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

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Abstract
Population dynamics of two spotted red spider mite, *Tetranychus urticae* on cow pea was initially noticed during 13th SMW (fourth week of March) with a lowest density of 0.70 mite per 2cm^2 and increased rapidly and attained its peak at 22nd SMW (last week of May) with a population density as high as 15.80 mites per 2cm^2. *T. urticae* population had significant and positive correlation with minimum temperature (r = 0.947), average temperature (r = 0.940), evening relative humidity (r = 0.840), average relative humidity (r = 0.800) and wind speed (r = 0.880) had significantly positive influence on *T. urticae* population. Whereas, non significant and positive influence was found with maximum temperature (r = 0.314), morning relative humidity (r = 0.313) and sunshine hours (r = 0.570). The regression equation revealed that the adjusted coefficient of determination explaining 92.30 per cent variation in mean population densities of *T. urticae* due to contribution of minimum temperature and morning relative humidity.

Keywords: Cow pea, population dynamics, mite, weather parameters, *Tetranychus urticae*

1. Introduction
Cow pea (*Vigna unguiculata* (L.)) is known as drought hardy crop. In India, cow pea is grown as sole, inter-crop, mix-crop and in agro-forestry combinations. It is grown an area of 9.50 thousand ha with total production of 37.50 thousand tones and productivity of 540 kg/ha during the year 2013-14, while in Gujarat it occupies about 18,811 ha area with the production of 1,66,391 MT [1]. In Indian context, it is a minor pulse cultivated mainly in arid and semi arid tracts of Rajasthan, Karnataka, Kerala, Tamil Nadu, Maharashtra and Gujarat. Cow pea is a native to Central Africa and belongs to the family Leguminaceae with subfamily Papilionaceae. It is eaten in the form of grain, green pods and leaves. Like other legumes, cow pea grains is cooked to make it edible, usually by boiling but the most important way to eat them is in curries. The roots are eaten in Sudan and Ethiopia. Peduncles and stems are used as fibres in Nigeria. Cow pea is known as 'vegetable meat' or 'Poor man's meat' due to high amount of protein in the green leaves with better biological value on dry weight basis. It also has the useful ability to fix atmospheric nitrogen through its root nodules. It grows well in poor soils with more than 85 per cent sand and with less than 0.2 per cent organic matter and low level of phosphorous. In addition, it is shade tolerant so it is compatible as an intercrop with maize, millet, sorghum, sugarcane and cotton. This makes cow pea is an important component of traditional intercropping systems. Also cow pea cover crops have been shown to suppress nematode in tomato production system [10]. The spreading indeterminate type of cow pea serves as a ground cover and thus suppresses weeds as well as protects the soil erosion.
The important insect species attacking cow pea crop include aphid (*Aphis craccivora* Koch), leafhopper (*Empoasca kerri* Pruthi), thrips (*Megaleurothrips spp.*), whitefly (*Bemisia tabaci* Genn.), leaf miner (*Acrocercops caerulea* Meyrick), spotted pod borer (*Maruca vitrata* Fab.), tobacco leaf eating caterpillar (*Spodoptera litura* Fab.) and blue butterfly (*Euchrysops cnejus* Cnidus) [8]. Among the non insect pests of these beans, mites are extremely important**.** Phytophagous mites are severe pests of over 150 agricultural crops including major food and fibre crops and ornamentals [9].
Silk webbing on the undersides of leaves is characteristic signs of spider mites. Under high population densities, the mites move to the tip of the leaf or top of the plant and congregate using strands of silk to form a ball-like mass, which will be blown by winds to new leaves or

plants, in a process known as "ballooning." It is estimated that 18 to 22 cells are destroyed per minute by a single mite. Continued feeding causes a stippled- bleached effect and later, the leaves turn yellow, grey or bronze. Complete defoliation may occur, if the mites are not controlled [3].
However, the information with respect to incidence of mites in cow pea is very limited. In the present study, seasonal incidence of mites in relation to abiotic factors has been found to understand the factors responsible for buildup of pest and also to know when the pest would be serious in cow pea.

2. Materials and methods
Population dynamics studies of red spider mite, *T. urticae* on cow pea 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 were also be calculated between spider mite, *T. urticae* population and prevailing abiotic and biotic factors. SPSS programme version 8.0 was used for analysis of simple correlation and multiple regression analysis.

3. Results and Discussion
3.1 Population dynamics of two spotted red spider mite, *T. urticae* on cow pea
Population dynamics of two spotted red spider mite, *T. urticae* on cow pea 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 cow pea during 2018
The data on population dynamics of *T. urticae* were recorded at weekly interval during the year 2018 were presented in Table - 1. During the course of investigation *T. urticae* population ranged from 0.80 to 17.3 mites per 2cm^2 area. The population of two spotted red spider mite was initiated from the month of April (14th SMW) with lowest population of 0.80 mite per 2cm^2 showed increased trend and reached to their peak population level of 17.3 mites per 2cm^2 area at last week of May during 22nd SMW. Thereafter, pest population declined and reached 9.20 mites per 2cm^2 during the 24th SMW *i.e.* second week of June.

3.1.2 Seasonal dynamics of *T. urticae* on cow pea during 2019
Observations on population of *T. urticae* were recorded at weekly interval during the year 2019 were presented in Table - 3. During the course of investigation *T. urticae* population ranged from 1.50 to 17.20 mites per 2cm^2 area. The population of two spotted red spider mite was initiated from the third week of March (13th SMW) with a minimum population of 1.50 mites per 2cm^2 showed increased trend and reached to their peak population level of 17.20 mites per 2cm^2 area at third week of May during 21st SMW and decreased trend upto crop maturity during 23rd SWM (10.30 mites per 2cm^2).

3.1.3 Population dynamics of two spotted red spider mite, *T. urticae* on cow pea (Overall average data)
Overall average data of 2018 and 2019 on population densities of *T. urticae* presented in Table - 5. During the course of investigation mean mite population from two years data on cow pea were found that the infestation of *T. urticae* was initially noticed during 13th SMW with a lowest density of 0.70 mite per 2cm^2. The pest population remained at moderate densities in the succeeding week, which increased rapidly and attained its peak at 22nd SMW with a population density as high as 15.80 mites per 2cm^2 and then gradually decreased.
From the present study (Table - 5) results revealed that the mean populations of *T. urticae* was steadily increased from the 13th SMW and attained its peak population in the last week of May during 22nd 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. Our observation on population dynamics of *T. urticae* was more or less similar with past studies of Ghosh (2013) [2] estimated the population of *T. urticae* on okra and it was active throughout the growing period with a peak population (6.18 mites/leaf) during 23rd SMW.
Monica *et al*. (2014) [6] reported that initial population of mite on brinjal was at lower level with an average of 0.57 mite per 1cm^2 leaf area. The mite population became significant from the fourth week of April (2.03 mites per 1cm^2 leaf area) and there was a gradual increase in the mite population in the months of May and June. The pest activity was peak (6.91 mites per 1cm^2 leaf area) in the first week of June and then sharply declined from 4th week of June onward. Similarly, Kumar *et al*. (2014) [5] who recorded the mite population of *T. ludeni* on cow pea and revealed that mite population commenced from 10 SMW of March and reached its peak in the month of May during 20th SMW (52.64 mites per leaf).

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 was observed between *T. urticae* population on cow pea and weather parameters (Table - 2) revealed that the minimum temperature (r = 0.883), average temperature (r = 0.883), evening relative humidity (r = 0.722), average relative humidity (r = 0.650) and wind speed (r = 0.823) had significantly positive influence on *T. urticae* population, while non significant positive influence was found with maximum temperature (r = 0.513), morning relative humidity (r = 0.279) and sunshine hours (r = 0.386).
The regression equation worked out based on goodness of fit (R^2) by taking *T. urticae* ($\hat{Y}_1$) as dependent variable and weather parameters as independent variables through stepwise regression analysis was:

$$\hat{Y}_1 = -72.124 + 2.693\ X_3 \ (Adj.R^2 = 0.760)$$

Where, $\hat{Y}_1$ = *T. urticae* population and X_3 = average temperature
The adjusted coefficient of determination (Adj.R^2) was 76.00 per cent variation in *T. urticae* population due to contribution

of average 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 was observed between *T. urticae* population on cow pea and weather parameters (Table - 4) revealed that the minimum temperature (r = 0.890), average temperature (r = 0.884), evening relative humidity (r = 0.766), average relative humidity (r = 0.701), wind speed (r = 0.710) and sunshine hours (r = 0.671) had significantly positive influence on *T. urticae* population, while non significant positive influence was found with maximum temperature (r = 0.355) and morning relative humidity (r = 0.037).

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

$\hat{Y}_1 = -33.944 + 1.024\ X_2 + 2.074\ X_3$ (Adj.$R^2 = 0.893$)

Where, $\hat{Y}_1$ = *T. urticae* population, X_2 = minimum temperature and X_3 = average temperature The adjusted coefficient of determination (Adj.R^2) was 89.30 per cent variation in *T. urticae* population due to contribution of minimum temperature and average 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 was observed between *T. urticae* population on cow pea and weather parameters (Table - 6) revealed that the minimum temperature (r = 0.947), average temperature (r = 0.940), evening relative humidity (r = 0.840), average relative humidity (r = 0.800) and wind speed (r = 0.880) had significantly positive influence on *T. urticae* population. Maximum temperature (r = 0.314), morning relative humidity (r = 0.313) and sunshine hours (r = 0.570) had non significant positive influence on mite 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. Whereas, maximum temperature, morning relative humidity and sunshine hours had showed positive and non significant effect on mean mite population of *T. urticae*.

Present studies were in agreement with the previous findings of Ghosh (2013) [2] observed showed that population had non-significant positive correlation with temperature (maximum, minimum and average) and maximum relative humidity where as significant positive correlation with minimum and average relative humidity. Kavad and Patel (2015) [4] revealed that population of mite had significant positive correlation with minimum temperature (r = 0.476), morning relative humidity (r = 0.621), evening relative humidity (r = 0.461) and mean relative humidity (r = 0.515). Moreover, Patel and Ghetiya (2015) [7] recorded mite population had highly significant association with minimum temperature (r = 0.876), morning relative humidity (r = 0.415), evening relative humidity (r = 0.760), wind speed (r = 0.707) and sunshine hours (r = -0.454), while non significant positive correlation with maximum temperature.

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

$\hat{Y}_1 = 26.384 + 1.793\ X_2 - 0.691\ X_4$ (Adj.$R^2 = 0.923$)

Where, $\hat{Y}_1$ = *T. urticae* population, X_2 = minimum temperature and X_4 = morning relative humidity

The adjusted coefficient of determination (Adj.R^2) was 92.30 per cent variation in *T. urticae* population due to contribution of minimum temperature and morning relative humidity taken into consideration in this investigation.

From the present study it can be concluded that the weather parameter such as minimum temperature had a positive relationship with abundance *T. urticae.* When these factors increased, the mean population densities of *T. urticae* were also increased and *vice-versa*.

Table 1: Population dynamics of red spider mite, *T. urticae* on cow pea 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 to25.03.18	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	0.80
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	2.50
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	3.40
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	5.10
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	6.60
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	8.50
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	11.30
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	13.20
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	17.30
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	15.70
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	9.20

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 cow pea and weather parameters during 2018

Weather Parameters		*T. urticae* ($\hat{Y}_1$)	
		Correlation coefficient (r)	Regression coefficient
Maximum Temp.	(X_1)	0.513	-
Minimum Temp.	(X_2)	0.883**	-
Average Temp.	(X_3)	0.883**	2.693
Morning RH	(X_4)	0.279	-
Evening RH	(X_5)	0.722**	-
Average RH	(X_6)	0.650*	-
Wind speed km/hr	(X_7)	0.823**	-
Sunshine hr/day	(X_8)	0.386	-
'Intercept' value			-72.124
'Adjusted R^2' value			0.760

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

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