^ standard week [9].

In the present investigation, highest whitefly population (7.67/three leaves) was noticed during 4^th^ SMW which is almost the same as noticed by the above workers. So, the results obtained in the present investigation are said to be in agreement with those of earlier reports.

Table 1: Population dynamics of major insect-pests of tomato during *Rabi* 2016-17

Weeks after transplanting	SMW	Whitefly adults/3 leaves	Number of mined leaves/plant	Number of mines/five leaves/plant
3	51	0.00	0.00	0.00
4	52	1.49	1.45	0.14
5	1	3.74	4.90	0.26
6	2	5.19	5.00	0.45
7	3	6.43	6.30	0.62

8	4	7.67	7.20	0.78
9	5	6.71	4.55	0.68
10	6	5.38	3.65	0.54
11	7	4.37	3.38	0.47
12	8	3.28	3.04	0.41
13	9	2.94	2.61	0.35
14	10	2.29	1.70	0.32
15	11	1.64	1.15	0.26
16	12	1.08	0.90	0.19
17	13	0.47	0.42	0.16

SMW: Standard Meteorological Week

3.2 Correlation of important insect-pests of tomato with weather parameters

The relationship of abundance of insect-pests of tomato with important weather factors has been assessed.

3.2.1 Leaf miner (*Liriomyza trifolii*)

3.2.1.1 Mined leaves/plant

Relationship between leaf miner damaged leaves per plant and weather factors indicated significant negative correlation with temperature (maximum and minimum) ('r' = -0.590* and -0.522*) and bright sunshine ('r' = -0.553*) implying that with unit increase in minimum temperature and duration of sun shine there was corresponding decrease of mined leaves per plant and vice-versa. However, relative humidity (morning and evening) ('r' = 0.264 and 0.511) indicated positive correlation (non-significant) with the pest abundance. On the other hand, wind velocity ('r' = -0.193) exhibited negative but non-significant relationship with abundance of leaf miner (Table 2).

Leaf miner damaged leaves per plant and weather factors relationship indicated non-significant positive correlation with relative humidity [5]. Relative humidity (morning and evening) had positive non-significant correlation on per cent mined leaves of *L. trifolii* [10]. Maximum, minimum and mean temperature had a negative significant correlation with the number of mines, larvae as well as per cent damaged leaves of *L. trifolii* [16].

In the present investigation, there was non-significant and positive correlation of mined leaves with relative humidity and significant negative correlation with temperature which is also indicated in the above reports, thus, confirms the present results.

3.2.1.2 Mines/five leaves/plant

Relationship between leaf miner oriented mines per five leaves per plant (Table 2) and weather factors indicated non-significant negative correlation with temperature (maximum and minimum) ('r' = -0.370 and -0.330) and bright sunshine ('r' = -0.260) implying that with unit increase in minimum temperature and duration of sun shine there was corresponding decrease of mined leaves per plant damage and vice-versa. However, relative humidity (morning and evening) ('r' = 0.017 and 0.315) and wind velocity ('r' = 0.052) indicated positive correlation (non-significant) with the pest abundance.

Leaf miner (*L. trifolii*) incidence exhibited positive correlation with wind velocity [6]. Relative humidity (morning and evening) had a positive non-significant correlation with the per cent mined leaves of *L. trifolii* [10]. Maximum, minimum and mean temperature had a negative significant correlation with the number of mines, larvae as well as per cent damaged leaves of *L. trifolii* [16].

In the present investigation, there was non-significant and positive correlation of mines per five leaves with relative humidity and wind velocity and non-significant negative correlation with temperature, which is also indicated in the above reports, thus, confirms the present results.

3.2.2 Whitefly (*Bemisia tabaci*)

3.2.2.1 Mean adult whitefly/3 leaves

Abundance of whitefly population could not establish any significant relationship with any of the weather factor, except the temperatures in this investigation. However, relative humidity (morning and evening) ('r' = 0.168 and 0.437) indicated positive correlation (non-significant) with the pest abundance. On the other hand, bright sunshine hours ('r' = -0.445) and wind velocity ('r' = -0.126) exhibited negative but non-significant relationship with abundance of whitefly. While, temperature (maximum and minimum) ('r' = -0.561* and -0.515*) indicated negative but significant correlation with the pest abundance (Table 2).

Relative humidity had positive influence on whitefly population [4]. Temperature (max. and min.) and sunshine (hrs) had a negative significant correlation, while morning and evening relative humidity had a positive correlation with the pest abundance [8]. Whitefly population was significantly negatively correlated with maximum temperature, minimum temperature and mean temperature [11].

In the present investigation, although none of the abiotic factors except temperature could establish significant correlation with abundance of whitefly. Yet, the results of positive correlation of relative humidity are more or less similar to the above reports conforming the results obtained in this investigation. It implies that with unit increase in relative humidity, there was corresponding increase in whitefly population and vice-versa. Similarly, negative correlation of temperature (maximum and minimum), bright sunshine hours and wind velocity with whitefly implied that with unit increase in their values, there was corresponding decrease of whitefly population and vice-versa.

Table 2: Correlations of major insect-pests of tomato in relation to major abiotic factors during 2016-17

Insect pests Abiotic factors	Correlation co-efficient ('r')		
	Whitefly adults/3 leaves	Number of mined leaves/plant	Number of mines/five leaves/plant
Maximum Temperature (°C)	-0.561*	-0.590*	-0.370
Minimum Temperature (°C)	-0.515*	-0.522*	-0.330
Morning Relative Humidity (%)	0.168	0.264	0.017
Evening Relative Humidity (%)	0.437	0.511	0.315

Bright Sunshine Hours (hours/day)	-0.445	-0.553*	-0.260
Wind Velocity (kmph)	-0.126	-0.193	0.052

n=15, *Significant at 5% level (r = ± 0.514), **Significant at 1% level (r = ± 0.641)

4. Conclusion
On the basis of investigation, the following conclusions could be drawn.

Highest mined leaves/plant (7.20%) and mines/five leaves/plant (0.78%) of leaf miner was recorded at 4th SMW. Peak whitefly population (7.67/three leaves) was noticed at 4th SMW. Relationship between leaf miner damaged leaves per plant and weather factors indicated significant negative correlation with temperature (maximum and minimum) ('r'= -0.590* and -0.522*) and relative humidity (morning and evening) ('r'= 0.264 and 0.511) indicated positive correlation (non-significant) with the pest abundance. Relationship between leaf miner oriented mines per five leaves per plant and weather factors indicated non-significant negative correlation with temperature (maximum and minimum) ('r'= -0.370 and -0.330). However, relative humidity (morning and evening) ('r'= 0.017 and 0.315) indicated positive correlation (non-significant) with the pest abundance. Abundance of whitefly population could not establish any significant relationship with any of the weather factor, except the temperature in this investigation. However, relative humidity (morning and evening) ('r'= 0.168 and 0.437) indicated positive correlation (non-significant) with the pest abundance. While, temperature (maximum and minimum) ('r'= -0.561* and -0.515*) indicated negative but significant correlation with the pest abundance.

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