Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

Journal of Entomology and Zoology Studies

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(5): 549-553

Received: 06-06-2020
Accepted: 04-08-2020

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Population dynamics of two spotted spider mite, *Tetranychus urticae* (L.) on French bean in relation to weather parameters

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Abstract
Population dynamics of *Tetranychus urticae* on french bean revealed that the populations of *T. urticae* was initiated from the fourth week of March during 13th SMW with 0.30 mite per 2cm^2 area and reached its peak during 22nd SMW with 15.90 mites per 2cm^2. The abundance of *T. urticae* was significant and positively correlated with minimum temperature (r = 0.921), average temperature (r = 0.899), evening relative humidity (r = 0.820), average relative humidity (r = 0.773) and wind speed (r = 0.892). Whereas, non significant and positive correlation with maximum temperature (r = 0.221), morning relative humidity (r = 0.251) and sunshine hours (r = 0.508). The regression equation revealed that the adjusted coefficient of determination explaining 83.30 per cent variation in mean population densities of *T. urticae* due to contribution of minimum temperature.

Keywords: French bean, population dynamics, mite, weather parameters, *Tetranychus urticae*

1. Introduction
French bean (*Phaseolus vulgaris* L.) is an important legume vegetable belonging to family Fabaceae. It has many synonyms like snap bean, kidney bean, haricot bean and also called raj mash in Hindi. According to Vavilov (1950) [10], the primary origin of french bean is Southern Mexico and Central America while Peruvian-Ecuadorian-Bolivian area is considered to be secondary centre. In India, french bean as a legume vegetable play a major role in nourishment of human population with a proteinaceous diet which supplies protein (1.8 g), calcium (132 mg), thiamin (0.08 mg), riboflavin (0.06 mg) and vitamin C (24 mg) per 100 g of edible pods. Besides, it is considered as nutritional fodder and also helps in maintaining soil fertility. It is also grown as cash crop due to its demand in canning industries and also has exporting value. It cultivated on about 28 m ha area with a production of 19 mtons. In India, it is grown on an area of about one lakh ha. It is extensively grown in Himachal Pradesh, Punjab, Haryana, Uttaranchal, Bihar, Gujarat, Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu. In Gujarat, it is grown near the cities like Surat, Baroda, Ahmedabad and Rajkot under polyhouses as well as open field condition. The beans are the rich source of proteins, carbohydrates, phosphorus, calcium and vitamins. The tender pods of these beans are used as fresh vegetable and dry seeds as pulses.
French bean, major insect and mite pests belongs to order Homoptera (aphids, whiteflies and mealybugs), Thysanoptera (thrips), Diptera (leaf miners) and Acarina (spider mites) [4, 5, 6]. Among the non insect pests of these beans, mites are very important. Phytophagous mites are serious pests of over 150 agricultural crops including major food and fibre crops and ornamentals [7].
Mites are typically found on the underside of leaves, but may colonise entire plants during outbreaks. The mites suck sap from cells on the underside of plant leaves, in the early stages and characteristic white speckles can be seen from the upper leaf surface. As mite number increases, these white speckles also increase and the leaf exhibits a bleached appearance [1, 3]. Now, it is well-known to cause both qualitatively and quantitatively yield loss through direct effects like leaf yellowing, loss of chlorophyll, stippling, webbing, defoliation, stunting of growth, leaf burning, reduction in size and quality of pods and appearance of various types of plant deformities.
However, the knowledge with respect dynamics of mites in french bean is very limited. In the present study, mite incidence in relation to abiotic factors has been elucidated to understand

the factors responsible for buildup of pest and also to know when the pest would be serious in french bean.

2. Materials and Methods

Population dynamics studies were done at College Farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari, (Gujarat) during summer 2018 and 2019. The observations on the incidence of red spider mite, *T. urticae* was recorded at weekly interval, beginning from two weeks after sowing and continued throughout the crop period till harvest. For sampling, three random leaves representing top, middle and bottom canopy were pluck from each of twenty five randomly selected plants. These leaves were kept in separate properly labeled polyethylene bags and bring to the Acarology laboratory for numerical mite counts (live) from $2cm^2$ leaf bit under stereo binocular microscope. Correlation and regression studies between spider mite, *T. urticae* population and prevailing abiotic and biotic factors were also be calculated. Simple correlation and multiple regression analysis were done by SPSS programme version 8.0.

3. Results and Discussion

3.1 Population dynamics of two spotted red spider mite, *T. urticae* on french bean

Population dynamics of two spotted red spider mite, *T. urticae* on french bean at College farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari, (Gujarat) during summer 2018, 2019 and overall average has been presented below.

3.1.1 Seasonal dynamics of *T. urticae* on french bean during 2018

Population abundance of *T. urticae* during the year 2018 on french bean were presented in Table - 1. The results revealed that the population densities of *T. urticae* during the crop season with a range of 0.70 to 15.80 mites per $2cm^2$ area indicating its commencement from 14^{th} SMW which continued upto crop maturity *i.e.*, 24^{th} SMW. There was increased population trend of *T. urticae* was noticed from the month of April (0.70 mite per $2cm^2$ area) and reached to their maximum population level of 15.80 mites per $2cm^2$ area during 22^{nd} SWM. Thereafter, started to decline and reached 8.2 mites per $2cm^2$ area during 24^{th} SMW (second week of June).

3.1.2 Seasonal dynamics of *T. urticae* on french bean during 2019

Population abundance of *T. urticae* during the year 2019 on french bean were presented in Table - 3. The results revealed that the population of *T. urticae* were found from 5^{th} WAS (13^{th} SMW) with a range of 0.60 to 18.40 mites per $2cm^2$ area which continued upto crop maturity *i.e.*, 23^{th} SMW. There was increased population trend of *T. urticae* was noticed from the month of March (0.60 mite per $2cm^2$ area) and reached to their maximum population level of 18.40 mites per $2cm^2$ area during 21^{st} SMW in the third week of May and declined upto 23^{rd} SMW (13.30 mites per $2cm^2$ area).

3.1.3 Population dynamics of two spotted red spider mite, *T. urticae* on french bean (Overall average data)

Overall average data during the year 2018 and 2019 on population abundance of *T. urticae* on french bean were presented in Table - 5. The results revealed that the population densities of *T. urticae* were found during the crop season with a range of 0.30 to 15.90 mites per $2cm^2$ area indicating its commencement from 13^{th} SMW which continued up to crop maturity i.e., 23^{th} SMW. There was increased population trend of *T. urticae* was noticed from the month of March (0.30 mite per $2cm^2$ area) and reached to their maximum population level of 15.90 mites per $2cm^2$ area in the month of May.

From the present study (Table - 5) results revealed that the mean populations of *T. urticae* was stated from fourth week of March (13^{th} SMW) and reached its peak during 22^{nd} SMW due to presence of high temperature, high relative humidity, prolonged dry spells, high wind speed and bright sunshine hour prevailing during particular period, which provide congenial condition for multiplication of mite population.

In previous study, Pokle and Shukla (2015) [8] who studied the mite population on tomato ranged from 0.07 to 7.33 mites per leaf ($2cm^2$). The population were started during 1^{st} week of January and gradually increased and reached its peak population in the month of June during 24^{th} SMW (7.33 mites/$2cm^2$). Moreover, Chauhan and Shukla (2016) [2] recorded the incidence of *T. urticae* on french bean was started from the 1^{st} SMW (first week of January), increased gradually and reached to its peak mean mite population during 21^{st} SMW (third week of May) (14.27 mites/$2cm^2$).

3.1.4 Correlation and regression between weather parameters and population densities of two spotted red spider mite, *T. urticae* on cow pea during 2018

The correlation coefficients were worked out between *T. urticae* population on french bean and weather parameters revealed (Table - 2) that the minimum temperature (r = 0.869), average temperature (r = 0.863), evening relative humidity (r = 0.706), average relative humidity (r = 0.630) and wind speed (r = 0.821) had significantly positive influence on *T. urticae* population. Whereas, maximum temperature (r = 0.469), morning relative humidity (r = 0.246) and sunshine hours (r = 0.339) had non significant positive influence on *T. urticae* population.

The regression equation worked out by taking *T. urticae* ($\hat{Y}_1$) as dependent variable and weather parameters as independent variables through stepwise regression analysis was:

$$\hat{Y}_1 = -23.116 + 1.267\ X_2\ (Adj.R^2 = 0.733)$$

Where, $\hat{Y}_1$ = *T. urticae* population, X_2 = minimum temperature

The adjusted coefficient of determination ($Adj.R^2$) was 73.30 per cent variation in *T. urticae* population due to contribution of minimum temperature taken into consideration in this investigation.

3.1.5 Correlation and regression between weather parameters and population densities of two spotted red spider mite, *T. urticae* on french bean during 2019

The correlation coefficients were worked out between *T. urticae* population on french bean and weather parameters revealed (Table - 4) that the minimum temperature (r = 0.858), average temperature (r = 0.818), evening relative humidity (r = 0.775), average relative humidity (r = 0.709), wind speed (r = 0.766) and sunshine hours (r = 0.579) had significantly positive influence on *T. urticae* population. Whereas, maximum temperature (r = 0.195) and morning relative humidity (r = 0.023) had non significant positive influence on *T. urticae* population.

The regression equation worked out by taking *T. urticae* ($\hat{Y}_1$) as dependent variable and weather parameters as independent variables through stepwise regression analysis was:

$\hat{Y}_1 = -23.005 + 1.375\ X_2$ (Adj.$R^2 = 0.712$)

Where, $\hat{Y}_1$ = *T. urticae* population and X_2 = minimum temperature

The adjusted coefficient of determination (Adj.R^2) was 71.20 per cent variation in *T. urticae* population due to contribution of minimum temperature taken into consideration in this investigation.

3.1.6 Correlation and regression between weather parameters and population densities of two spotted red spider mite, *T. urticae* on french bean (Overall average data)

The correlation coefficients were worked out between mean population densities of *T. urticae* population on french bean and weather parameters revealed (Table - 6) that the minimum temperature (r = 0.921), average temperature (r = 0.899), evening relative humidity (r = 0.820), average relative humidity (r = 0.773) and wind speed (r = 0.892) had significantly positive influence on *T. urticae* population. Whereas, maximum temperature (r = 0.221), morning relative humidity (r = 0.251) and sunshine hours (r = 0.508) had non significant positive influence on *T. urticae* population.

In present investigation minimum temperature, average temperature, evening relative humidity, average relative humidity and wind speed had showed positive and significant effect on development of mean mite population, while maximum temperature, morning relative humidity and sunshine hours had found positive and non significant effect on mean mite population.

Present studies were in agreement with the previous findings of Pokle and Shukla (2015) [8] reported the mite population had a significant positive correlation with average temperature (r = 0.678). Similarly, it had also significantly positively correlated with average relative humidity (r= 0.574). Chauhan and Shukla (2016) [2] found that mite population were significant positive correlation with maximum temperature, minimum temperature, average temperature, evening relative humidity and average relative humidity, whereas morning relative humidity had non-significant positive relation. Shah and Shukla (2014) [9] reported that the *T. urticae* showed a non-significant negative correlation with temperature and non-significant positive correlation with relative humidity of polyhouse on gerbera.

The regression equation worked out by taking *T. urticae* ($\hat{Y}_1$) as dependent variable and weather parameters as independent variables through stepwise regression analysis was:

$\hat{Y}_1 = -29.478 + 1.605\ X_2$ (Adj.$R^2 = 0.833$)

Where, $\hat{Y}_1$ = *T. urticae* population and X_2 = minimum temperature

The adjusted coefficient of determination (Adj.R^2) was 83.30 per cent variation in *T. urticae* population due to contribution of maximum temperature and minimum temperature taken into consideration in this investigation.

From the present study it can be concluded that the weather parameters such as minimum temperature had a positive relationship with abundance of *T. urticae.*

Table 1: Population dynamics of red spider mite, *T. urticae* on french bean and weather parameters during year 2018

SMW	Period	WAS	TMax. (°C)	TMin. (°C)	TAv. (°C)	RHMor. (%)	RHEve. (%)	RHAv. (%)	Wind speed (km/hr)	Sunshine hr/day	Average number of *T. urticae* / leaf area (2cm²)
12	19.03.18 to 25.03.18	3	35.0	16.7	25.8	82.1	23.9	53.0	3.1	7.9	0.00
13	26.03.18 to 01.04.18	4	35.1	17.5	26.3	80.5	29.5	55.0	3.3	8.1	0.00
14	02.04.18 to 08.04.18	5	35.8	20.3	28.1	83.0	43.0	63.0	4.5	8.7	0.70
15	09.04.18 to 15.04.18	6	35.9	20.4	28.2	86.4	42.4	64.4	3.8	8.9	1.90
16	16.04.18 to 22.04.18	7	36.0	21.9	29.0	92.8	57.4	75.1	4.9	9.2	2.20
17	23.04.18 to 29.04.18	8	36.1	23.0	29.6	84.3	38.6	61.5	4.4	9.4	3.30
18	30.04.18 to 06.05.18	9	36.2	21.9	29.1	88.5	51.4	69.9	4.6	9.7	5.20
19	07.05.18 to 13.05.18	10	36.6	24.6	30.6	86.3	60.1	73.2	8.3	10.3	7.00
20	14.05.18 to 20.05.18	11	37.0	24.3	30.6	85.3	53.6	69.5	5.9	10.2	9.10
21	21.05.18 to 27.05.18	12	36.8	26.7	31.7	84.7	57.2	71.0	7.5	9.9	10.90
22	28.05.18 to 03.06.18	13	36.1	26.1	31.1	83.6	54.3	68.9	7.3	8.9	15.80
23	04.06.18 to 10.06.18	14	35.8	26.7	31.3	90.3	66.4	78.3	8.6	8.6	12.60
24	11.06.18 to 17.06.18	15	35.2	27.7	31.5	92.6	70.9	81.8	8.8	8.4	8.20

SMW- Standard Meteorological Week, WAS- Week After Sowing,
TMax. – Maximum temperature, TMin. - Minimum temperature, TAv. - Average temperature
RHMor. – Morning relative humidity, RHEve. - Evening relative humidity, RHAv. - Average relative humidity

Table 2: Correlation and regression coefficients between incidence of red spider mite, *T. urticae* and natural enemies on French bean and weather parameters during 2018

Weather Parameters		*T. urticae* ($\hat{Y}_1$)	
		Correlation coefficient (r)	Regression coefficient
Maximum Temp.	(X_1)	0.469	-
Minimum Temp.	(X_2)	0.869**	1.267
Average Temp.	(X_3)	0.863**	-
Morning RH	(X_4)	0.246	-
Evening RH	(X_5)	0.706**	-
Average RH	(X_6)	0.630*	-
Wind speed km/hr	(X_7)	0.821**	-

Sunshine hr/day	(X_8)	0.339	-
'Intercept' value			-23.116
'Adjusted R^2' value			0.733

Note: *Significant at 5 % level of significance, **Significant at 1% level of significance
The stepwise regression method was adopted to obtain regression coefficients

Table 3: Population dynamics of red spider mite, *T. urticae* on french bean and weather parameters during year 2019

SMW	Period	WAS	TMax. (°C)	TMin. (°C)	TAv. (°C)	RHMor. (%)	RHEve. (%)	RHAv. (%)	Wind speed (km/hr)	Sunshine hr/ day	Average number of *T. urticae* / leaf area (2cm²)
11	12.03.18 to 18.03.18	3	33.4	13.8	23.6	85.4	38.6	62.0	2.4	8.4	0.00
12	19.03.18 to 25.03.18	4	35.7	15.7	25.7	85.7	44.4	65.1	2.5	8.9	0.00
13	26.03.18 to 01.04.18	5	35.8	18.1	27.0	83.6	45.6	64.6	2.7	8.4	0.60
14	02.04.18 to 08.04.18	6	34.9	21.2	28.1	89.9	61.4	75.6	4.3	8.5	1.50
15	09.04.18 to 15.04.18	7	36.2	20.9	28.5	86.9	43.7	65.3	2.9	8.9	2.30
16	16.04.18 to 22.04.18	8	36.7	21.9	29.3	80.7	50.1	65.4	3.1	8.4	3.70
17	23.04.18 to 29.04.18	9	37.0	22.0	29.5	84.0	45.6	64.8	2.7	9.2	5.70
18	30.04.18 to 06.05.18	10	36.0	23.9	29.9	86.4	65.3	75.9	6.9	10.3	7.90
19	07.05.18 to 13.05.18	11	36.2	23.2	29.7	84.1	60.5	72.3	5.3	10.8	10.20
20	14.05.18 to 20.05.18	12	36.9	24.1	30.5	84.5	58.3	71.4	4.5	10.0	11.00
21	21.05.18 to 27.05.18	13	36.7	25.3	31.0	85.3	60.7	73.0	5.0	10.5	18.40
22	28.05.18 to 03.06.18	14	34.9	26.2	30.6	86.6	71.0	78.8	7.3	10.1	16.00
23	04.06.18 to 10.06.18	15	34.5	27.1	30.8	88.2	68.2	78.2	7.7	7.7	13.30

SMW- Standard Meteorological Week, WAS- Week After Sowing
TMax. – Maximum temperature, TMin. - Minimum temperature, TAv. - Average temperature
RHMor. – Morning relative humidity, RHEve. - Evening relative humidity, RHAv. - Average relative humidity

Table 4: Correlation and regression coefficients between incidence of red spider mite, *T. urticae* and natural enemies on french bean and weather parameters during 2019

Weather Parameters		*T. urticae* ($\hat{Y}_1$)	
		Correlation coefficient (r)	Regression coefficient
Maximum Temp.	(X_1)	0.195	-
Minimum Temp.	(X_2)	0.858**	1.375
Average Temp.	(X_3)	0.818**	-
Morning RH	(X_4)	0.023	-
Evening RH	(X_5)	0.775**	-
Average RH	(X_6)	0.709**	-
Wind speed km/hr	(X_7)	0.766**	-
Sunshine hr/day	(X_8)	0.579*	-
'Intercept' value			-23.005
'Adjusted R^2' value			0.712

Note: *Significant at 5 % level of significance, **Significant at 1% level of significance
The stepwise regression method was adopted to obtain regression coefficients

Table 5: Population dynamics of red spider mite, *T. urticae* on french bean and weather parameters during year 2018 and 2019 (Overall pooled)

SMW	TMax. (°C)	TMin. (°C)	TAv. (°C)	RHMor. (%)	RHEve. (%)	RHAv. (%)	Wind speed (km/hr)	Sunshine hr/day	Average number of *T. urticae* / leaf area (2cm²)
12	35.4	16.2	25.8	83.9	34.2	59.0	2.8	8.4	0.00
13	35.5	17.8	26.6	82.1	37.6	59.8	3.0	8.2	0.30
14	35.4	20.8	28.1	86.4	52.2	69.3	4.4	8.6	1.10
15	36.0	20.7	28.3	86.6	43.1	64.8	3.3	8.9	2.10
16	36.4	21.9	29.1	86.7	53.7	70.2	4.0	8.8	2.90
17	36.6	22.5	29.5	84.2	42.1	63.2	3.6	9.3	4.50
18	36.1	22.9	29.5	87.5	58.3	72.9	5.7	10.0	6.60
19	36.4	23.9	30.1	85.2	60.3	72.7	6.8	10.6	8.60
20	37.0	24.2	30.6	84.9	56.0	70.5	5.2	10.1	10.00
21	36.8	26.0	31.4	84.5	58.9	71.7	6.3	10.2	14.70
22	35.5	26.2	30.8	85.1	62.6	73.9	7.3	9.5	15.90
23	35.2	26.9	31.0	89.2	67.3	78.3	8.1	8.1	13.00

SMW- Standard Meteorological Week, *24th SWM was omitted in 2018 year, *11th SWM was omitted in 2019 year
TMax. – Maximum temperature, TMin. - Minimum temperature, TAv. - Average temperature
RHMor. – Morning relative humidity, RHEve. - Evening relative humidity, RHAv. - Average relative humidity

Table 6: Correlation and regression coefficients between incidence of red spider mite, *T. urticae* and natural enemies on french bean and weather parameters during 2018 and 2019 (Overall pooled)

Weather Parameters		*T. urticae* ($\hat{Y}_1$)	
		Correlation coefficient (r)	Regression coefficient
Maximum Temp.	(X_1)	0.221	-
Minimum Temp.	(X_2)	0.921**	1.605
Average Temp.	(X_3)	0.899**	-
Morning RH	(X_4)	0.251	-
Evening RH	(X_5)	0.820**	-
Average RH	(X_6)	0.773**	-
Wind speed km/hr	(X_7)	0.892**	-
Sunshine hr/day	(X_8)	0.508	-
'Intercept' value			-29.478
'Adjusted R^2' value			0.833

Note: *Significant at 5 % level of significance, **Significant at 1% level of significance
The stepwise regression method was adopted to obtain regression coefficients

Conclusion

Mite pests are the serious emerging problem of agricultural and horticultural crops causes significant losses. Hence, the present investigation will be helpful in monitoring the mite pest population and to understand the factors responsible for buildup of pest throughout the summer season to elucidate safer and eco-friendly Integrated Pest Management strategies in french bean.

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