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Population dynamics of major insect pests infesting to tomato, *Lycopersicon esculentum* (Miller)

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Abstract
The present investigation was carried out on population dynamics of major insect pests of tomato at Research Farm of Department of Agricultural Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani - 431402 (Maharashtra), India during *Kharif* 2018-19. The results revealed that the appearance of sucking pests, fruit borer and leaf miner on tomato was recorded two weeks after transplanting up to the end crop season. However, the peak incidence of sucking pests i.e. aphids (*Aphis gossypii* Glover), whitefly (*Bemisia tabaci* Gennadius) and thrips (*Frankliniella schultzei* Trybom) of 8.0, 10.2 and 6.7 population/3 leaves of plant on 41st, 42nd and 44th standard meteorological week (SMW), respectively. Whereas, the peak activity of tomato fruit borer, *Helicoverpa armigera* (Hubner) was recorded on 41st SMW (3.7 larvae/plant) and tomato leaf miner, *Tuta obsoluta* (Meyrick) was reached its peak on 41st SMW (3.5 larvae/ 3 leaves/ plant). As regards the fruit damage, the tomato fruit borer, *H. armigera* and leaf miner, *T. obsoluta* was recorded of 44.48 and 10.58 per cent fruit damage at the time of 6th picking i.e. the last picking of the fruit on 20th November.
The relationship of the insect pests with the abiotic factors revealed that the maximum temperature (r = 0.606**, 0.679**, 0.706**, 0.638** and 0.618**), Evaporation (r = 0.592**, 0.658**, 0.704**, 0.622** and 0.645**) and Bright sunshine hours (0.601**, 0.625**, 0.726**, 0.570* and 0.683**) was highly significantly positive correlated with tomato fruit borer, leaf miner, aphid, whitefly and thrips population, respectively. While, negative significantly / non-significantly correlated with minimum temperature (r = -0.414, -0.522*, -0.822**, -0.399 and -0.729**), morning relative humidity (R = -0.285, -0.544*, -0.630**, -0.328 and -0.479*), morning relative humidity (r = -0.631**, -0.755**, -0.900**, -0.657** and -0.795**), rainfall (r = -0.216, -0.274, -0.383, -0.232 and -0.258) and wind speed (r = -0.489*, -0.551*, -0.634**, -0.499* and -0.543*), respectively.

Keywords: Population dynamics, insect pests, tomato

Introduction
Tomato, *Lycopersicon esculentum* (Miller), is one of the most popular and nutritive vegetable crops grown all over the world. Tomato belongs to family Solanaceae and is native of Peru and México. It is a warm season crop. It is grown as an offseason vegetable in the hills of India and farmers fetch good income. The fruit can be eaten raw or cooked. Tomato in large quantities is used to produce soup, juice, ketchup, puree, paste and powder. Tomato fruit contain water 93%, protein 1.9%, fat 0.3 g, fibre 0.7%, carbohydrates 3.6%, calorie 23, vitamin ‘A’ 320 I.U., vitamin ‘B1’ 0.07 mg, vitamin ‘B2’ 0.01mg, vitamin ‘C’ 31 mg, nicotinic acid 0.4 mg, calcium 20 mg, phosphorus 36 mg and iron 0.8 mg.
Globally, India ranks second in tomato production after China. The area under cultivation of vegetables was 10383 thousand hectare with production of 179692 thousand metric tons during 2017-18 (Anonymous, 2018) [1]. In India, tomato was grown in an area of 786 thousand hectare with production of 19377 metric tons during 2017-18. The area of tomato in Maharashtra was 50 thousand hectares with production of 1200 thousands metric ton and productivity 24 metric tons per hectare.
In India, productivity of tomato is very low as compare to its production potential of the developed countries. There are many factors for low production potential, among them insect-pests infestation is one of the major factors that is responsible for reduction in productivity. The production and quality of tomato fruits are considerably affected by array of insect pests infesting at different stages of crop growth. Though there are number of pests on tomato, some of them causes great to economic damage, some important insect pests include, Fruit borer, *Helicoverpa armigera (*Hubner), *Spodoptera litura (*Fabricus), sucking pests like whitefly, *Bemisia tabaci* (Gennadius), aphid, *Aphis gossypii* (Glover) and thrips *Frankliniella schultzei* (Trybom). *Ferrisisa virgate* (Cockerell), serpentine leaf miner, *Liriomyza trifoli* (Burgess) and Tomato Leaf miner, *Tuta obsoluta* (Meyrick).

The sucking pests *viz.*, aphid, whiteflies and thrips cause severe damage to crop by transmitting virus disease rather than direct feeding. In sucking pest complex, whitefly is important as it imparts direct damage to the crop by desaping and also acts as vector for transmission of leaf curl virus disease in tomato (De Barro, 1995 and Jones, 2003) [4, 7]. Yield losses due to direct and indirect damage caused by whiteflies were reported to the extent of 20 to 100% (Papisarta and Garzia, 2002) [14]. Considerable economic losses due to *H. armigera* reported by many workers to the extent about 50-80% (Tewari and Moorthy, 1984) [18]. And Tomato leaf miner, *Liriomyza trifoli* (Burgess) can cause damage up to 90% under greenhouse and field conditions.

As the meteorological parameters play a vital role in the biology of any pest, the interaction between pest activity and abiotic factors will help in deriving at predictive models that aids in forecast of pest incidence. Any pest management programme will require the use of monitoring practices to be effective. It is, therefore, imperative to study the population fluctuation of the crop pest in relation to weather parameters that largely direct the activity of a given species of insect pest. Muhammad *et al.* (2014) [10] reported that the occurrence of climate change is evident from increase in global average temperature, changes in the rainfall pattern. The seasonal and long term changes would affect the fauna, flora and population dynamics of pests. The abiotic parameters are known to have direct impact on insect population dynamics. Therefore, keeping in view the economic importance of the crop and the magnitude of the damage caused by various insect pests, the present study was carried out to study the population build up of major insect pests on tomato in relation to the abiotic factors.

Materials and Methods

Field experiment was conducted on population dynamics of major insect pests of tomato during *Kharif* 2018 at Research Farm of Department of Agril. Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra), India. The climate is subtropical and is situated on 408-500 m above mean sea level. It lies between 18°58' to 20.2' North latitude and 76°47' to 77°4' East longitude. The mean annual rainfall of Parbhani is 903 mm receiving mostly during June to September and mean maximum temperature vary from December to May. The mean temperature vary from 11.3 °C to 25.7 °C in winter. The experiment was conducted on tomato crop cv. Laxmi (Hybrid) in non-replicated plot design in 10 x 10 m^2 in quadrate having spacing of 60 cm x 60 cm. The crop was transplanted on 06th July, 2018 and the crop season was up to the last picking of the fruit i.e. fourth week of November, 2018.

The observation on the incidence of aphids, whitefly and thrips was recorded at weekly interval in morning hours starting from initial appearance to final disappearance or harvest of the final fruits. The observations on nymphs and adult of sucking pests was recorded on three leaves per plant from the top, middle and bottom in five randomly selected plants and express to the number of population three leaves per plant. The observation on larval population of tomato fruit borer was recorded on five randomly selected and tagged plants and similarly, the larval population of tomato leaf miner was recorded on three leaves per plant from the top, middle and bottom in five randomly selected plants The per cent fruit damage was also worked out by recording the total number of fruits and number of damaged fruits due to fruit borers at each picking on five randomly selected and tagged plants as per following formula.

$$\text{Per cent fruit damage} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits}} \times 100$$

The meteorological data *viz.*, temperature, humidity, rainfall, evaporation, wind velocity and bright sunshine hours during the cropping period was obtained from the Meteorological Observatory, VNMKV, Parbhani. The correlation analysis was done to find out the relationship between incidence of sucking pests and fruit borers with weather parameters. The data was statistically analyzed by standard analysis of variance method suggested by Panse and Sukhatme (1967) [13].

Results and Discussion

The data on seasonal abundance of sucking pests (aphids, whitefly and thrips), fruit borer and leaf miner on tomato during *Kharif* 2018-19 and worked out their correlation with weather parameters and the results are presented in Table 1 and 2 and graphically depicted in Fig. 1.

Table 1: Population dynamics of major insect pests of tomato during *kharif* 2018-19

Std. Met. Week	Period	Population / 3 leaves			Fruit borer/ larvae/ plant	Leaf miner larvae/3 leaves	Rainfall (mm)	Temperature (°C)		Relative humidity (%)		EVP (mm)	BSS (hrs/ day)	Wind speed (kmps)
		Aphids	Whitefly	Thrips				Max.	Min.	Morn.	Even.			
29	16-22 July	1.2	0.0	0	0.0	0.0	1.8	30.5	22.0	80	66	3.7	7.1	6.2
30	23-29 July	1.4	0.0	0.1	0.0	0.0	0	29.7	22.5	81	68	3.0	0.8	4.1
31	30-05 Aug.	2.3	0.6	1.8	0.0	0.0	0	33.6	22.0	77	48	4.9	5.4	5.0
32	06-12 Aug.	28	1.9	2.2	0.5	0.1	0	29.5	21.5	81	63	4.6	0.0	5.5
33	13-19 Aug.	1.4	2.6	1.8	1.0	0.3	59.4	23.3	21.2	100	100	0.0	0.3	7.3
34	20-26 Aug.	1.6	4.9	1.9	1.8	0.8	3.2	30.2	20.6	95	62	2.4	1.1	6.2
35	27-02 Sep.	3.8	4.7	2.5	2.2	1.0	0	29..8	20.0	79	61	4.8	9.8	5.2
36	03-09 Sep.	4.2	6.7	3.2	2.3	1.3	0	31.0	20.0	78	55	5.4	8.5	7.0
37	10-16 Sep.	5.2	7.3	4.1	2.5	1.5	0	33.5	19.6	86	41	5.7	6.9	3.6
38	17-23 Sep.	4.9	7.6	4.3	2.8	1.7	1.8	34.2	19.6	89	41	3.5	5.6	3.8
39	24-30 Sep.	5.0	8.4	4.6	3.4	1.9	0	34.5	20.3	86	41	5.8	8.5	2.2
40	01-07 Oct.	5.8	9.9	5.3	3.5	2.7	0	34.5	20.5	79	41	6.0	9.5	3.0
41	08-14 Oct.	8.0	10.0	5.0	3.7	3.5	0	36.0	17.2	64	16	6.5	7.5	3.7
42	5-21 Oct.	5.6	10.2	4.9	3.2	3.3	0	34.4	18.0	74	27	6.0	7.4	2.9
43	22-28 Oct.	6.6	8.5	6.2	2.9	2.0	0	34.0	18.5	70	33	6.1	8.5	3.2
44	29-04 Nov.	6.5	7.5	6.7	2.8	2.5	0	32.2	15.5	73	29	6.4	10.0	6.4
45	05-11 Nov.	6.9	6.6	5.9	2.3	2.7	0	33.5	16.3	71	35	5.0	9.6	2.5
46	12-18 Nov.	7.9	5.5	5.2	2.2	1.5	0	33.5	11.0	81	19	4.7	9.8	2.6
47	19-25 Nov.	7.2	4.4	5.5	1.5	1.4	0	32.2	14.0	76	28	4.6	8.4	3.8

Table 2: Correlation of weather parameters with incidence of pest complex in tomato

	Temperature		Relative Humidity		Rainfall	EVP	BSH	WS
	Max.	Min.	Mor.	Eve			(hr)	(Km/h)
Fruit borer	0.606**	-0.414	-0.285	-0.631**	-0.216	0.592**	0.601**	-0.489*
Leaf miner	0.679**	-0.522*	-0.544*	-0.755**	-0.274	0.658**	0.625**	-0.551*
Aphid	0.706**	-0.822**	-0.630**	-0.900**	-0.383	0.704**	0.726**	-0.634**
Whitefly	0.638**	-0.399	-0.328	-0.657**	-0.232	0.622**	0.570*	-0.499*
Thrips	0.618**	-0.729**	-0.479*	-0.795**	-0.258	0.645**	0.683**	-0.543*

*Significant at *p* =0.05%, *r* (5%) = 0.456 and *r* (1%) = 0.575

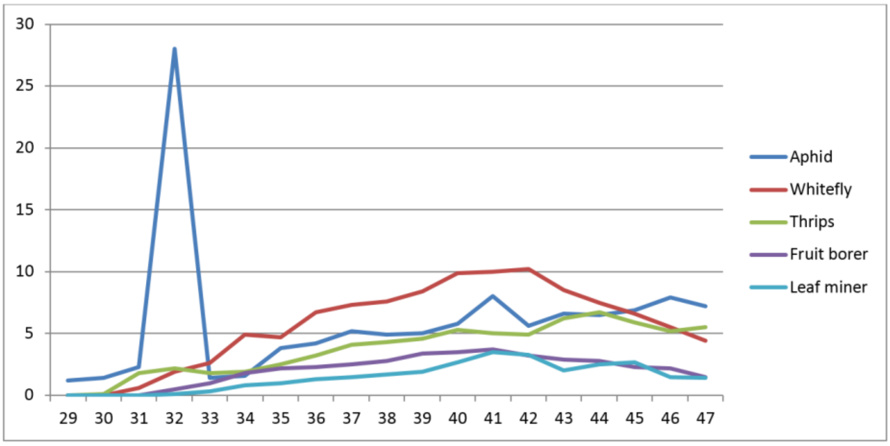

Fig 1: Population dynamics of major insect pests of tomato during *kharif* 2018-19

Aphid, ***Aphis gossypii***:

The population of aphid was recorded from 18th July to 25th November (29th SMW to 47nd SMW). The population ranged from 1.2 aphids/3 leaves (29th SMW) and there after the population reaches to 5.2 aphids /3 leaves in the 37th SMW and reached its peak level of infestation (8 aphids /3 leaves) on 41th SMW. Second peak was on 46th SMW (7.9 aphids/3 leaves) and at the end of season the aphis population was 7.2 aphids/3 leaves on 47th SMW.

The correlation of aphids population results revealed that there was highly significant positive correlation of aphid incidence with maximum temperature (r = 0.706**), EVP (r = 0.704**) and BSH (r = 0.726**). Whereas, relationship of minimum temperature (r= -0.822**), morning RH (r = -0.630**), evening RH (r = -0.900**) and WS (r = -0.634**) were highly significantly negative and also rainfall (r = -0.383) was negatively non significant with aphid population. These present results are in accordance with the results reported by Muhammad *et al.* (2014) [10], aphid population showed significant negative correlation with minimum and maximum temperature, whereas significant positive correlation with relative humidity, and non significant correlation with rainfall.

Whitefly, *Bemisia tabaci*:

The population of whitefly was recorded from 30th July to 22th November (31th SMW to 47nd SMW). The incidence of whitefly started from 31st SMW (0.60/3 leaves) and there after increasing in population and reached its peak (10.2 whiteflies /3 leaves) on 42nd SMW. Then population decreases up to the end of cropping season (47nd SMW) with 4.4 whiteflies /3 leaves.

The relationship between whitefly incidence and maximum temperature (r = 0.638**) and EVP (r = 0.622**) was highly significantly positive correlated and BSH (r = 0.570*) also found positively significant. The relationship of evening RH (r = -0.657**) was highly significantly negative and WS (r = -0.499*) was significantly negative correlated with whitefly incidence. Minimum temperature (r = -0.399), rainfall (r = -0.232) and morning RH (r = -0.328) play a role of negatively non significant with whitefly population. The present findings are supported with the results of Subba *et al.* (2017) [17] who reported that the weekly population counts on whitefly showed non-significant negative correlation with temperature and rainfall, whereas significant negative correlation with relative humidity.

Thrips, *Frankliniella schultzei*:

The population of thrips was recorded from 28th July to 20th November (30th SMW to 47nd SMW). The incidence of thrips started from 30th SMW (0.1 thrips /3 leaves) and it was reached its peak (5.3 thrips /3 leaves) in 40th SMW and second peak was recorded on 44th SMW (6.7 thrips /3 leaves) and there after the population was decreases and reached 5.5 thrips/3 leaves on 47th SMW i.e. end of the season.

The correlation with thrips population revealed that maximum temperature (r = 0.618**), EVP(r = 0.645**) and BSH (r = 0.683**) was highly positively significant correlated. Minimum temperature (r = -0.729**), morning RH (r = -0.479*), evening RH (r = -0.795**) and WS (r = -0.543*) was negatively significant relationship with thrips incidence and rainfall (r = -0.258) was also negatively non significant with thrips population.

Tomato fruit borer, *H. armigera*:

The population of *H. armigera* was recorded from 12th August to 25th November (32nd SMW to 47th SMW). The incidence started from 32nd SMW (0.5 larva/plant) to 47th SMW (1.5 larvae/ plant) and the population reached its peak of 3.7 larvae/plant in the 41st SMW and thereafter decreases in population up to the end of season i.e. 47th SMW. These findings are in confirmation with Kamble *et al.* (2005) [8] who reported first incidence of *H. armigera* on 35th SMW with the peak larval population on 37th SMW and then population decreased until the 44th SMW, *H. armigera* had 2 generations on tomato. The peak larval population coincided with the flowering and fruiting season. Nadaf and Kulkarni (2006) [11] recorded peak fecundity of *H. armigera* during second fortnight of September and peak incidence of larvae during November first fortnight. *H. armigera* larvae ranged from 1.45 to 2.02 larvae/plant.

The relationship between fruit borer, *H. armigera* incidence and maximum temperature (r = 0.606**), EVP (r = 0.592**) and BSH (r = 0.601**) was recorded significant highly positive. Whereas the significant highly negative with evening RH (r = -0.631**) and significant negative with WS (r= -0.489*) and minimum temperature (r = -0.414), rainfall (r = -0.216), morning RH (r = -0.285) was also are negatively non significant correlated with the larval population of *H. armigera*. The similar results are reported by Nadaf and Kulkarni (2006) [11] revealed that maximum temperature showed significant positive relation with incidence of *H. armigera* larvae. Whereas, Kamble *et al.* (2005) [8] reported the population of larvae was non-significantly correlated with minimum and maximum temperatures, rainfall and minimum and maximum relative humidity. Chula *et al.* (2017) [3] reported that the maximum and minimum temperatures, wind velocity and sunshine showed significantly positive correlation with occurrence of tomato fruit borer, *H.armigera* (Hub.) on tomato, whereas, the relative humidity and rainfall showed negative significant correlation with fruit borer population.

Tomato Leaf miner, *T. absoluta*:

The incidence of leaf miner started from 32nd SMW. (0.1 larva/3 leaves/plant) which was reached its peak (3.5 larvae /3 leaves) in 41st SMW and the highest population recorded during fruiting stage in the month of October. There after the population were decreases and further increases in population of 2.7 larvae/3 leaves on 45th SMW. The present findings are in corroborated with the results of Nitin *et al.* (2017) [12] who reported that *T. absoluta* frequency reached maximum densities of 30-100 larvae/plant during March-April and infestation did not exceed 25 larvae / plant during October to November.

The maximum temperature (r = 0.679**), EVP (r = 0.658**) and BSH (r = 0.625**) showed highly positive significant relationship between leaf miner and evening RH (r = -0.755**), minimum temperature (r = -0.522*), morning RH (r = -0.544*), WS (r = -0.551*) was correlated with negatively significant and negatively non-significant with rainfall (r = -0.274). These findings are in confirmation with the results are reported by Selvaraj *et al.* (2016) [15], who reported that pest population exhibit non significant correlation with various abiotic factors, except significant positive correlation with sunshine hours and significant negative correlation with morning and evening relative humidity. Variya and Patel (2012) [19] indicated that number of mines, larvae as well as percent damaged leaves by leaf miner (*L. trifolii*) had significant negative correlation with negative temperature. Mines and larvae significantly and negatively correlated with morning vapour pressure deficit and evening relative humidity.

Per cent fruits damage

The data recorded on per cent of damaged fruits by *H. armigera* and *T. absoluta* on tomato during *kharif* 2018-19 are presented in Table 3. The damaged fruits were recorded picking wise from 1st Sept. to 20th Nov. (35th SMW to 47th SMW). The fruit infestation was recorded from 1st picking of 28.32, 7.08 and 35.40 per cent fruit damage by *H. armigera, T. absolut* and total fruit damage, respectively and reached its pick level at 6th picking on 1st November i.e. last picking of 44.48, 10.58 and 55.06 per cent, with the average fruit damage of six pickings was 38.08, 8.57 and 46.66 per cent, respectively, respectively. The peak level of per cent of fruits damage coincided with the fruiting stage of crop. Overall the infestation of *H. armigera* and *T. absoluta* was severe from October month onwards and yield loss of tomato was higher during this period. These findings are in accordance with the results of earlier research workers, Singh and Gupta (2017) [16] who reported that initial fruit infestation by *H. armigera* was recorded in November. Correlation of *H. armigera* fruit damage (%) with maximum temperature was strongly positively (r= 0.5082 and 0.5393) and similarly with minimum temperature (r= 0.5880 and 0.6866) as well. Kumar *et al*. (2013) [9] observed that 40 to 60 per cent tomato fruits losses by fruit borer (*H. armigera*) between 21th - 25th standard weeks. Chula *et al.*, (2017) [3] reported that the occurrence of tomato fruit borer *H.armigera* (Hub.) commenced from 8th standard week (February third week) with an average population of 2.04% infestation. Chakraborty (2011) [2] observed the highest level of damage 18.45 and 24.43 per cent in timely sown and late sown crop, respectively. Desneux *et al.* (2010) [5] reported that rapidly invaded pest cause up to 80- 100 % yield loss. Ganapathy *et al.* (2010) [6] revealed that incidence of leaf miner was least (9.0%) in November and maximum (32.5%) in March. During July-August also incidence levels were higher to an extent of 28.3 and 26.2 per cent, respectively. In the cooler months the incidence was comparatively low (9.0 to 13.70%). Thus the above reports are more or less corroborated with the present findings.

Table 3: Per cent fruit damage by tomato fruit borer, *H. armigera* and tomato leaf miner, *T. absoluta*

Number of picking	Date of picking	Per cent damaged fruits		
		H. armigera	***T. absoluta***	**Total**
1st	1st Sept.	28.32	7.08	35.40
2nd	20th Sept.	34.55	7.10	41.65
3rd	1st Oct.	39.12	8.55	47.67
4th	20th Oct.	40.05	9.02	49.07
5th	1st Nov.	42.00	9.14	51.14
6th	20th Nov.	44.48	10.58	55.06
Average		38.08	8.57	46.66

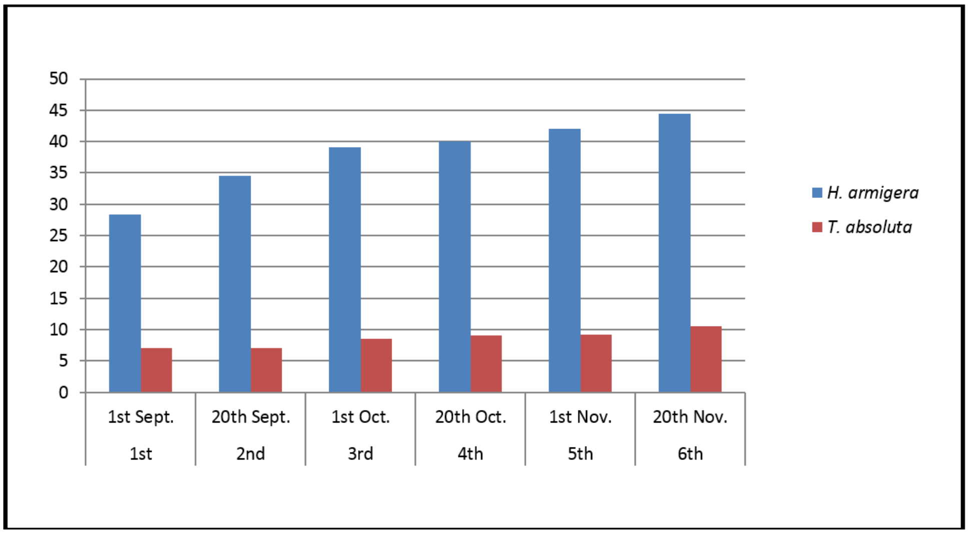

Fig 2: Per cent fruit damage by tomato fruit borer, *H. armigera* and tomato leaf miner, *T. absoluta*

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