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Seasonal population dynamics of natural enemies in tomato in relation to weather parameters in the Chhattisgarh plains

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Abstract

The study on the seasonal incidence of mirid bugs, spiders, and ladybird beetles in tomato (*Solanum lycopersicum* Mill.) was conducted during the Rabi seasons of 2016–17 and 2017–18 at the Horticulture Research-cum-Instructional Farm, Department of Vegetable Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. Based on the pooled data of both years, the maximum populations of the mirid bug (*Nesidiocoris tenuis*) were recorded during the 3rd Standard Meteorological Week (SMW) (3.5 adults plant^{-1}) and 4th SMW (3.4 adults plant^{-1}) during the Rabi seasons of 2016–17 and 2017–18, respectively. Correlation analysis revealed a non-significant negative association between mirid bug population and maximum temperature (r = −0.391), minimum temperature (r = −0.441), wind velocity (r = −0.181), and sunshine hours (r = −0.013). However, positive correlations were observed with rainfall (r = 0.104), morning relative humidity (r = 0.212), and sunshine hours (r = 0.041). The maximum spider populations were recorded during the 6th SMW (0.36 adults plant^{-1}) and 3rd SMW (0.33 adults plant^{-1}) during the Rabi seasons of 2016–17 and 2017–18, respectively. Spider population exhibited a non-significant negative correlation with maximum temperature (r = −0.480), rainfall (r = −0.117), evening relative humidity (r = −0.069), and wind velocity (r = −0.396). In contrast, positive correlations were observed with morning relative humidity (r = 0.283) and sunshine hours (r = 0.047). However, minimum temperature showed a significant negative correlation with spider population (r = −0.620*). The maximum populations of ladybird beetles were recorded during the 7th SMW in both Rabi seasons, with 0.20 and 0.80 adults plant^{-1} during 2016–17 and 2017–18, respectively. Ladybird beetle population exhibited non-significant negative correlations with maximum temperature (r = −0.154), minimum temperature (r = −0.078), and sunshine hours (r = −0.128). However, positive correlations were observed with morning relative humidity (r = 0.252), evening relative humidity (r = 0.354), and wind velocity (r = 0.145). Rainfall exhibited a significant positive correlation with ladybird beetle population (r = 0.565*).

Keywords: Tomato, Natural enemies, Seasonal incidence, Population dynamics, Weather parameters, Chhattisgarh Plains

Introduction

Tomato (*Solanum lycopersicum* Mill) is the major important vegetables, with the world being the second highest after the potato in the worlds. It is a crop of warm seasons. Tomato is grown during off seasons on hill of India and farmers gain higher income by transporting their produce to plains area between June to September. Tomato contains vitamin C and they provide a variety of colours and flavors to food. Large number of tomatoes are used to prepare soups, juices, ketchup, puree, pickle, paste and powders (Choudhary, 2002) [1]. Vegetable production can be adopted as a strategy for to improve livelihood and alleviating status of the people. Tomato is a rich source of vitamins A, C and E and minerals which are very good for health (Olaniyi, 2010) [2]. Numerous epidemiological studies conducted recently have demonstrated that tomatoes guard against prostate and digestive tract cancer (Ali *et al*., 2021) [3]. Additionally, including tomatoes in your diet might cut your risk of prostate cancer by up to 45% (Rai *et al*., 2005) [4]. Natural enemy such as mirid bug, *Nesidiocoris tenius* (Reuter) was also recorded (Rasheed *et al*., 2017) [5].

Material and Methods

The trials were carried out on Horticulture Research cum instructional, Department of vegetable science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Chhattisgarh. Weekly observations of major natural enemies were recorded on five randomly selected plants. The natural enemies were

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recorded at weekly interval on randomly selected five plants. Natural enemies succession was recorded as:

- Appearance of insect
- Stage of crop
- Peak period of activity
- Disappearance of insect

A weekly basis was considered to collect the weather data. Among weather parameters, relative humidity (morning and evening), temperature (maximum and minimum) and rainfall were considered to correlate with the occurrence of the insect pests of tomato (Shukla *et al*., 2005, Meena *et al*., 2010) [6]. Correlation and multiple linear regressions (MLR) method was used to find out the association between the occurrence of the insect pests of tomato and their natural enemies with the weather parameters (Panse *et al.*, 1985) [7].

Results and Discussion

Mirid bug, Nesidiocoris tenuis

During the 2016-17 cropping season, the occurrence of mirid bug, *Nesidiocoris tenuis* population on tomato was first observed in 3rd week of December on account of 0.6 mirid bug plant^{-1}. Maximum mirid bug were (3.5 adult plant^{-1}) noticed during third week of January (3th SMW) (Table 2 & Fig. 1); during this period rainfall (0.00 mm), maximum temperature (28.9 °C) and minimum temperature (11.8 °C), relative humidity (85%), wind velocity (1.2 Km h^{-1}) and bright sunshine hours (8 h day^{-1}) prevailed (Table 1). Subsequently, the population of the mirid bug was gradually decreased and ultimately reached 0.4 mirid bug plant^{-1} during final week of February. The numbers of mirid bug was correlated with prevailing rainfall, temperature, relative humidity, sunshine hours and wind velocity. The relationship between the population of mirid bug and maximum temperature, minimum temperature, wind speed and hours of sunshine were exhibited a negative non significant correlation, with '*r*' value of -0.300, -0.295 and -0.135, respectively at 5 per cent significance level. However, rainfall, morning relative humidity and evening relative humidity with '*r*' value of 0.023, 0.148 and 0.158, respectively at 5 per cent level of significance were recorded positive correlation during 2016-17 year (Table 4).

During the 2017-18 cropping season, the population of mirid bug, *Nesidiocoris tenuis* population on tomato was first observed on tomato in the third week of December (0.8 mirid bug plant^{-1}). The maximum number of mirid bug (3.4 adult plant^{-1}) was noticed during last week of January (4th SMW) (Table 2 & Fig. 1). During this period rainfall, maximum temperature and minimum temperature, relative humidity, wind velocity and bright sunshine hours were recorded 0.00 mm, 30.8 °C, 11.0 °C, 80%, 2.6 Km h^{-1} and 9.8 h day^{-1}, respectively (Table 1). After that, the number of mirid bugs laid declined gradually 0.5 adult plant^{-1} during the third week of February. Likewise, a non-significant negative correlation trend was observed between the adult population of mirid bugs and maximum temperature, evening relative humidity and wind velocity, with '*r*' value of -0.447, -0.114 and -0.046, respectively, however, a positive correlation trend was found between the mirid bugs population and rainfall (r = 0.104), morning relative humidity (r = 0.266) and sunshine hours (r = 0.098). however, a significant negative correlation was observed between maximum temperature (-0.514*) and the population of mirid bugs and regression line was derived for the number of mirid bugs as $Y = 4.02\text{-}0.19X_1$, R^2 0.25 (Table 4).

Based on the pooled data for the 2016-2017 and 2017-18 cropping season, the population of mirid bug, *Nesidiocoris tenuis* was first observed in first week of December with 0.7 adult plant^{-1}. The peak population (3.2 adult plant^{-1}) was observed during last week of January (5th SMW) (Table 2 & Fig. 1). During this period the pooled rainfall (0.00 mm), maximum temperature (30.6 °C) and minimum temperature (11.5 °C), morning relative humidity (74.5%), wind velocity (2.10 Km h^{-1}) and bright sunshine hours (9.6 h day^{-1}) prevailed (Table 1). Thereafter, the adult number gradually decreased & reached 0.2 adults plant^{-1} during fourth week of February. There was a non-significant negative trend of correlation between the adult population of mirid bugs and maximum temperature, minimum temperature, wind velocity and sunshine hours which was '*r*' value of -0.391, -0.441, -0.181 and -0.013, respectively at 5 per cent significance level, however, a positive correlation was observed between the mirid bugs population and rainfall (r = 0.104) morning relative humidity (r = 0.212) and sunshine hours (r = 0.041) (Table 4).

Rasheed *et al.* (2018) [8] reported that the mirid bug, *Nesidiocoris tenuis* was observed preying on the eggs and first instar larvae of *Tuta absoluta.* The mean number of adults and nymphs of *Nesidiocoris tenuis* per plant ranged from 1.04 to 1.45. The highest predator population was recorded in Vayalpadu mandal (1.45) whereas, the lowest was recorded in Kalikiri mandal (1.04). Similarly, Taram (2016) [9] revealed that the correlation coefficient of *Nesidiocoris* population was observed non-significant relationship with all the weather parameter. Sridhar *et al.* (2014) [10] reported that the correlation analyses between abiotic factors and the incidence of *N. tenuis* mean population plant^{-1}, across both varieties, showed a positive correlation with minimum temperature and wind velocity. Morning relative humidity recorded significant negative correlation, whereas maximum temperature, evening relative humidity, wind velocity and rainfall exhibited a non-significant negative correlation with *N. tenuis*.

Table 1: Weekly meteorological data recorded during the crop growth period 2016-17 and 2017-18 IGKV, RAIPUR

Meteorological Week No.	Month	Date	Max. Temp (°C)	Min. Temp (°C)	Rainfall (mm)	Relative humidity (%) Morning	Relative humidity (%) Evening	Wind Velocity	Sun shine (hr day^{-1})
48	November	26-02	30.2	12.5	0.0	86.0	26.5	1.5	8.7
49	December	03-09	28.7	13.7	0.0	87.5	34.5	1.9	8.0
50	December	10-16	29.3	12.1	0.0	84.0	29.0	2.0	8.3
51	December	17-23	28.2	9.9	0.0	86.5	26.5	1.7	8.2
52	December	24-31	28.3	9.7	0.0	85.5	26.0	1.5	8.1
1	January	01-07	28.0	11.1	0.0	80.0	29.0	1.8	7.1
2	January	08-14	27.7	11.0	2.8	82.5	29.0	2.3	7.7
3	January	15-21	29.2	10.9	0.0	85.0	24.5	1.7	8.7
4	January	22-28	29.3	12.3	0.0	83.0	27.0	2.1	8.1
5	January	29-04	30.6	11.5	0.0	74.5	21.5	2.1	9.6
6	February	05-11	31.8	15.2	0.0	79.5	30.0	2.2	7.8
7	February	12-18	29.7	15.2	8.2	84.5	36.0	3.3	7.4
8	February	19-25	33.8	15.6	0.0	73.0	19.5	2.4	9.8

(continued on next page)

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Table 1: Weekly meteorological data recorded during the crop growth period 2016-17 and 2017-18 IGKV, RAIPUR									
9	February	26-04	34.9	16.5	0.0	74.5	18.5	2.3	9.6
10	March	05-11	33.9	19.4	2.8	67.0	29.0	3.4	7.1
11	March	12-18	33.6	18.7	0.6	65.5	25.5	3.7	7.6

Table 2: Weekly population of natural enemies on tomato during *rabi* 2016-17 and 2017-18

SMW	Mirid bug plant^{-1}			Spider plant^{-1}			Lady bird beetle plant^{-1}		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
48	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00
49	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00
50	0.0	0.0	0.0	0.30	0.00	0.15	0.17	0.02	0.10
51	0.6	0.8	0.7	0.23	0.10	0.17	0.19	0.08	0.14
52	1.2	1.5	1.4	0.35	0.15	0.25	0.04	0.13	0.09
1	2.2	1.9	2.1	0.33	0.21	0.27	0.08	0.15	0.12
2	3.0	2.3	2.6	0.24	0.31	0.28	0.07	0.00	0.04
3	3.5	2.8	3.1	0.19	0.33	0.26	0.10	0.23	0.17
4	2.6	3.4	3.0	0.30	0.20	0.25	0.12	0.15	0.14
5	3.4	3.0	3.2	0.34	0.24	0.29	0.15	0.18	0.17
6	3.0	2.5	2.7	0.36	0.27	0.32	0.17	0.50	0.34
7	2.2	2.0	2.1	0.26	0.00	0.13	0.20	0.80	0.50
8	0.6	0.5	0.5	0.24	0.10	0.17	0.10	0.10	0.10
9	0.4	0.0	0.2	0.00	0.05	0.03	0.09	0.00	0.05
10	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00
11	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00
Mean	1.41	1.29	1.35	0.20	0.12	0.16	0.09	0.15	0.12

Table 3: Occurrence of natural enemies on tomato insect pests during *rabi* season, 2016-17 and 2017-18

Sr. No.	Natural enemies	Population rang 5 plant^{-1}	Period of activity	Peak activity period
1	Mirid bug (*Nesidiocoris tenuis*)	0.2-3.6	(IIIrd week of December to IVth week of February)	Ist week of February
2	Spider (Oxyopidae sp.)	0.03-0.32	(IInd week of December to IVth week of February)	IInd week of February
3	Lady bird beetle (*Coccinella septempunc-tata*)	0.05-0.50	(IInd week of December to IVth week of February)	IIIrd week of February

Table 4: Correlation coefficient among natural enemies of tomato insect pests and weather parameters

Weather parameter	Correlation coefficient (r)								
	Spider			Mirid bug			Lady bird beetle		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Maximum Temperature (°C)	-0.413	-0.342	-0.480	-0.300	-0.447	-0.391	0.004	-0.261	-0.154
Minimum Temperature (°C)	-0.552*	-0.541*	-0.620*	-0.295	-0.514*	-0.441	-0.057	-0.014	-0.078
Rainfall (mm)	-0.203	-0.287	-0.117	0.023	0.104	0.104	-0.298	0.789**	0.565*
Morning relative humidity	0.209	0.125	0.283	0.148	0.266	0.212	0.113	0.364	0.252
Evening relative humidity	0.048	-0.379	-0.069	0.158	-0.114	0.041	0.012	0.603*	0.354
Wind velocity (km h^{-1})	-0.340	-0.358	-0.396	-0.259	-0.046	-0.181	-0.064	0.424	0.145
Sunshine hours (hours)	-0.071	0.200	0.047	-0.135	0.098	-0.013	-0.027	-0.243	-0.128

*: Significant at 5% = 0.497
**: Highly significant at 1% = 0.623

Plate 1. Occurrence of natural enemies on insect pests of tomato

2. Spider

During the 2016-17 cropping season, the occurrence of spider on tomato was first observed in second week of December with 0.3 spider plant^{-1}. Maximum spider were (0.36 adult plant^{-1}) noticed during first week of February (6th SMW) (Table 2 & Fig. 2); during this period rainfall (0.00 mm), maximum temperature (32.2 °C) and minimum temperature (14.1 °C), relative humidity (81%), wind velocity (1.8 Km h^{-1}) and bright sunshine hours (9.3 h day^{-1}) prevailed (Table 1). Thereafter, the spider was gradually decreased and reached 0.24 spider plant^{-1} during third week of February. The abundance of spiders was found correlated accompanied by rainfall, temperature, relative humidity, sunshine hours and wind speed. The spider population showed a negative non-significant correlation with maximum temperature, rainfall, wind velocity and sunshine hours which was '*r*' values of -0.413, -0.203, -0.340 and -0.071, respectively. However, morning relative humidity and evening relative humidity exhibited non-significant positive correlation, with '*r*' value of 0.209 and 0.048, respectively, at 5 per cent of significance level (Table 4).

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Lady bird beetle, *Coccinella septempunctata*

Spider , Oxyopidae sp.

During the 2017-18 cropping season, the occurrence of spider on tomato was first observed in third week of December (0.10 spider plant^{-1}). The maximum no. of spider (0.33 adult plant^{-1}) was noticed during third week of January (3th SMW) (Table 2 & Fig. 2). During this period rainfall, maximum temperature and minimum temperature, relative humidity, wind velocity and bright sunshine hours were recorded 0.00 mm, 29.5 °C, 9.9 °C, 85%, 2.1 Km h^{-1} and 9.3 h day^{-1}, respectively (Table 1). Thereafter, the number of spiders laid gradually decreased 0.05 adult plant^{-1} during fourth week of February. Similarly, the adult population of spider was recorded negative non – significant correlation with maximum temperature, rainfall, evening relative humidity and wind velocity with '*r*' value of -0.342, -0.287, -0.379 and -0.358, respectively at 5 per cent level of significance. In spite of that morning relative humidity (*r* = 0.125) and sunshine (*r* = 0.200) was observed positive trend of correlation. But in case of minimum temperature (-0.541*) negative significant correlation with spider.

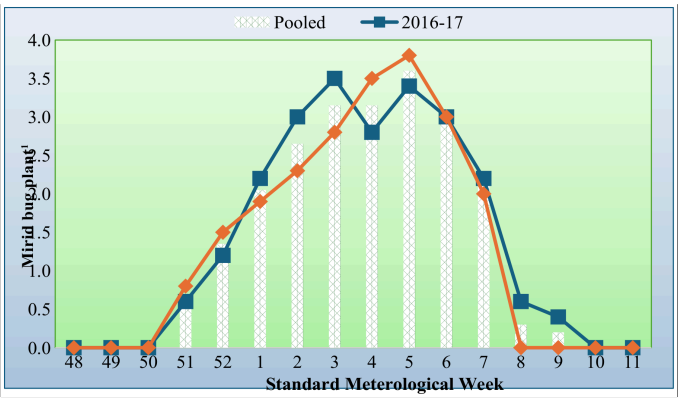


Figure 1. Mirid bug, *Nesidiocoris tenuis* population on tomato during 2016-17 and 2017-18

Based on the pooled data for the 2016-2017 and 2017-18 cropping season, the population of spider on tomato was first observed in second week of December with 0.15 adult plant^{-1}. The peak population (0.32 adult plant^{-1}) was observed during first week of February (6th SMW) (Table 2 & Fig. 2). During this period the pooled rainfall (0.00 mm), maximum temperature (31.75 °C) and minimum temperature (15.15 °C), relative humidity (79.5%), wind velocity (2.20 Km h^{-1}) and bright sunshine hours (7.8 h day^{-1}) prevailed (Table 1). Thereafter, the adult number gradually decreased & reached 0.03 adult plant^{-1} during fourth week of February. Whereas, the adult population was found negative non – significant with maximum temperature, rainfall, evening relative humidity and wind velocity which '*r*' values of -0.480, -0.117, -0.069 and -0.396 at 5 per cent level of significance and in case of morning relative humidity (*r* = 0.283) and sunshine (*r* = 0.047) was observed positive correlation. Whearas, minimum temperature (-0.620*) was recorded negative significant correlation during years 2016-17 and 2017-18.

These finding are consistent with Mondal *et al.* (2019) [11] observed that the spider population was recorded from initial vegetative stage to final fruit harvest stage of tomato which higher population of spiders (0.90 spider/plant) was found during the third week of March. It also looked like the higher natural enemy population found to correlated with the pest population in the field. Maximum population of spider (1.07-1.83 plant^{-1}) was observed on 3rd week of February to 2nd week of March and minimum population of spider (0.10 plant^{-1}) is recorded on 3rd week of April and 4th week of May (Subba *et al.* (2016) [12]. Mondal *et al.* (2019) [11] confirmed that the correlation with weather parameter like maximum temperature and minimum temperature showed positively correlation, but, relative humidity and rainfall negatively associated with spider population.

3. Lady bird beetle

During the 2016-17 cropping season, the occurrence of lady bird beetle on tomato was first observed in second week of December with 0.17 lady bird beetle plant^{-1}. Maximum lady bird beetle were (0.20 adult plant^{-1}) noticed during second week of February (7th SMW) (Table 2 & Fig. 3); during this period rainfall (0.00 mm), maximum temperature (31.0 °C) and minimum temperature (15.8 °C), relative humidity (80%), wind velocity (2.6 Km h^{-1}) and bright sunshine hours (6.8 h day^{-1}) prevailed (Table 1). Thereafter, the lady bird beetle was gradually decreased and reached 0.09 lady bird beetle plant^{-1} during fourth week of February. The numbers of lady bird beetle were correlated with prevailing rainfall, temperature, relative humidity, sunshine hours and wind velocity. However, the lady bird beetle population was observed negative non-significant correlation with minimum temperature, rainfall, wind velocity and sunshine which was '*r*' values of -0.057, -0.298, -0.064 and -0.027, respectively and in case of maximum temperature, morning relative humidity and evening relative humidity were found non-significant positive correlation with '*r*' values of 0.004, 0.113 and 0.012, respectively at 5 per cent level of significance (Table 4).

During the year 2017-18, the incident of lady bird beetle (0.02 lady bird beetle plant^{-1}) on tomato was first noted in 2nd week of December. The population of lady bird beetle (0.80 adult plant^{-1}) was noticed maximum during 2nd week of February (7th SMW) (Table 2 & Fig. 3). During experiment period, rainfall, maximum temperature, minimum temperature, relative humidity, wind velocity and bright sunshine duration were observed to 16.4 mm, 28.4 °C, 14.5 °C, 89%, 4 Km h^{-1} & 7.9 h day^{-1}, respectively (Table 1). Later, the number of lady bird beetle laid gradually decreased 0.10 adult plant^{-1} during 3rd week of February. Likewise, the trend of correlation was recorded negative but non-significant between the adult population and maximum temperature, minimum temperature and sunshine hours with '*r*' values of -0.261, -0.014 and -0.243, respectively but in the case of morning relative humidity (*r* = 0.364) and wind velocity (*r* = 0.424) the trend of correlation was observed positive at 5 per cent level of significance. However, in the case of rainfall (0.789**), the trend of correlation was recorded highly positive significant whereas evening relative humidity (*r* = 0.603*) was recorded positive significantly during the year 2017-18 (Table 4).

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Based on the pooled data for the year 2016-2017 and 2017-18, the population of lady bird beetle (0.10 adult plant^{-1}) was first observed in 2nd week of December. The highest population of lady bird beetle (0.50 adult plant^{-1}) was observed in 2nd week of February (7th SMW) (Table 2 & Fig. 3). The values of the pooled rainfall (8.2 mm), maximum temperature (29.7 °C), minimum temperature (15.15 °C), relative humidity (84.5%), wind velocity (3.30 Km h^{-1}) and bright sunshine hours (7.3 h day^{-1}) were recorded during trial period (Table 1). After that, the adult population of lady bird beetle was noted gradually decreased & reached 0.05 adult plant^{-1} in the fourth week of February. A negative non – significant correlation was calculated between the adult population and max. temp, min. temp and sunshine with '*r*' values of -0.154, -0.078 and -0.128, respectively while positive correlation was calculated between adult population and morning relative humidity (r = 0.252), evening relative (r = 0.354) humidity and wind velocity (r = 0.145) positive correlation was observed (Table 4). But in case of rainfall (r = 0.565*), positive significant correlation was found with lady bird beetle observed (Table 4). The population of lady bird beetle was noticed throughout the growth stages from initial vegetative stage up to last fruit harvest stage of tomato (Mondal *et al.,* 2019) [11]. The maximum population of lady bird beetle (1.4 lady bird beetle/plant) was recorded during the 13th SMW of March. Khuhro *et al.* (2014) [13] reported that highly positive significant correlation was observed between the population of lady bird beetle and relative humidity with temperature. The overall effect of RH revealed that majority of the insect pest showed negative correlation.

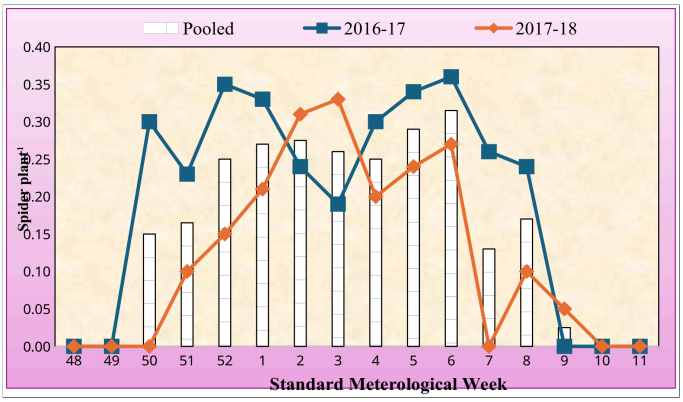


Figure 2. Spider population on tomato during 2016-17 and 2017-18

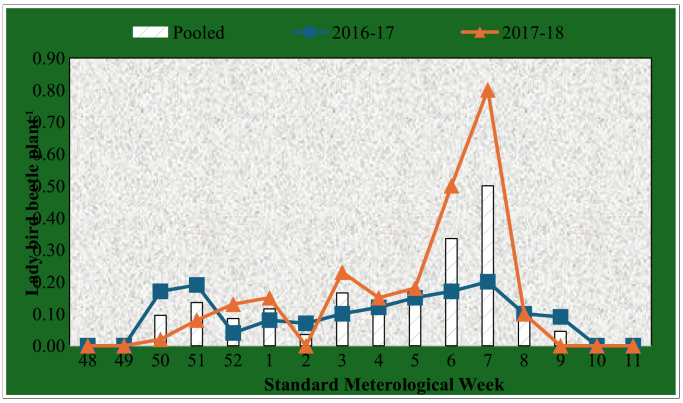


Figure 3. Lady bird beetle population on tomato during 2016-17 and 2017-18

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