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SEASONAL INCIDENCE OF TOMATO PINWORM, *TUTA ABSOLUTA* (MEYRICK) (GELECHIIDAE : LEPIDOPTERA)

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ABSTRACT : South American tomato pinworm, *Tuta absoluta* (Meyrick) (Lepidoptera : Gelechiidae), an invasive pest on tomato (*Solanum lycopersicum* Miller) is an oligophagous invasive alien pest associated with solanaceous crops. It causes reductions in yield and fruit quality up to 100 per cent both in greenhouses and open fields, if control measures are not applied (Shashank *et al*, 2015). Present study was conducted to understand the influence of weather parameters on *T. absoluta* in open field in 2017-18 to 2018-19. Infestation level of *T. absoluta* was low during early phenological cycle of the crop. Then onwards,*T. absoluta* density increased with advancement of the crop. During the present study, the incidence of *T. absoluta* showed the positive correlation with the maximum temperature, negative relation with relative humidity and rain fall. Based on the results, it is inferred that, management should be initiated in the early growth period itself to avoid build-up of the pest in the late phenological cycle of the crop.

Key words : Leaf miner, tomato pinworm, *Tuta absoluta*.

INTRODUCTION

South American tomato pinworm, *Tuta absoluta* (Meyrick) (Lepidoptera : Gelechiidae), an invasive pest on tomato (*Solanum lycopersicum* Miller), also known as the tomato leaf miner is an oligophagous pest associated with solanaceous crops. At present, India is the second largest producer, representing 11.5 per cent of the world's production and 18.27 per cent of area (Anonymous, 2018). In India, tomato is grown over an area of 8.08 lakh ha with an annual production of 196.97 lakh MT and productivity of 31.58 MT/ha (Anonymous, 2018). Recently, the production of tomato has been decreasing due to various factors including pests and diseases. Major insect problems encountered in tomato production are; the fruit borer, *Helicoverpa armigera* (Hub.), *Liriomyza trifolii* (Burgess) and sucking pests as direct feeders or those that act as vectors of pathogens (Lange and Bronson, 1981). The South American tomato pinworm, *T. absoluta* otherwise called the tomato leaf miner has assumed a major pest status in India soon after its introduction. It has been a key pest of tomato in the South American region since 1960s (Garcia and Espul, 1982) and it is native to South America (Urbaneja *et al*, 2013). It was recorded for the first time on tomato in India, from the state of Maharashtra during October, 2014 (Shashank *et al*, 2015) and in Karnataka at ICAR- Indian Institute of Horticultural Research (ICAR-IIHR), Hesaraghatta, Bengaluru, during the *rabi* 2014 (Sridhar *et al*, 2014). It causes reductions in yield and fruit quality up to 100 per cent both in greenhouses and open fields, if control measures are not applied (Shashank *et al*, 2015; Daniel *et al*, 2017). Larvae feed on leaves, buds, stem and fruits of tomato. Fruit rot occurs due to secondary invasion of pathogens into the fruits bored by this insect (Daniel *et al*, 2017). Introduced populations are probably resistant to the various group of insecticides and basic studies like population dynamics, life cycle, and reproductive biology are need of the hour to provide the information to devising management strategies. Keeping in view and the above considerations, the present investigation was undertaken.

MATERIALS AND METHODS

Arka Rakshak, a popular variety of tomato was grown for conducting experiment. The seeds were sown in portrays and maintained in the polyhouse of the Vegetable Science division during all the three different seasons (*Rabi* 2017, Summer and *Kharif* 2018). Main experimental field was prepared thoroughly by ploughing and harrowing to bring the soil to fine tilth. The seedlings of 25 days old were planted in an area of ten guntas with row-to-row and plant to plant spacing of 90 and 60 cm, respectively. Gap filling was done after one week of planting up to 15 days to maintain the optimum plant population. The crop was raised as per the Package of Practices of University of Horticultural Sciences, Bagalkot, except pest management (Anonymous, 2017). Two blocks of five guntas each were maintained separately to observe the population of tomato pinworm and the natural enemies associated with it. Observations on the tomato pinworm and their natural enemies were recorded from randomly selected and tagged 25 plants. The observations were made at weekly intervals from seven days after transplanting (DAT) during four seasons from 2017-18 to 2018-19. Larval population of *T. absoluta* was recorded by counting the number of mines having live larvae. Plant parts were examined thoroughly for the presence of the larvae. During early stage of the crop, whole plant was considered for taking observations. Later three leaves from bottom, middle and top were considered.

Influence of weather parameters on the incidence of *Tuta absoluta*

The weekly means of meteorological data on weather parameters *viz.*, maximum, minimum and average temperature (°C), morning and noon relative humidity (%) and total rainfall (mm), were obtained from the Agro Meteorological Observatory of MHREC, UHS, Bagalkot.

RESULTS AND DISCUSSION

Studies on seasonal incidence of tomato pinworm

***Rabi* 2017-18 (October 2017 to April 2018)**

The activity of *T. absoluta* was observed throughout the cropping period from transplanting to harvesting of tomato and it ranged from 0.01 to 12.33 larvae per three leaves. Incidence of larvae was initially noticed on crop during third week of November 2017 (46th SW) with a population of 0.01 per 3 leaves. The incidence increased drastically with advancement of the crop growth stage with a peak incidence of 12.33 larvae per 3 leaves during 15th SW (2nd week of April 2018). The larval population reached its peak towards maturity stage of the crop (fruiting and ripening of fruit) with 10.53 to 12.33 larvae per 3 leaves. The moderate population density with 1.16 to 2.60 larvae per three leaves was observed during 4th SW to 6th SW of 2018 (3rd week of January to 2nd week of February 2018). There was no incidence during 44th and 45th SW of (1st and 2nd week of November) 2017 (Table 1 and Fig. 1a).

The data on correlation analysis between different weather factors and larval population of *T. absoluta*are presented in Table 2. The larval population showed significantly positive correlation with temperature throughout the experimental period. *T. absoluta* had significant positive correlation with maximum temperature (r= 0.94), minimum temperature (r=0.68) and average temperature (r=0.85). Whereas, *T. absoluta* had significantly negative correlation with morning humidity (r=-0.72) and noon humidity (r=-0.67). But, there was non-significant negative correlation (r = -0.13) between larval population of *T. absoluta* and rainfall.

Multiple regression analysis between the major weather factors and larvalpopulation (Table 3) indicated that all the weather parameters contributed to significant variation in population of the pest. The contribution of all the major weather variables, as indicated by R^2 values was 93 per cent to the larval population fluctuation of *T. absoluta* during cropping period.

***Kharif* 2018 (June 2018 to November 2018)**

The cropping season witnessed very low larval population of *T. absoluta* on the crop particularly during the early growth stages of the crop (27th SW to 41st SW) with the population ranging from 0.40 to 3.08 larvae per three leaves (Table 1 and Fig. 1b). The peak incidence was observed during 39th SW (3.08 larvae/3 leaves) and followed a declining trend afterwards with the population reaching 1.00 to 0.52 between 40th and 41st SW of 2018.

The correlation analysis between different weather factors and *T. absoluta* larval population (Table 2) indicated that minimum temperature (r=-0.60) had significantly negative correlation with larval population but maximum temperature (r=-0.16) and average temperature (r=-0.10) had non-significant positive correlation with larval population. Whereas, *T. absoluta* showed non-significant positive correlation with morning humidity (r=0.26) and noon humidity (r=-0.67) had non-significant negative correlation with larval population. Rainfall exhibited a non significant positive correlation with larval population of *T. absoluta* (r = 0.45).

Multiple regression analysis on the effect of different weather parameters together on larval population of *T. absoluta* (Table 3) showed significant influence of the major weather parameters to the extent of 91 per cent.

***Rabi* 2018-19 (October 2018 to March 2019)**

The larval population was observed during major cropping period from 40th SW 2018 to 10th SW of 2019 and population ranged from 0.06 to 15.02 larvae per three leaves (Table 1). The incidence of tomato pinworm increased gradually with advancement of growth of crop. The peak incidence with maximum larval count (15.02 larvae/3 leaves) was recorded during the 10th SW of 2019. During the 5th to 10th SW of 2019, larval population varied

Plate 1 : Larvae of *Tuta absoluta*.

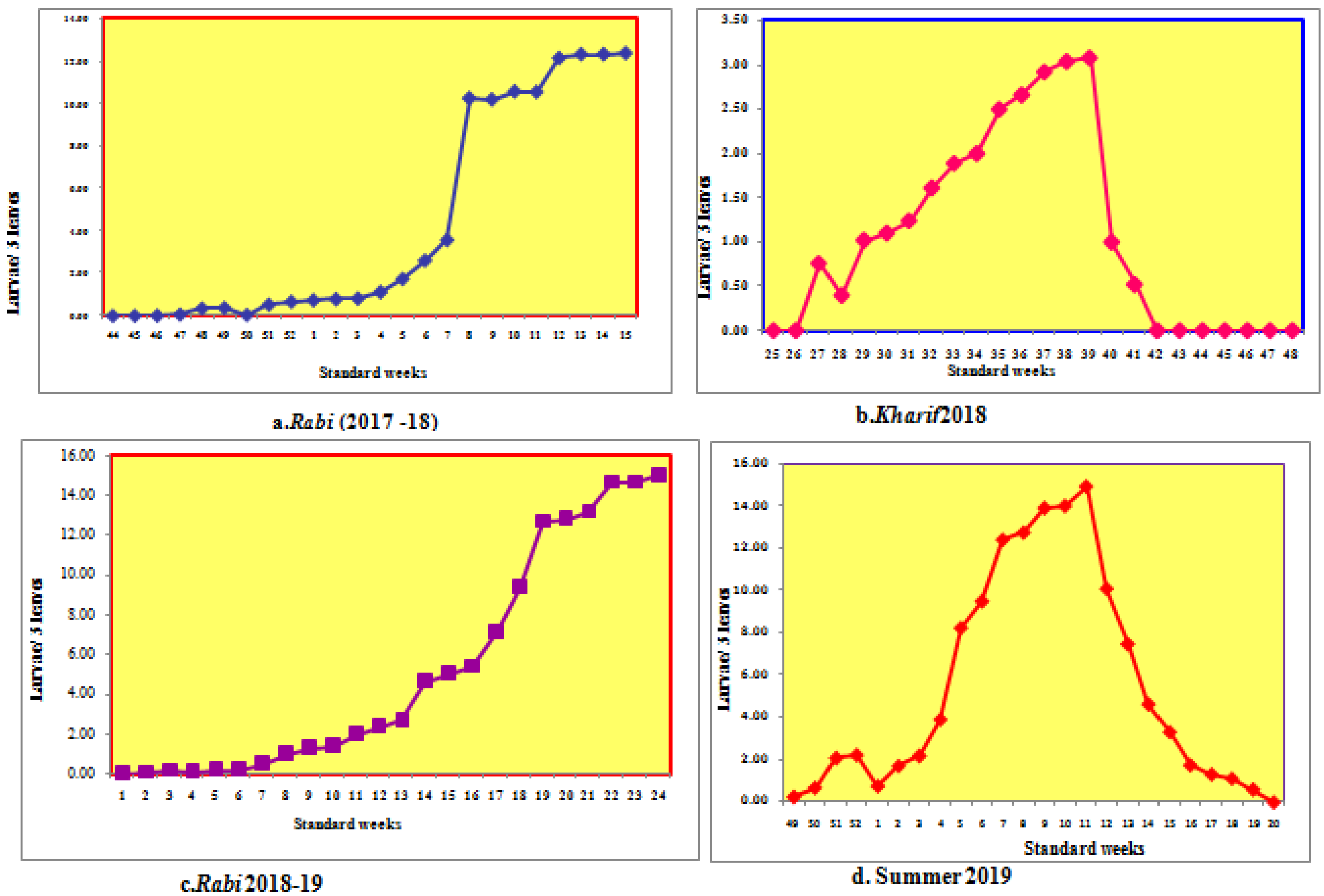

Fig. 1 : Seasonal incidence of tomato pinworm during different seasons.

from 12.69 to 15.02 larvae per three leaves (Fig. 1c).

Larval population of *T. absoluta* had non-significant negative correlation with minimum temperature (r = -0.37), average temperature (r = -0.02), morning relative humidity (r = -0.41) and rainfall (r = -0.24). Maximum temperature showed non-significant positive correlation (r=0.41). Noon relative humidity influenced negatively on the larval population of *T. absoluta* significantly (r = -0.77) (Table 2).

Multiple linear regression equations between the larval population and weather parameters revealed the contribution of weather parameters to the extent of 70

Table 1 : Incidence of tomato pinworm during 2017-18 to 2018-19.

S. No.	*Rabi* (2017 -18)		*Kharif* 2018		*Rabi* 2018-19		Summer 2019	
	SW	Larvae/3 leaves (Mean±SD)	SW	Larvae/3 leaves (Mean±SD)	SW	Larvae/3 leaves (Mean±SD)	SW	Larvae/3 leaves (Mean±SD)
1	44 (2017)	0.00 ± 0.00	25	0.00 ± 0.00	39	0.00 ± 0.00	49	0.25 ± 0.18
2	45	0.00 ± 0.00	26	0.00 ± 0.00	40	0.06 ± 0.06	50	0.68 ± 0.27
3	46	0.01 ± 0.01	27	0.76 ± 0.44	41	0.16 ± 0.09	51	2.10 ± 1.57
4	47	0.06 ± 0.06	28	0.40 ± 0.32	42	0.11 ± 0.08	52	2.24 ± 2.15
5	48	0.35 ± 0.22	29	1.02 ± 1.08	43	0.17 ± 0.13	1 (2019)	0.76 ± 0.35
6	49	0.38 ± 0.18	30	1.10 ± 1.05	44	0.22 ± 0.11	2	1.72 ± 1.21
7	50	0.04 ± 0.03	31	1.24 ± 1.03	45	0.53 ± 0.33	3	2.20 ± 2.14
8	51	0.53 ± 0.38	32	1.61 ± 1.13	46	1.01 ± 0.56	4	3.92 ± 2.47
9	52	0.67 ± 0.49	33	1.89 ± 1.27	47	1.28 ± 0.79	5	8.25 ± 4.66
10	1 (2018)	0.74 ± 0.63	34	2.00 ± 1.38	48	1.39 ± 1.08	6	9.51 ± 5.69
11	2	0.79 ± 0.63	35	2.50 ± 1.62	49	1.98 ± 1.08	7	12.42 ± 4.29
12	3	0.82 ± 0.71	36	2.66 ± 1.66	50	2.38 ± 1.30	8	12.76 ± 4.74
13	4	1.16 ± 0.92	37	2.92 ± 1.80	51	2.70 ± 1.35	9	13.92 ± 3.46
14	5	1.73 ± 0.68	38	3.04 ± 1.90	52	4.64 ± 1.91	10	14.02 ± 4.89
15	6	2.60 ± 1.22	39	3.08 ± 2.12	1(2019)	5.01 ± 1.98	11	14.94 ± 3.46
16	7	3.56 ± 0.97	40	1.00 ± 0.83	2	5.38 ± 1.54	12	10.10 ± 3.41
17	8	10.21 ± 2.36	41	0.52 ± 0.44	3	7.08 ± 2.86	13	7.48 ± 5.63
18	9	10.15 ± 4.16	42	0.00 ± 0.00	4	9.36 ± 2.58	14	4.64 ± 1.91
19	10	10.53 ± 3.56	43	0.00 ± 0.00	5	12.69 ± 4.07	15	3.32 ± 1.68
20	11	10.50 ± 2.05	44	0.00 ± 0.00	6	12.81 ± 4.70	16	1.76 ± 0.97
21	12	12.10 ± 2.65	45	0.00 ± 0.00	7	13.18 ± 4.40	17	1.32 ± 0.63
22	13	12.28 ± 2.63	46	0.00 ± 0.00	8	14.66 ± 2.62	18	1.12 ± 0.78
23	14	12.28 ± 2.65	47	0.00 ± 0.00	9	14.66 ± 2.19	19	0.60 ± 0.37
24	15	12.33 ± 2.32	48	0.00 ± 0.00	10	15.02 ± 3.37	20	0.00 ± 0.00

SD: Standard Deviation, SW: Standard Weeks.

per cent during cropping period (Table 3).

Rabi 2018-19 (December to May 2019)

The larval population of *T. absoluta* was found throughout the experimental period ranging from 0.25 to 14.94 larvae per three leaves. Initially the larval population was noticed during 49th SW of 2018 with 0.25 larvae per three leaves. The population increased with advancement of the crop stage. The peak incidence (14.94 larvae/3 leaves) of *T. absoluta* was recorded during the 11th SW. Later population declined towards the end of the cropping period reaching 0.60 per 3 leaves (19th SW 2019) (Table and Fig. 1c).

The larval population of *T. absoluta* had significant positive relation with maximum temperature (r = 0.91), minimum temperature (r = 0.81) and average temperature (r = 0.89). Noon relative humidity showed significantly negative correlation with the larval population but morning relative humidity (r=-0.47) and rainfall (r=-0.31) did not show any significant influence on larval population during the experimental period (Table 2).

The larval population was regressed with the abiotic parameters (Table 3). The influence of weather parameters on *T. absoluta* larval population was to the extent of 70 per cent (R^2 values) during the cropping season.

Every insect has its own favourable zone of weather parameters for multiplication and further population buildup, depending upon availability of resources. The results are in conformity with earlier reports of Andrew *et al* (2013), who suggested population development ceased at lower temperatures (7-10°C) and increased at higher temperatures (23°C and above). Assaf *et al* (2013) recorded the population density and infestation percentage of *T. absoluta* on tomato under polyhouse conditions at two locations of Iran (Duhok and Kurdistan) and documented maximum percentage infestation during September (100 and 72%, at Summel and Zawita, respectively). Similarly, maximum moths were (56.66 males/trap/week) caught in Summel during September. Simala *et al* (2011) reported eight peaks. Five peaks were recorded in the summer plantations and three peaks in winter plantations. The rate of increase in population reached a maximum during March-April. Similarly, Cocco

Table 2 : Correlation matrix between abiotic factors and *Tuta absoluta* during 2017 -18 to 2018-19.

Parameters	Maximum temperature (°C)	Minimum temperature (°C)	Average temperature (°C)	Morning RH (%)	Noon RH (%)	Rainfall (mm)
***Rabi* (2017 -18)**	0.94*	0.68*	0.85*	-0.72*	-0.67*	-0.13 ^{NS}
***Kharif* 2018**	0.16 ^{NS}	-0.60*	0.10 ^{NS}	0.26 ^{NS}	-0.21 ^{NS}	0.45 ^{NS}
***Rabi* (2018-19)**	0.41 ^{NS}	-0.37 ^{NS}	-0.02 ^{NS}	-0.41 ^{NS}	-0.77*	-0.24 ^{NS}
Summer 2019	0.23 ^{NS}	-0.01 ^{NS}	0.19 ^{NS}	-0.44 ^{NS}	-0.53*	-0.20 ^{NS}

* Significant at 5%, NS: Non Significant.

Table 3 : Multiple regression analysis between abiotic factors and incidence of tomato pinworm during 2017 -18 to 2018-19.

Different dependent factors (Y)	Prediction model (Regression Equation)	F value	R^2
***Rabi* (2017 -18) October 2017 to April 2018)**	$Y= -28.613 +6.618X_1+ 7.701 X_2-13.119 X_3-0.101 X_4+ 0.001X_5 -0.026X_6$	1.34	0.93
***Kharif* 2018 (June 2018 -October 2018)**	$Y = -7.978 -0.704 X_1+0.544X_2-0.155 X_3+ 0.159 X_4+ 0.004 X_5+0.043 X_6$	0.01	0.91
***Rabi* (2018-19) (September 2018 to March 2019)**	$Y=3.902 -23.407X_1-23.052X_2+46.563 X_3+0.289X_4-0.697X_5+0.092 X_6$	0.008	0.70
Summer 2019 (December 2018 to May 2019)	$Y =56.206 -1.271X_1+0.584 X_2+1.620 X_3+0.039X_4-0.795 X_5-7.062 X_6$	0.015	0.61

Y= Larval population /3 leaves
X_1= Minimum Temperature (^{0}C), X_2=Maximum Temperature (^{0}C), X_3=Average Temperature (^{0}C)
X_4 = Morning Relative Humidity (%), X_5 = Noon Humidity (%), X_6 = Rainfall (mm).

et al (2015) reported *T. absoluta* population to be low in winter and increased steadily in spring. Allache *et al* (2015); Balzan and Moonen (2012); Ramesh (2016) documented that the maximum population coincided with the end of crop cycle than the early stage of the cropping period, which was also seen in the present study. Incidence of *T. absoluta* was noticed from second fortnight of September onwards and continued till the harvesting. The peak activity of *T. absoluta* was during second fortnight of January at Raichur (Anonymous, 2016). Venkataramanaiah (2016) noticed maximum moth catches during 44th standard week (204.0 moths/trap) and lowest during 3rd standard week (8.00 moths/trap). Taram (2016) noticed peak seasonal activity of *T. absoluta* during February and March. Devaraj *et al* (2017) observed a low leaf infestation (5.92%) during November 2015 and fruit damage (1.59%) during July 2015, whereas, maximum leaf and fruit damage (27.7 and 13.99%, respectively) were noticed during February 2016. Nitin *et al* (2017) reported highest number of moths in traps during March and April. Similarly, the highest level of tomato borer infestation coincided during January to May and the lowest, during October to November (6 moths/trap). Incidence of *T. absoluta* during March to April reached maximum densities of 30 to 100 larvae per plant and the average infestation did not exceed 25 larvae per plant. El-Badawy *et al* (2017) also documented higher incidence of this pest in early summer and summer plantations. Nayana *et al* (2018) recorded low infestation level of *T. absoluta*both in *Kharif* and *Rabi* during first phenological cycle ofcrop and then populationdensity increased with age of crop under both polyhouse and open field condition, which was also confirmed in the present study. Spakal *et al* (2018) observed maximum incidence (3.6 larvae/plant and 28.2 mines/plant and fruit damage (10.93%)) during 41st SW. Zekeya (2019) reported higher population density of *T. absoluta* in dry season than in rainy season. According to Bacci *et al* (2019) population fluctuations of *T. absoluta* during rainy season were very low compared to dry season and reached highest peak. In addition, larval incidence correlated positively with temperature, wind velocity, photoperiod and rainfall.

In the present study, maximum temperature showed positive correlation with larval population in all the seasons and across the different months. Maximum infestation was noticed during summer months, which were hottest of the months during the study period. The present results are supported by the reports of Cocco *et al* (2015). The studies further revealed that rainfall had a negative relationship with the incidence pattern of *T. absoluta.* Infestation was very low in the month of November, which recorded less rain fall.

CONCLUSION

Tomato was attacked by the pinworm during all the stages and the population was observed to vary with season and stage of the crop. The peak incidence of larva was during 10^{th} SW of 2018. *T. absoluta* larval population had significant positive correlation with maximum temperature and average temperature while morning and noon humidity exhibited significant negative relation but rainfall exhibited non significant negative correlation.

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