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Seasonal abundance of serpentine leaf miner and whitefly infesting tomato cultivated under poly house condition

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Abstract
Investigations on seasonal abundance of serpentine leaf miner, *Liriomyza trifolii* (Burgess) and whitefly, *Bemisia tabaci* (Gennadius) were carried out in Hi-Tech Horticulture Park at Department of Horticulture & Department of Entomology, College of Agriculture, Junagadh Agricultural University, Junagadh during the *Kharif*, 2014-15 and the results revealed that the mines were increasing with the increasing of SMW as the first peak was observed after ninth week of transplanting (44th SMW) and thereafter population declined upto 46th week (11th WAT). Once again, the mines were continuously increased up to the second peak during 9th SMW (26th WAT) and then the population was slightly declined. While, the highest whitefly population was recorded during 49th SMW (14th WAT) and considered as a peak damaging stage. The correlation matrix indicated that number of mines caused by serpentine leaf miner on tomato leaves exhibited negative correlation with maximum temperature, whereas minimum temperature, morning relative humidity and evening relative humidity were found highly significant and negatively correlated with mines on leaves.

Keywords: Poly house, seasonal abundance, serpentine leaf miner, tomato, whitefly

1. Introduction
Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetables grown worldwide under both natural as well as protected conditions. As it is a relatively short duration crop and gives high yield, it is economically attractive and the area under cultivation is increasing day by day. Tomato belongs to the *Solanaceae* family. It is an important source of vitamins and an important cash crop for small landholders and medium-scale commercial farmers (Shankara *et al.* 2005) [17]. Tomatoes contribute to a healthy, well-balanced diet. They are rich in minerals, vitamins, essential amino acids, sugars and dietary fibres. Tomato contains much vitamin B and C, iron and phosphorus. Tomato fruits are consumed fresh in salads or cooked in sauces, soup and meat or fish dishes. They can be processed into purées, juices and ketchup. Canned and dried tomatoes are economically important processed products.
Various factors are responsible for reducing the crop yield, of which, insect pests are one of the important factors causes considerable losses in tomato production. The important insect pests of tomato are fruit borer, army worm, leaf miner, whitefly and spider mites (Nagaraju *et al.*, 2002) [11]. Among the various insect pests listed above, leaf miner (*L. trifolii*) and whitefly (*B. tabaci*) are major insect pests of tomato (Brust, 2008; Sharma *et al.*, 2013) [1, 18] that cause 70 per cent and 50-70 per cent yield loss on tomato fruit, respectively (Rai *et al.*, 2014; Tarate *et al.*, 2016; Mishra *et al.*, 2014) [14, 20, 10].
Poly house farming offers many advantages in terms of higher and more consistent yields, protection from adverse weather factors, longer growing season, better quality produce and higher input use efficiency. But at the same time the congenial environment inside the protected condition favours the faster multiplication and reproduction of pests due to abundant availability of foods and absence of natural enemies. Therefore, there was need to study seasonal abundance of serpentine leaf miner and whitefly in order to gain understanding and valuable insight regarding the development so that a management programme might be formulated for these pests on tomato.

2. Materials and Methods
Seasonal abundance of serpentine leaf miner and whitefly was carried out on tomato, Hybrid

(Shaktiman) under poly house condition at Hi-Tech Horticulture Park, Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh during 2014-15. The crop was sown in a plot size of 6.0 m x 16.2 m at spacing of 100 cm x 45 cm. All the recommended agronomic practices were carried out timely to raise crop. Ten quadrates each of 2.0 m X 3.6 m size were formed. Five plants were selected randomly and tagged from each quadrate; thus total 50 plants were observed at weekly interval. The pest population was recorded at weekly interval starting from 15 day after transplanting to harvest of crop. The meteorological data on maximum (MaxT) and minimum temperature (MinT), morning (RH_1) and evening relative humidity (RH_2) were recorded through humidity cum temperature meter under poly house condition. These data were correlated with pest population.

2.1. Serpentine leaf miner
The observations on number of mines taken from three leaves per plant, each selected at random from three middle twigs of the selected plants. The data on average number mines per three leaves per plant was worked out and analyzed statistically for correlation study.

2.2. Whitefly
The observations on number of whitefly (adults and nymphs) taken from three leaves per plant, each selected at random from top, middle and lower portion of the selected plants. The data on average number of whitefly population per three leaves per plant was worked out and analyzed statistically for correlation study.

3. Results and Discussion
The results obtained are presented under the following heads:

3.1. Serpentine leaf miner, *L. trifolii*
3.1.1. Number of mines
The data on serpentine leaf miner oriented mines per three leaves per plant during *Kharif*, 2014-15 on tomato (Table 1) revealed that the damage was noticed from 37th standard meteorological week (SMW) and second week after transplanting (WAT) (0.08 mines / 3 leaves /plant) of 2014 to 11th SMW (28th WAT) (17.58 mines / 3 leaves /plant) of 2015. The mines were increasing with the increasing of SMW as the first peak (3.76 mines /3 leaves /plant) was observed after ninth week of transplanting (44th SMW) and thereafter population declining up to 46th week (11th WAT). Thereafter, the mines were continuously increased up to the second peak (17.66 mines /3 leaves /plant) *i.e.*, 9th SMW (26th WAT) and then the population was slightly declined. After that the crop was matured and so harvested.

In the present investigation, the major difference in population trend was due to crop growing condition *i.e.*, poly house condition instead of open field condition during 2014-15. In protected condition, the micro-environment has positive impact on biotic factors. During this study, it was found that the observed biotic factor *i.e.*, serpentine leaf miner, *L. trifolii* was multiplied with considerable fluctuation of micro-environment. It was found that the population was built up and multiplied very fast in poly house condition when it was compared with open field condition. The available literature revealed that the peak level of *L. trifolii* was observed at second week of January (Chavan *et al.*, 2013) [4], while it attained the highest peak (10.26 mines/leaf) during 1st standard meteorological weeks (SMW) (3rd week of January) (Variya and Patel, 2013) [21]. However, the higher incidence of serpentine leaf miner (*L. trifolii*) was noticed during 4, 7 and 9th (SMW) (Waluniba and Alemla, 2014) [22]. Leaf miner, *L. trifolii* incidence was commenced from the third week of November and reached a peak in fourth week of January while a second peak was observed in the second week of February on tomato (Choudary and Rosaiah, 2000) [5]. The above results are more or less in line with our findings because those researches were carried out under field condition.

3.2. Whitefly, *B. tabaci*
3.2.1. Number of whitefly
The whitefly population was noticed from 40th SMW (5th WAT) of 2014 to 11th SMW (28th WAT) of 2015 in the range of 0.06 to 17.60 whitefly /3 leaves /plant on tomato (Table 1). Whitefly population was noticed absent during 37th to 39th SMW (2nd to 4th WAT). The initiation of whiteflies was started from 40th SMW (5th WAT) with least population (0.06 whitefly /3 leaves /plant) and thereafter it was continuously multiplied with higher rate. With the increasing trend, the highest whitefly population (17.60 whitefly /3 leaves /plant) was recorded during 49th SMW (14th WAT) and considered as a peak damaging stage. Thereafter, the population declined steadily till 11th SMW (28th WAT).

In the present investigation, the major difference in population trend was due to crop growing condition *i.e.*, poly house condition instead of open field condition during 2014-15. In protected condition, the new flush of leaves was observed with asynchrony of population of whitefly. During this study, it was found that the newer and succulent leaves attracts more whiteflies than the older leaves. It was found that the population was built up and multiplied very fast in poly house condition. The different trend in the present investigation could be due to different sowing periods as well as the crop was raised in the poly house. The available literature revealed that the incidence of white fly (*B. tabaci*) was maximum during January (2nd SMW) and lowest in March (12th SMW) (Indirakumar *et al.*, 2016) [6]. The whitefly (*B. tabaci*) population was present throughout the crop growing season and noticed maximum in October on tomato crop (Rafiq *et al.*, 2008) [13]. The peak population of whitefly (7.40 whitefly /leaf) was recorded during 12th week after planting on tomato (Jogani, 2004) [8]. Due to the limited literature on the seasonal abundance of whitefly infesting tomato under poly house condition, the results of present investigation were supported with the same study carried out in the field.

3.3. Effect of weather parameters on leaf miner and whitefly population
A study on effect of various weather parameters on the fluctuation of leaf miner and whitefly population in tomato crop under poly house was carried out during 2014-15 and data obtained are presented in Table 2. The correlation matrix (Table 2) indicated that number of mines caused by serpentine leaf miner on tomato leaves showed negative correlation with maximum temperature (r = -0.244), whereas minimum temperature (r = -0.595**), morning relative humidity (r = -0.557**) and evening relative humidity (r = -0.516**) were found highly significant and negatively correlated with mines on leaves. The result on correlation study of whitefly population showed that maximum temperature (-0.383),

minimum temperature (-0.393) and evening humidity (r = -0.017) were negatively correlated with the activity of the whitefly, while morning humidity (r = 0.049) showed the positive correlation with the population build up of whitefly.

In the present study, number of mines was found negatively correlated with the all studied abiotic factors *i.e.*, maximum & minimum temperature and morning & evening relative humidity. Thus, as maximum & minimum temperature and morning & evening relative humidity deficit increased; mines on leaves decreased or vice versa. Due to meagre literature on the effect of abiotic factors on serpentine leaf miner infesting tomato under poly house condition, the results of present investigation were supported with the same study carried out in the field. According to Singh (2017) [19] and Selvaraj *et al.* (2016) [15], the population of serpentine leaf miner was found significant and negative correlated with morning & evening relative humidity. However, Variya and Patel (2013) [21] reported significant negative correlation of mines, larvae as well as per cent damaged leaves of *L. trifolii* with maximum, minimum, mean temperature and evening humidity. With the accordance of above scientist, Chaudhuri and Senapati (2004) [3] revealed that the temperature and relative humidity showed significant negative correlation with leaf miner incidence, while negative correlation of *Liriomyza trifolii* (Burgess) with minimum temperature and evening relative humidity on tomato was recorded by Choudary and Rosaiah (2000) [5]. In the present investigation, minimum temperature and relative humidity were found significant and negatively correlated with mines caused by *L. trifolii*, thus above reports are strongly supporting the present findings.

In the context none of the abiotic factors *i.e.*, maximum & minimum temperature and morning & evening relative humidity could establish a significant relation with abundance of whitefly. In the present study, whiteflies were found negatively correlated with the maximum and minimum temperature and evening relative humidity while positively correlated with the morning relative humidity. It implies that with unit increase in maximum & minimum temperature and evening relative humidity, there was corresponding decrease in whitefly population but non-significantly and vice-versa. Thus, unit increase in morning relative humidity, there was corresponding increase in whitefly population non-significantly and vice-versa.

Due to limited literatures on the effect of abiotic factors on whitefly infesting tomato under poly house condition, the results of present investigation were supported with the same study carried out in the field. According to Chakraborty (2012) [2], whitefly, *B. tabaci* population was significant and negatively correlated with abiotic conditions while there was significant and negative correlation of whitefly population with minimum temperature on tomato (Jogani, 2004 and Chavan *et al.*, 2013) [8, 4]. The relationship between whitefly population and relative humidity (maximum and minimum) was found negative and non-significant (Sharma *et al.*, 2013 and Patra *et al.*, 2016) [18, 12]. Shaikh and Patel (2013) [16] reported the whitefly population which was negatively correlated with maximum temperature, minimum temperature, mean temperature, evening relative humidity and mean relative humidity. The similar result was reported by Jha and Kumar (2017) [7] that temperature (max. and min.) was found significant and negatively correlated with the pest abundance. A significant positive correlation was recorded between whitefly population and maximum temperature, whereas, it was found non-significant and negatively correlated with morning relative humidity while a significant and negatively correlated with evening relative humidity (Kumar *et al.*, 2019) [9]. However, the results of negative correlation of temperature and evening relative humidity with whitefly population are more or less in accordance with the reports of earlier researchers. Hence, it confirms the results of present investigation.

Table 1: Seasonal abundance of serpentine leaf miner, *L. trifolii* and whitefly, *B. tabaci* infesting tomato under poly house condition during 2014-15

Sr. No	WAT	SMW	Number(s) per 3 leaves per plant	
			Mines	Whitefly
1	2	37	0.08	-
2	3	38	0.68	-
3	4	39	0.74	-
4	5	40	0.92	0.06
5	6	41	1.18	0.88
6	7	42	1.56	2.20
7	8	43	2.86	2.34
8	9	44	3.76	3.58
9	10	45	2.64	5.66
10	11	46	2.88	8.44
11	12	47	4.62	11.60
12	13	48	5.54	14.36
13	14	49	5.76	17.60
14	15	50	6.12	15.28
15	16	51	6.48	12.52
16	17	52	7.64	11.44
17	18	1	8.92	8.60
18	19	2	9.44	8.44
19	20	3	9.82	7.84
20	21	4	10.38	5.68
21	22	5	12.52	3.20
22	23	6	14.88	1.64
23	24	7	17.54	1.24
24	25	8	17.62	0.98
25	26	9	17.66	0.92
26	27	10	17.42	0.84
27	28	11	17.58	0.18
SMW: Standard Meteorological Week, WAT: Week after transplanting				

Table 2: Correlation of serpentine leaf miner, *L. trifolii* and whitefly, *B. tabaci* with abiotic factors in tomato under poly house condition during 2014-15

Insect pests	Temperature		Relative Humidity	
	Maximum, ^{0}C (MaxT)	Minimum, ^{0}C (MinT)	Morning, % (RH_1)	Evening, % (RH_2)
No. of mines	-0.244	-0.595**	-0.557**	-0.516**
Whitefly	-0.383	-0.393	0.049	-0.017
* Significant at 5% level ** Significant at 1% level				

4. Conclusion

The activity of leaf miner and whitefly were recorded at weekly intervals and correlated with temperature and relative humidity during *Kharif*, 2014-15. The data on serpentine leaf miner oriented mines per three leaves per plant on tomato revealed that the mines were increasing with the increasing of SMW as the first peak (3.76 mines /3 leaves /plant) was observed after ninth week of transplanting (44th SMW) and thereafter population declining up to 46th week (11th WAT). Thereafter, the mines were continuously increased up to the second peak (17.66) *i.e.*, 9th SMW (26th WAT) and then the population was slightly declined. The initiation of whitefly

population was started from 40th SMW (5th WAT) with least population (0.06 whitefly / 3 leaves /plant) and continuously multiplied with higher rate. With the increasing trend, the highest whitefly population (17.60) was recorded during 49th SMW (14th WAT) and considered as a peak damaging stage during *Kharif*, 2014-15. A study on effect of various weather parameters on the fluctuation of leaf miner and whitefly population in tomato crop under poly house condition indicated that number of mines of leaf miner exhibited highly significant negative correlation with minimum temperature (r = -0.595**), morning humidity (r = -0.557**) and evening humidity (r = -0.516**) during 2014-15. In case of whitefly population, it was found negatively correlated with maximum temperature (-0.383), minimum temperature (-0.393) and evening humidity (r = -0.017) non-significantly while morning humidity (r = 0.049) showed the positive correlation non-significantly during 2014-15. The findings of present study revealed that all the weather parameters were found very less responsible for the population built up of whitefly.

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