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Seasonal abundance of tomato pinworm, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) on tomato in Western Maharashtra, India

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Abstract
An investigation was undertaken to study seasonal abundance of tomato pinworm, *T. absoluta* on field tomato in Western Maharashtra, India. The results showed that the infestation level of *T. absoluta* was low during the early phonological cycle of the crop. However, with the advancement of the crop, it was developed. Recorded population data was correlated with weather parameters. It was noticed that in *Kharif* correlation of larval population, leaf mines per plant, and fruit infestation by the pest is significantly positive with maximum temperature (^{0}C) and sunshine (hours/day). However, it was negative and significant with minimum temperature (^{0}C) and evening relative humidity. In *Rabi*, the correlation of the larval population was significantly positive with maximum temperature (^{0}C) and significantly negative with rainfall.

Keywords: tomato pinworm, *Tuta absoluta*, weather parameter, correlation, seasonal abundance

Introduction
Tomato (*Solanum lycopersicum* L.), a member of the family Solanaceae, is one of the most popular and extensively grown vegetables of both tropics of the world [1, 2, 3]. There are many impediments that come in the way of tomato production. Among them diseases and pests are the main impediments of tomato cultivation. Tomato requires protection from variety of pests, including pathogens, weeds, nematodes, insects and other arthropods. Wherever grown, tomato is a host for many kind of insect pests. All parts of the plants offer food, shelter and reproduction site for insect pests. Insect pests can cause severe damage to tomato vegetation and to fruits in the form of tissue destruction and aberration in shape or colour. Tomato leaf miner *Tuta absoluta* is an oligophagous pest associated with solanaceous crops. *T. absoluta* is one of the most destructive insect pest attacking tomato plant, *S. lycopersicum*. It is a South American originated pest, but this pest crossed several international borders and introduced in African, European, Middle East and Asian countries. In India this pest was initially observed in Pune on tomato plants grown in polyhouse and field during October 2014. Subsequently, the pest was identified from major tomato growing regions of Maharashtra viz., Pune, Ahmednagar, Dhule, Jalgoan, Nasik and Satara [4]. Subsequently pest was recorded from Karnataka [5, 6, 7], Tamil Nadu [8], Andhra Pradesh and Telangana [9], New Delhi [10], Gujarat [7], Madhya Pradesh [11], Punjab [12], Meghalaya [13], Himachal Pradesh [14] and Uttarakhand [15] causing severe damage to tomato in invaded areas in India. In Kerala it was first reported on brinjal in 2015 [16]. Further reporting of this pest from different states of India and neighbouring countries is still continue.

The pest is multivoltine having nearly 12 generations per year. The biological cycle is completed in 29-38 days, depending on the environmental conditions. Adults are nocturnal and usually hide during the day between leaves. Females lay eggs on the aerial parts of their host plants, and a single female can lay a total of about 260 eggs during its life time. Larvae passes through four larval instars. Pupation may take place in the soil, on the leaf surface or within the mines, depending on the environmental conditions. The pest may over winter in the form of egg, pupa or as adult [17].

This pest recorded in many states of India, information about its seasonal incidence and correlation with weather parameters in such diverse Indian climatic situation is still scares. So, this study was carried out to know the incidence and damage level of *T. absoluta* in *Kharif* and *Rabi* season.

2. Materials and Methods

2.1 Location of experiment

The study of seasonal abundance of tomato pinworm and its correlation with different weather parameters was carried out in farmer's field at Satara (Maharashtra). This study was carried out during *Kharif* 2018 and *Rabi* 2018-19. All the recommended cultivation practices were followed during the period of investigation except, plant protection measures.

2.2 Method of recording observations

From selected field three plots were selected having an area about 4.8 X 2.5 m2 for recording observations on tomato pinworm. Five randomly marked plants were selected form each plot for recording observations. Number of larvae per plant, Number of leaf mines per plant and per cent fruit damage were recorded on weekly basis.

$$\text{Per cent fruit infestation (Number basis)} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \text{ X } 100$$

2.3 Correlation with weather parameters

The observations on number of larvae per plant, number of mines per plant and percent fruit damage were correlated with six different weather parameters like total maximum temperature (^{0}C), minimum temperature (^{0}C), morning relative humidity (%), evening relative humidity (%) and bright sunshine hours (hour/day), rainfall (mm). Multiple regression analysis was also performed with same parameters. The weekly meteorological data were collected from nearest observatory from farmer field i.e. from Department of Agronomy, College of Agriculture Karad, Dist- Satara.

3. Results:

3.1 Seasonal incidence of tomato pinworm on tomato during *Kharif*, 2018

The incidence of tomato pinworm, *T. absoluta* on tomato crop has presented in Table 1. The data indicated that the pest incidence commenced from 31st SMW (1st week of August) with 0.6 larvae per plant. The tomato pinworm population ranged between 0.6 and 7.1 larvae per plant, with an average of 3.1 $\pm$ 1.8 larvae per plant. There was peak incidence of *T. absoluta* population during the crop growth period was observed at 40th SMW (1st week of October) with 7.1 larvae per plant.

The number of mines were recorded during crop growth period. Leaf mining due to larval damage was observed from 1st week of August and it ranged from 1.1 to 56.2 mines/plant. Maximum number of mines per plant was noticed in 41st SMW (2nd week of October). The mean number of mines per plant were 23.9 $\pm$ 20.2.

Fruit infestation was noticed from 2nd week of September. Fruit infestation ranged between 15.7 and 39.2 percent on number basis. The peak incidence of pinworm on fruit was observed during 41th SMW. The mean per cent fruit infestation was 28.0 + 8.6 during crop growth period.

Table 1: Seasonal abundance of tomato pinworm *T. absoluta* in *Kharif* 2018

Sr. No.	Meteorological Week	Period	Number of larvae/ plant	Number of mines/ plant	Per cent fruit infestation/ picking
1	28	09-07-18 to 18-07-18	0.0	0.0	0.0
2	29	16-07-18 to 22-07-18	0.0	0.0	0.0
3	30	23-07-18 to 29-07-18	0.0	0.0	0.0
4	31	30-07-18 to 05-08-18	0.6	1.1	0.0
5	32	06-08-18 to 12-08-18	1.1	2.1	0.0
6	33	13-08-18 to 19-08-18	1.8	3.6	0.0
7	34	20-08-18 to 26-08-18	2.4	8.1	0.0
8	35	27-08-18 to 02-09-18	2.8	12.3	0.0
9	36	03-09-18 to 09-09-18	3.1	22.8	15.7
10	37	10-09-18 to 16-09-18	3.0	27.1	20.5
11	38	17-09-18 to 23-09-18	3.8	36.7	27.9
12	39	24-09-18 to 30-09-18	4.3	42.9	32.4
13	40	01-10-18 to 07-10-18	7.1	50.4	39.2
14	41	08-10-18 to 14-10-18	4.6	56.2	32.3
Mean (±SD)			3.1 (±1.8)	23.9 (±20.2)	28.0 (±8.6)

3.2 Seasonal incidence of tomato pinworm on tomato during *Rabi*, 2018-19

The data recorded about incidence of tomato pinworm on tomato crop during *Rabi* season is presented in table 2. The data indicated that the pest incidence commenced from 42nd SMW (3rd week of October) with 0.5 larvae per plant. The tomato pinworm population was ranged between 0.5 and 6.6 larvae per plant, with an average 3.9 $\pm$ 1.4 larvae per plant during the season. The peak incidence of *T. absoluta* population during the crop growth period was observed at 44th SMW (1st week of November) with 6.6 larvae per plant.

Leaf mining due to larval damage was observed in 42th SMW (3rd week of October) and ranged from 3.1 to 61.1 mines/plant. Maximum number of mines per plant was noticed in 3rd SMW (3rd week of January). The mean number of mines per plant was 35.7 + 18.8. Fruit infestation was noticed from 50th SMW (2nd week of December). Fruit infestation was ranged from 26.4 to 35.6 percent on number basis. The mean per cent fruit infestation was 30.9 $\pm$ 3.6 observed during crop growth period.

Table 2. Seasonal abundance of tomato pinworm *T. absoluta* in *Rabi*, 2018-19

Sr. No.	Meteorological Week	Period	Number of larvae/ plant	Number of mines/ plant	Per cent fruit infestation/ picking
1	42	15-10-18 to 21-10-18	0.5	3.1	0.0
2	43	22-10-18 to 28-10-18	2.9	9.0	0.0
3	44	29-10-18 to 04-11-18	6.6	14.0	0.0
4	45	05-11-18 to 11-11-18	4.3	20.3	0.0

5	46	12-11-18 to 18-11-18	4.9	27.9	0.0
6	47	19-11-18 to 25-11-18	5.1	31.8	0.0
7	48	26-11-18 to 02-12-18	4.6	33.1	0.0
8	49	03-12-18 to 09-12-18	4.2	41.1	0.0
9	50	10-12-18 to 16-12-18	4.1	42.1	34.1
10	51	17-12-18 to 23-12-18	3.7	52.3	35.6
11	52	24-12-18 to 31-12-18	3.5	52.9	28.3
12	1	01-01-19 to 07-01-19	3.8	54.9	32.1
13	2	08-01-19 to 14-01-19	3.1	55.6	28.6
14	3	15-01-19 to 21-01-19	2.9	61.1	26.4
Mean (±SD)			3.9 (±1.4)	35.7 (±18.8)	30.9 (±3.6)

3.3 Correlation between weather parameters and incidence of tomato leaf miner during *Kharif*, 2018 under field condition

The correlation studies carried out during *Kharif* 2018 between Tuta absoluta and weather parameters revealed that, larval population of pinworm correlated significantly positive with maximum temperature (0.810**) and bright sunshine hours (0.737**). Whereas, it was negative and significant with minimum temperature (-0.650*) and evening relative humidity (-0.720**). The correlation of no. of mines/plant was significantly positive with maximum temperature (0.936**) and bright sunshine hours (0.805**). However, it was negative and significant with minimum temperature (-0.573*) and evening relative humidity (-0.937**). The per cent fruit infestation was correlated significantly positive with maximum temperature (0.949**) and bright sunshine hours (0.802**). While, significantly negative with minimum temperature (-0.582*) and Evening relative humidity (-0.936**). Correlation of *T. absoluta* population with rainfall and morning relative humidity was non-significant.

3.4 Correlation between weather parameters and incidence of tomato leaf miner during *Rabi*, 2018-19 under field conditions

During *Rabi* 2018-19 correlation between *T. absoluta* and weather parameters indicated that, larval population was significant and positively correlated with maximum temperature (0.739**) and it was negative and significant with rainfall (-0.654*), while non-significant with minimum temperature, morning relative humidity, evening relative humidity and bright sunshine hours. The correlation of total no. of mines/plant was positive and significant with maximum temperature (0.783**) and morning relative humidity (0.610*). However, significantly negative with rainfall (-0.565*). The per cent fruit infestation showed positive and significant correlation with maximum temperature (0.744**). While, significantly negative with minimum temperature (-0.704**). Correlation of *T. absoluta* population with rainfall and relative humidity and bright sunshine hours was non-significant.

Table 3: Correlation coefficient (r) between weather parameters and incidence of tomato pinworm in *Kharif 2018* in field condition

Particulars	Correlation coefficient					
	Temperature (^{0}C)		Relative humidity (%)		Sunshine (hours/day) (X_5)	Total rainfall (mm) (X_6)
	Maximum (X_1)	Minimum (X_2)	I (X_3)	II (X_4)		
Total no. of larvae/ plant	0.810**	-0.650*	0.345 ^{NS}	-0.720**	0.737**	-0.333 ^{NS}
Total no. of mines/ plant	0.936**	-0.573*	0.060 ^{NS}	-0.937**	0.805**	-0.380 ^{NS}
% Fruit infestation/ Plant	0.949**	-0.582*	0.033 ^{NS}	-0.936**	0.802**	-0.351 ^{NS}
** correlation is significant at the 0.01 level (r = 0.661) N= 14			* correlation is significant at the 0.05 level (r = 0.533)			

Table 4: Correlation coefficient (r) between weather parameters and incidence of tomato pinworm in *Rabi*, 2018-19 in field condition

Particulars	Correlation coefficient					
	Temperature (^{0}C)		Relative humidity (%)		Sunshine (hours/day) (X_5)	Total rainfall (mm) (X_6)
	Maximum (X_1)	Minimum (X_2)	I (X_3)	II (X_4)		
Total no. of larvae/ plant	0.739**	-0.101 ^{NS}	-0.416 ^{NS}	0.154 ^{NS}	0.293 ^{NS}	-0.654*
Total no. of mines/ plant	0.783**	-0.896**	0.610*	-0.192 ^{NS}	0.070 ^{NS}	-0.565*
% Fruit infestation/ Plant	0.744**	-0.704**	0.477 ^{NS}	0.002 ^{NS}	-0.086 ^{NS}	-0.349 ^{NS}
** correlation is significant at the 0.01 level (r = 0.661) N= 14			* correlation is significant at the 0.05 level(r = 0.533)			

Discussion

The above findings are in confirmation with the earlier research work done by [18] who found that seasonal incidence of *T. absoluta* on tomato in Karnataka state. Infestation of *T. absoluta* started in 2nd week of August and increased its infestation in subsequent weeks. Infestation level was low in both seasons during first phonological cycle and at the end of crop cycle *T. absoluta* infestation increased due to rising temperature and availability of food. The negative influence was observed when *T. absoluta* population was correlated with minimum temperature, rainfall and afternoon relative humidity, also non-significant but positive correlation with maximum temperature and bright sunshine hours. These results gives more corroboration to current findings. These

results were confirmative with [19, 20, 21]. Several other researcher reported the initial slow increase in *T. absoluta* population but rapid increase in later period. Also current findings corroborative with findings of [22].

Conclusion

Infestation level of *T. absoluta* noticed low at first phonological cycle of the crop but as per the advancement of crop, pest build up a considerable population density. Better to follow management tactics at early stage of the crop. The seasonal abundance of pest and correlation with weather parameters may assist to develop the suitable forewarming model in initiation of insecticide application

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