



Factors affecting *Tetranychus urticae* koch (Acari: Tetranychidae) population dynamics and effect of the mite infestation on fruit parameters of African marigold

Karuna Bamel*, Rachna Gulati, Reecha

Department of Zoology and Aquaculture, CCS Haryana Agricultural University, Hisar, Haryana, India

Abstract

We recorded weekly incidence of *Tetranychus urticae* on African marigold plant throughout the year from third week of March, 2018 to first week of March, 2019. A highly significant positive correlation of mite population with minimum temperature ($r=0.90$) and average wind speed ($r=0.76$) was observed. Regarding leaf stage, grown up leaves on ventral surface were more susceptible to mite infestation. The analysis showed that in summer season plants harbour more mites per leaf as compared to rainy and winter. Assessment of yield loss is fundamental to *T. urticae* management as they are the means by which this mite is adjudged as a pest. Highly significant negative correlation was found between number of mites and fruit parameters like no. of flower ($r=-0.953$), flower diameter ($r=-0.933$), flower weight ($r=-0.816$), and yield per plant ($r=-0.923$). Statistically, higher yield was observed in uninfested plants (223.98 g/plant) as compared to infested plants (124.96 g/plant).

Keywords: two spotted spider mite, abiotic factors, leaf stage, yield

Introduction

African marigold (*Tagetes erecta* L.) marks a notable place in ornamental horticulture. Its habit of free flowering, attractive colours, size, shape, good keeping quality and short duration to produce marketable flowers attract the flower growers. Due to its wide adaptability to climate and soils, it can be grown in three seasons namely, summer, rainy and winter in Haryana, India.

Tetranychus urticae is a devastating pest of marigold in both screen house and field conditions. In a study on bionomics of spider mite on marigold, the life cycle of *T. urticae* passed through five different stages, namely egg, larvae, protonymph, deutonymph, adult^[7]. Its populations can build up to tremendous numbers and can destroy the crops in a very short time under favourable conditions. Mite stylets puncture the leaf cell, inject saliva and contents are released due to turgor pressure^[1]. A number of studies agree with the fact that early infestation of mites result in yield losses^[9]. This ubiquitous phytophagous mite, living in groups, quickly exhausts the host plant and must recurrently disperse to new host resources. In *T. urticae*, a collective displacement occurs in conditions of overcrowding and food depletion on a host plant. It leads to loss of chlorophyll, stippling, webbing, stunting of growth, leaf yellowing, leaf burning, defoliation, reduction in photosynthetic activity and quality of fruits; ultimately leading to death of the plant^[11].

Incidence of this mites changes with weather conditions. Therefore, it is important to correlate mite population with factors that affect its population built up for its effective management and forecasting mite outbreaks. Our study represents the weekly population dynamics and influence of season, leaf stage, leaf surface and environmental factors on *T. urticae* infesting *T. erecta*.

Materials and Methods

Marigold plants

Seeds were procured from Department of Horticulture, CCSHAU, Hisar. Under replicated conditions seeds of *Tagetes erecta* were sown in January, May and August for summer, rainy and winter season respectively. Transplantation was done in the month of February for summer season crop, first week of June for rainy season crop and fourth week of September for winter season crop. These plants were kept free from any chemical treatment and were allowed to get naturally infested with *T. urticae*.

Collection of marigold leaves

Five marigold plants were selected randomly from each plot for counting the mite number. Readings were taken each week stating from appearance of mites till harvesting of crop. From each plant two leaves each from tender, grown up and older leaves were taken in labeled polybags.

Counting mite number

The plucked leaves were bought to acarology laboratory and with the help of stereo zoom binocular microscope mixed population i.e. egg, larva, nymph and adult were counted. Both the leaf surfaces; dorsal as well as ventral, were examined. Symptoms of damage and pattern of *T. urticae* distribution was noted.

Influence of Environmental Factors

For the study period, meteorological data was procured from the Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar (Haryana). The effect of maximum, minimum temperature ($^{\circ}\text{C}$), morning and evening relative humidity (%), wind speed (km/h), sunshine hours (h), evaporation (mm) and rainfall (mm) on the occurrence of the spider mite, *T. urticae* was worked out systematically.

Effect of *Tetranychus urticae* infestation on marigold yield

The damage symptoms, number of flowers, flower diameter, weight and yield were recorded during winter season. At every harvest flower diameter was assessed by using a scale before the flowers were weighed on a weighing balance. Similarly, yield was also measured at the end of season. The replicated data for ten plants per plot (experimental unit) was pooled and subjected to statistical analysis. The experiment was continued till the harvesting of the flowers. At the end of the study period, yields of infested and uninfested plants were compared to see the effect of mite infestation. The difference in the flower yields of marigold was calculated and the per cent yield reduction was worked out by following formula:

$$\text{Reduction in crop yield} = \frac{\text{Mean yield of uninfested crop} - \text{Mean yield of infested crop}}{\text{Mean yield of uninfested crop}} \times 100$$

Statistical analysis

Data was analyzed using software ‘OPSTAT’. Effect of observation period, leaf surface and leaf stage on population

dynamics of the two spotted spider mite (*T. urticae*) was noted by calculating critical difference and two factor Completely Randomized Design was applied. Statistical significance of data was assessed and correlation matrix was also calculated between *T. urticae* incidence and abiotic factors or fruit parameters to see their effect on population build up of *T. urticae*.

Results

Summer season

On first day of sampling 0.31, 2.55, 1.54 mites/leaf on dorsal surface; 2.05, 5.10, 4.08 mites/leaf on the ventral surface of tender, grown up and older leaves respectively were recorded. Afterwards, *T. urticae* population represented an increasing trend up to third week of May (17.5.18) when a peak in population was observed. Then the mite population decreased continuously with every week and before harvesting only 14.24, 19.82, 11.19 mites/leaf on the dorsal surface and 46.24, 53.36, 28.97 mites/leaf on the ventral surface were observed on the leaves of tender, grown up and older leaves respectively (Table 1).

Table 1: Population dynamics of *Tetranychus urticae* on African marigold in summer season

Observation period	Average number of <i>Tetranychus urticae</i> /leaf*					
	Tender Leaves		Grown up Leaves		Older Leaves	
	Dorsal surface	Ventral surface	Dorsal surface	Ventral surface	Dorsal surface	Ventral surface
15.3.18	0.31±0.44	2.05±0.04	2.55±0.05	5.10±0.09	1.54±0.03	4.08±0.07
22.3.18	3.06±0.06	8.14±0.15	5.09±0.10	13.22±0.26	2.55±0.05	6.11±0.11
29.3.18	6.62±0.13	16.27±0.32	10.17±0.2	27.45±0.55	6.11±0.12	16.78±0.33
5.4.18	7.12±0.14	20.34±0.4	12.71±0.25	28.46±0.57	7.63±0.15	19.32±0.38
12.4.18	9.66±0.19	24.4±0.48	14.74±0.29	31.51±0.63	8.65±0.17	21.86±0.43
19.4.18	11.19±0.22	29.99±0.60	15.25±0.3	34.56±0.69	10.17±0.2	23.38±0.46
26.4.18	12.2±0.24	34.56±0.69	17.79±0.35	40.15±0.80	11.19±0.22	25.92±0.51
3.5.18	13.73±0.27	37.61±0.75	17.28±0.34	45.23±0.91	14.24±0.28	27.45±0.55
10.5.1	17.28±0.34	42.18±0.85	18.81±0.37	46.75±0.94	15.76±0.31	30.50±0.61
17.5.18	17.79±0.35	51.32±1.03	25.41±0.51	58.44±1.18	15.25±0.3	33.04±0.66
24.5.18	16.78±0.33	48.78±0.98	21.35±0.42	55.9±1.13	12.71±0.25	31.51±0.63
31.5.18	14.24±0.28	46.24±0.93	19.82±0.39	53.36±1.07	11.19±0.22	28.97±0.58

* Mean ±S.E.

Rainy season

A decrease in the population of mites was witnessed with every observation period in rainy season and only 0.01, 1.54, 2.04 mites/leaf on dorsal surface and 1.32, 4.08, 4.59 mites/leaf on ventral surface were observed on the leaves of tender, grown up and older stages respectively on the last week of August

(30.8.18). Higher number of mites were recorded on grown up leaves followed by tender and older leaves. These results are in conformity with Sonika *et al.* (2017)^[10] who recorded population dynamics of *T. urticae* on brinjal. In the month of September no mites under natural conditions in the field on randomly collected samples were observed (Table 2).

Table 2: Population dynamics of *Tetranychus urticae* on African marigold in rainy season

Observation period	Average number of <i>Tetranychus urticae</i> /leaf*					
	Tender Leaves		Grown up Leaves		Older Leaves	
	Dorsal surface	Ventral surface	Dorsal surface	Ventral surface	Dorsal surface	Ventral surface
7.6.18	11.70±0.23	43.70±0.88	18.30±0.36	52.34±1.05	9.66±0.19	25.92±0.51
14.6.18	10.68±0.21	40.66±0.81	17.28±0.34	49.8±1.00	8.14±0.16	25.42±0.50
21.6.18	12.71±0.25	35.58±0.71	16.78±0.33	47.77±0.96	7.63±0.15	24.91±0.49
28.6.18	12.2±0.24	32.02±0.64	15.76±0.31	46.24±0.93	6.11±0.12	23.38±0.46
5.7.18	10.68±0.21	25.92±0.51	14.24±0.28	41.67±0.84	4.58±0.09	21.35±0.42
12.7.18	7.12±0.14	20.84±0.41	9.16±0.18	39.64±0.79	4.08±0.08	19.83±0.39
19.7.18	6.62±0.13	17.29±0.34	8.65±0.17	38.12±0.76	3.06±0.06	18.3±0.36
26.7.18	6.11±0.12	15.76±0.31	8.14±0.16	37.10±0.74	2.55±0.05	6.11±0.11
2.8.18	4.58±0.09	12.21±0.24	13.22±0.26	31.51±0.63	1.54±0.03	4.59±0.08

9.8.18	3.06±0.06	8.65±0.16	10.68±0.21	26.94±0.54	0.52±0.02	2.56±0.05
16.8.18	2.04±0.04	6.11±0.11	9.16±0.18	21.35±0.42	0.01±0.03	0.52±0.03
23.8.18	1.03±0.03	3.57±0.07	5.60±0.11	15.26±0.3	0.01±0.03	0.32±0.26
30.8.18	0.01±0.03	1.32±0.58	1.54±0.03	4.08±0.07	2.04±0.04	4.59±0.08

* Mean ±S.E.

Winter season

In winter months on the first day of sampling (4.10.18.) only few mites/leaf were recorded. Afterwards the mite population increased gradually and the peak population was observed on the

fifth week of November (22.11.18) when 9.66, 14.24, 6.11 mites/leaf on the dorsal surface and 23.38, 31.00, 15.26 mites/leaf on the ventral surface were observed (Table 3).

Table 3: Population dynamics of *Tetranychus urticae* on African marigold in winter season

Observation period	Average number of <i>Tetranychus urticae</i> /leaf*					
	Tender Leaves		Grown up Leaves		Older Leaves	
	Dorsal surface	Ventral surface	Dorsal surface	Ventral surface	Dorsal surface	Ventral surface
4.10.18	1.03±0.03	3.57±0.07	2.04±0.04	6.11±0.11	2.55±0.05	5.10±0.09
11.10.18	3.57±0.07	8.65±0.16	5.60±0.11	12.21±0.24	3.06±0.06	6.62±0.12
18.10.18	5.09±0.10	10.18±0.19	7.63±0.15	15.76±0.31	3.57±0.07	7.13±0.13
25.10.18	5.60±0.11	11.7±0.23	9.66±0.19	17.8±0.35	4.08±0.08	8.65±0.16
1.11.18	6.62±0.13	15.76±0.31	10.17±0.20	19.83±0.39	4.58±0.09	10.18±0.19
8.11.18	8.14±0.16	18.81±0.37	10.68±0.21	22.37±0.44	5.09±0.10	11.19±0.22
15.11.18	8.65±0.17	20.84±0.41	11.70±0.23	26.94±0.54	5.60±0.11	13.73±0.27
22.11.18	9.66±0.19	23.38±0.46	14.24±0.28	31.00±0.62	6.11±0.12	15.26±0.30
29.11.18	11.7±0.23	25.42±0.50	13.73±0.27	28.97±0.58	5.6±0.11	14.24±0.28
6.12.18	10.17±0.2	23.89±0.47	12.2±0.24	26.43±0.52	5.09±0.10	13.73±0.27
13.12.18	8.65±0.17	22.88±0.45	11.7±0.23	24.91±0.49	4.08±0.08	12.21±0.24
20.12.18	7.12±0.14	20.34±0.40	11.19±0.22	23.89±0.47	3.57±0.07	11.19±0.22
27.12.18	6.62±0.13	18.81±0.37	10.17±0.20	21.35±0.42	3.06±0.06	10.18±0.19
3.1.19	6.11±0.12	17.8±0.35	9.66±0.19	20.34±0.4	2.04±0.04	8.14±0.15
10.1.19	5.09±0.10	17.29±0.34	9.16±0.18	19.32±0.38	1.03±0.03	6.11±0.11
17.1.19	4.58±0.09	14.24±0.28	8.65±0.17	17.29±0.34	0.52±0.02	3.57±0.07
24.1.19	5.09±0.10	20.84±0.41	9.16±0.18	27.45±0.55	1.54±0.03	4.08±0.07
31.1.19	7.12±0.14	23.38±0.46	10.17±0.20	33.04±0.66	2.04±0.04	5.1±0.09
7.2.19	8.65±0.17	26.43±0.52	13.73±0.27	34.05±0.68	3.06±0.06	6.62±0.12
14.2.19	9.16±0.18	27.96±0.56	14.74±0.29	37.1±0.74	2.55±0.05	7.64±0.14
21.2.19	13.68±0.21	30.5±0.61	16.78±0.33	37.61±0.75	0.52±0.02	9.16±0.17
28.2.19	11.39±0.29	31.53±0.33	17.54±0.35	38.84±0.29	1.47±0.32	10.62±0.27
7.3.19	13.60±1.78	35.00±1.58	19.10±1.6	45.86±1.72	2.98±0.78	12.38±1.08

* Mean ±S.E.

From analyzing tables 1, 2 and 3 its clear that in summer season plants harbor maximum number of mites/leaf followed by winter and rainy season. Patiladiti and Ghetiya (2015) [6] recorded that mite population reaches its peak during fifth week of July while Ganai et al. (2018) [2] recorded the peak in the month of March. All such variations may come due to differences in environmental conditions, cultivar and sowing time.

Effect of leaf surface on *T.urticae* population during summer season

A comparison of *T. urticae* population on dorsal and ventral surface of marigold leaves is presented in Table 4. The results showed that ventral surface was more susceptible to mite infestation as the distribution of *T. urticae* was statistically higher (CD = 2.98; p = 0.05) on ventral surface (29.67 mites/leaf) than on dorsal surface (11.88 mites/leaf). Statistical analysis of *T. urticae* incidence showed a significant effect of the observation period (CD = 7.30; p = 0.05). A peak in population was observed in the third week of May (33.54 mites/ leaf) which was at par with the population recorded in the second and fourth week of May (28.54 and 31.17 mites/leaf).

Table 4: Effect of marigold leaf surface on *Tetranychus urticae* infestation under field conditions

Observation period	Average number of <i>Tetranychus urticae</i> /leaf		
	Dorsal	Ventral	Mean
3 rd Week March, 2018	1.46	2.89	2.18 ^a
4 th Week March, 2018	3.56	9.15	6.36 ^a
5 th Week March, 2018	7.63	20.16	13.90
1 nd Week April, 2018	9.15	22.70	15.93 ^b
2 nd Week April, 2018	11.01	25.92	18.47 ^{b,c}
3 th Week April, 2018	12.20	29.31	20.75 ^{b,c,d}
4 th Week April, 2018	13.72	33.54	23.63 ^{c,d,e}
1 st Week May, 2018	15.08	36.76	25.92 ^d
2 nd Week May, 2018	17.28	39.81	28.54 ^{e,f}
3 rd Week May, 2018	19.48	47.60	33.54 ^f
4 th Week May, 2018	16.94	45.39	31.17 ^f
5 th Week May, 2018	15.08	42.85	28.97 ^e
Mean	11.88	29.67	

CD (p=0.05) for Observation Period =7.30; S E (m) = 2.56

CD (p=0.05) for Leaf surface=2.98; S E (m) = 1.04

CD (p=0.05) for Observation Period × Leaf surface =10.30; S E (m) = 3.62

Values with the same superscript do not differ significantly

The number of mites were lowest in third week of March (2.18 mites/leaf) which was at par with the number of mites observed in the fourth week of March (6.36 mites/leaf) ($CD = 7.30$; $p = 0.05$). A significant interaction was observed between the observation period and the leaf surface ($CD = 10.30$; $p = 0.05$). Previous studies on the distribution pattern of *T. urticae* also recorded higher mite population on the ventral leaf surface as compared to the dorsal surface of leaf on various crops like, okra^[3], cucumber^[4], brinjal^[10]. This might be to protect themselves from the harsh environmental conditions including dangerous UV rays.

Influence of Environmental Factors

Results on the influence of weather parameters on *T. urticae* population build on marigold crop in summer season are presented in Tables 5. During this investigation, maximum temperature ($r=0.90$), minimum temperature ($r=0.90$), wind speed ($r=0.76$) and evaporation ($r=0.92$) showed highly positive correlation at the one percent level of significance. Morning relative humidity showed negative correlation with the mite population ($r=-0.77$). Evening relative humidity, sunshine hours

and rainfall under the field conditions showed no significant correlation with the mite population. However, Rajkumar *et al.* (2005)^[8] at Raichur, Karnataka on Jasmine revealed negative significant relationship with mite population and rainfall.

At the highest population of *T. urticae* (67.09 mites/leaf) on third week of May (Table 5), maximum temperature was recorded to be 39.70°C (Table 5). This indicates that a higher temperature favoured the population buildup of *T. urticae*. With decrease in temperature, a gradual decrease in *T. urticae* population was also recorded. For example, at 29.80°C only 12.73 mites/leaf were present. Wermelinger *et al.* (1991)^[12] also reported that developmental rate of the spider mite and its intrinsic rate of natural increase were linearly related to temperature in the range between 15°C and 35°C. The environmental factors like average wind speed, minimum temperature, evaporation, rainfall, sunshine hours, morning and evening relative humidity were, 23.30°C, 6.9 Km/h, 23.30°C, 8.20 mm, 0.00 mm, 4.70 hours, 63% and 40% at peak population while in the whole season they ranged between 2.50 to 9.10 Km/h, 12.5°C to 26.4°C, 3.50 mm to 9.30 mm, 0.00 to 14 mm, 4.70 hours to 8.60 hours, 82.00% to 48.00% and 42.00% to 21.00% respectively (Table 5).

Table 5: Influence of abiotic factors on *Tetranychus urticae* population build up

Observation period	Number of mites/ leaf	Max. Temp. (°C)	Min. temp (°C)	Morning Relative Humidity (%)	Evening Relative Humidity (%)	Average wind speed	Sun-shine Hours (h)	Evapo-ration (mm)	Rain-fall (mm)
15.3.18	5.21	31.80	12.70	80.00	31.00	2.50	7.30	3.80	0.00
22.3.18	12.73	29.80	12.50	82.00	42.00	3.10	6.70	3.50	0.00
29.3.18	27.80	34.70	13.80	73.00	27.00	3.60	7.80	5.20	0.00
5.4.18	31.86	35.70	19.80	61.00	33.00	5.60	5.40	5.60	0.00
12.4.18	36.94	33.70	18.00	72.00	39.00	6.10	7.00	5.40	14.00
19.4.18	41.52	37.60	19.40	56.00	31.00	5.50	8.30	7.70	0.00
26.4.18	47.27	39.30	20.60	52.00	27.00	5.30	8.50	6.90	0.00
3.5.18	51.85	39.40	25.20	57.00	30.00	9.10	6.80	9.10	0.00
10.5.18	57.10	39.10	22.30	57.00	24.00	7.10	7.50	7.70	0.00
17.5.18	67.09	39.70	23.30	63.00	40.00	6.90	4.70	8.20	0.00
24.5.18	62.34	42.50	22.80	48.00	21.00	4.70	8.60	9.00	0.00
31.5.18	57.94	43.80	26.40	66.00	36.00	8.10	6.60	9.30	0.00
Correlation with mite population		0.90**	0.90**	-0.77**	0.25 ^{NS}	0.76**	-0.06 ^{NS}	0.92**	-0.07 ^{NS}

**Significant at 1% level of significance

* Significant at 5% level of significance

Effect of *Tetranychus urticae* infestation on fruit parameters of marigold leaves

The results of the impact of *T. urticae* infestation on the flower parameters of marigold (Table 6) clearly revealed a significant decrease in flower parameters with increase in mite population. At 8.97 mites/leaf stage, number of flowers, flower diameter and weight was reduced to 35.23, 4.75 cm, 4.43 g as compared to 39.34, 5.83 cm, 6.30 g in uninfested plants. With increase in

number of mites from 8.97 mites/leaf in March, 2018 to 37.07 mites/leaf in April, the number of flowers, flower diameter and weight decreased to 20.96, 4.11 cm 4.21 g in April, 2018 and 28.76, 4.50 cm and 4.54 g in April, 2019 (31.48 mites/leaf). Highly significant negative correlation was found between number of mites and fruit parameters like no. of flower ($r = -0.953$), flower diameter ($r = -0.933$), flower weight ($r = -0.816$), and yield per plant ($r = -0.923$).

Table 6: Correlation between *T. urticae* and various fruit parameters for African marigold crop in winter season

Duration	No. of mites/leaf	No. of flower	Flower diameter(cm)	Flower weight(g)	Yield (g/plant)
March, 2018	8.97	35.23	4.75	4.43	156.06
	(0.00)	(39.34)	(5.83)	(6.30)	(247.84)
April, 2018	37.07	20.96	4.11	4.21	88.24
	(0.00)	(38.00)	(5.54)	(5.95)	(226.10)
February, 2019	31.48	28.76	4.50	4.54	130.57
	(0.00)	(36.00)	(5.59)	(5.50)	(198.00)
Correlation		-0.953**	-0.933**	-0.816*	-0.923**

Values in the parenthesis shows the parameters of uninfested plant

**Significant at 1% probability level

*Significant at 5% probability level

Table 7 summarizes the effect of *T. urticae* infestation on yield of the African marigold plant in winter season. Statistically, higher yield was observed in uninfested plants (223.98 g/plant) as compared to infested plants (124.96 g/plant) (CD=33.03; p=0.05). The average yield taken in different months was found to be comparable as no effect of observation period was recorded during the present study. Highest yield per plant was observed in March, 2018 (201.95 g/plant), followed by February, 2019 (164.29 g/plant) and April, 2018 (157.17 g/plant).

Table 7: Effect of *Tetranychus urticae* on yield/plant of African marigold during flowering season in winter

Observation period	Uninfested(g/plant)	Infested(g/plant)	Mean
March, 2018	247.84	156.06	201.95
April, 2018	226.10	88.24	157.17
February, 2019	198.00	130.57	164.29
Mean	223.98	124.96	

Yield expressed as g/plant

CD (p=0.05) for Observation period=N/A; SE (m) = 13.09

CD (p=0.05) for Plant =33.03; SE (m) = 10.69

CD (p=0.05) for Observation Period \times Leaf =N/A; SE (m) = 18.51

The reduction in leaves affects the photosynthetic rate which in turn reduces the number of flowers and hence the yield. *T. urticae* infestation is known to create havoc in the crops of marigold, rose, chrysanthemum, carnation and gerbera during summer months [5].

Conclusion

It can be concluded that the mite prevailed in all the seasons on the crop plants but the rainy season crop was least susceptible to mite infestation. *T. urticae* prefer grown up leaves and reside mostly on ventral surfaces of leaf. Weather parameters analysis can also forecast the mite population dynamics. *T. urticae* is a serious pest of African marigold plant that leads to a great reduction in plant yield.

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