Original Research Article

Biology and population dynamics of two spotted spider mite (*Tetranychus urticae* Koch) in Cucumber *(Cucumis sativus* Linnaeus*)* under protected cultivation

Abstract

Two spotted spider mite, *Tetranychus urticae* Koch is the major polyphagous pest on crops and cause considerable yield. Cucumber cultivation become possible throughout the year in closed condition with improved agronomic practices. The cultivation of cucumber under controlled condition is threatened by the occurrence of various pests, of which mites occupied greater importance in yield reduction. The influences of weather parameters on population dynamics of *T. urticae* were studied under protected condition and observations revealed that mite population was significantly increased under closed condition as observed that the total developmental period was 6.47 ± 0.003 days, these changes in the biology might resulted from variation in the weather parameters in closed conditions. The population dynamics of two spotted spider mites differed significantly under the protected cultivation compared to the open field condition and a peak population of mites were observed during the second fortnight of march (16^{th} standard meteorological week) and the lowest population was observed during month of November and December.

Keywords: *T. urticae*, cucumber, weather parameters, polyhouse

Introduction

Cucumber *(Cucumis sativus* Linnaeus*)* is an important vegetable that is currently grown under protected cultivation for year-round production, regardless of the season. Cucumber production increased dramatically once it began to grow in protected condition, where environmental parameters such as temperature, relative humidity, and, to a lesser extent, light conditions were all controlled. The cucumber was threatened by numerous major pests such as leaf folder, fruit borer, thrips, white flies, aphids and mites, of which mites were considered as one of the significant and difficult to constrain effectively below economic threshold level compared to other pests, attributed by short developmental period, high fecundity and sex ratio [1].

The two-spotted spider mite, *Tetranychus urticae* Koch is the most prevalent polyphagous pest on fruit and vegetable crops. It causes massive loss of the crops by draining fluids from leaves, thereby reducing the total chlorophyll content up to 45.45 to 47.27 percent and fruits yield jeopardized up to 12.45 percent of cucumber plants [2]. Mites could develop rapidly in warm conditions, and modest rising temperatures significantly increased *T. urticae* growth and development**.** The infestation of *T. urticae* hampered their successful cultivation and yield of cucumber was reduced up to 12.7 percent per plant [3].

The life cycle of *T. uticae* consists of egg, larvae, protonymph, deutonymph, and adult [4, 5]. At the end of each instar mite will undergo an inactive period in which the mite anchors itself and molts to the succeeding stage [6]. The increased temperature either directly or indirectly favours the growth and development of *T. urticae. T. urticae* has the potential to build up their population under the warm weather condition and their population was also persisting under the protected condition due to regulated environmental conditions [7] and indiscriminate use of pesticide regularly, which resulted in the mite had developed resistance to sprayed chemical pesticides [8].

Tetranychus urticae Koch, a two-spotted spider mite, is a major pest in the horticultural, orchard, and field crops such as apple [9], cotton [10], grape [11], bean [12], strawberry [13], burning bush [14], and recorded for occurrence of *T. urticae* [15]. Hussey and Parr (1963) developed a visual measure for *T. urticae* on cucumber leaf damage [16], while Park and Lee (2002) quantified *T. urticae* cucumber leaf photosynthetic rate and chlorophyll content reductions [17].

Compared with the field condition, the glasshouse condition moderates temperature extremes, and automation of facilities provides relatively stable cultivation of vegetables. The glasshouse setting not only provides ideal conditions for plants, but also gives suitable conditions for *T. urticae* population growth. The ideal temperature for *T.urticae* is 30°C [18], whereas for cucumber growth, the temperature in the glasshouse should be between 22°C and 28°C [17]. As a result, *T.urticae* outbreaks occur in glasshouses and influence cucumber yields, particularly when *T. urticae* colonizes early in the growing season. The production and productivity of cucumber was increased significantly as it was started to grow under protected condition, later their successful cutivation threatened by many pests, of which mites contributing major part in crop loss.

2. Materials and methods

Life cycle studies were conducted at the insectary (latitude: 11.0162913˚N and longitude: 76.9286577˚E), Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore.

2.1. Culturing of mites in the laboratory

The mites were collected from the cucumber grown under protected condition at kannam palayam (latitude: 11˚0030N and longitude: 77˚0608E), Coimbatore, Tamil Nadu. The collected mites were cultured on cucumber leaves collected from the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore. A 75mm leaf disc of cucumber leaf was cut and placed upon a filter paper layered on the adsorbent cotton in the petridish and the mites were transferred with help of camel hairbrush, which was kept inside the BOD incubator at presetted temperature of 30 ℃. Cotton was watered regularly to maintain the leaf fresh for as long as possible. Leaf discs were also changed regularly when the old discs dried out to maintain enough nutrition.

2.2. Studies on the biology of *T. urticae*

Thirty gravid females were collected from the pot culture and transferred with help of camel hairbrush to the individual leaf disc at the rate of one mite per petridish. The number of eggs laid by the female mite daily and the total number of eggs laid per female was counted. Thirty eggs were randomly picked and put into individual petridish containing 2 cm^2 cucumber leaves-maintained upside down on filter paper laid over an absorbent cotton that was wet periodically to keep the leaf fresh for a longer period to observe the period of development taken at each phase of the mites.

2.4. Population dynamics of *T. urticae* under protected cultivation

In cucumber variety of Multistar Rizwan F1 was observed weekly as per standard meteorological weeks to perform population dynamics of two-spotted spiders under the protected condition. The mite population was examined through a 2 cm^2 window on three chosen leaves from 10 randomly selected plants, in which one from the top, one from the middle, and one from the bottom. The plants were chosen from five separate locations, two from each field's corners and two from the middle. Using a 10X hand lens, the window paper (paper with 2 cm^2 square were cut in middle) was carefully placed on the underside of the leaf, and a count on mite population was made. At weekly intervals, the change in the population of mites was recorded.

2.5. Statistical analysis

The data recorded from the population dynamics of *T. urticae* in cucumber under protected conditions were correlated and regressed with environmental parameters with help of IBM SPSS software. The weather parameters inside the polyhouse were measured by using the temperature and relative humidity meter and light intensity were measured by using lux meter.

3. Results

3.1. Biology of *T. urticae*

Egg

T. urticae preferred to lay eggs on the under surface of leaves of cucumber. Matured gravid females laid eggs singly preferably inside the dense webbing near the veins and midrib. Eggs were transparent and round shaped initially and changed into dark colour before hatch. The incubation period of eggs was 2.64 days.

larva

larva emerged from the eggs and this newly hatched larva was petite and cream-colored. The colour turned from cream to pale green after feeding. At this phase, the simple eyes on the dorsolateral idiosoma were instantly distinguishable. The mean period of larva was 1.86 days.

Protonymph

Larva moulted into protonymph by splitting open in the middorsal line at end of larval phase. In this stage, mites observed to have four pairs of legs. Mean period of protonymph was 0.92 days

Deutonymph

Deutonymph moulted into the tritonymph, a third nymphal stage. From this stage onwards, mites could be seen easily by normal vision and sexual traits might well be differentiated. The colour of Deutonymph was mild reddish and the Mean period of duetonymph was 1.05 days.

Adult

In the adult stage, the mites showed sexual dimorphism. Males were smaller and pale blood red, with a body that tapered posteriorly to a blunt end. Female mites were dark red.

Total development period

The total developmental period of two spotted spider mites under the protected condition on cucumber was completed within 6.47 days.

Adult longevity

T. uticae observed mean longevity of 12.5 days.

Table 1

Duration of development of *T. urticae* on cucumber under protected condition

Stages	Developmental period (mean days ± SD) *
Egg	2.64 ± 0.005
Larva	1.86 ± 0.002
Protonymph	0.92 ± 0.002
Deutonymph	1.05 ± 0.003
Total development period	6.47±0.003
Adult longevity	12.5 ± 0.2

*Mean value of thirty mites, SD: Standard Deviation

3.2. Population dynamics of *T. urticae* under protected condition

The occurrence of two spotted spider mite, *T. urticae* under the protected cultivation was more frequent and very difficult to eradicate sufficiently. Their occurrence was recorded weekly intervals and the peak population of mites was observed during the 16th standard meteorological week (April. 18, 2022 to 24, 2022) and the lowest incidence was recorded during the entire month of December and their incidence was started from the first week of January and attained a peak from second fortnight of April. The population of mites was significantly positive correlation with maximum temperature (r=0.932) and minimum temperature (r=0.571) and negative correlation with maximum relative humidity (r=-0.606) and minimum relative humidity (r=-628), while the mites were non-significantly positive correlation with sunshine (r=-0.168) and negative correlation with rainfall (r=-0.90). The eggs of *T. urticae* were significantly positive correlation with maximum temperature (r=0.917) and minimum temperature (r=0.457) and negative correlation with maximum relative humidity (r=-0528) and minimum relative humidity (r=-579), while the eggs were non-significantly positive correlation with sunshine (r=0.196) and negative correlation with rainfall (r=-0.170). The regression equation of nymph and adults of two sported spider mite was Y=47.224+ 3.63X1- 0.831X2- 0.289X3- 0.244X4+ 0.071X5+ 0.548X6 and the eggs was Y=-84.066+ 6.701X1- 3.743X2- 0.123X3+ 0.009X4- 0.011X5+0.372X6. The R^2 value for nymph and adult was 0.897 and eggs 0.909 indicated that weather parameters influence greatly the population built up of two spotted spider mites under protected cultivation. According to the above equations, increase in one unit of temperature and sunshine significantly increase nymph and adults by 3.63 % and 0.548 % and eggs by 6.701 % and 0.372 % respectively, while one unit increase in the relative humidity negatively distresses the adults and eggs population by 0.831 % and 3.743 % respectively. The correlation and regression relationship were represented in the figure (1 & 2).

Table 2

Mean population of *T. urticae* in top, middle and bottom leaves of cucumber under polyhouse

SMW	Top leaf		Middle leaf		Bottom leaf		Mean + SD	Mean + SD
	Eggs	Nymph/adult	Eggs	Nymph/adult	Eggs	Nymph/adult	Eggs	Nymph/adult
50	0.26	0.75	1.14	1.24	0.81	0.75	0.74 ± 0.44	0.91 ± 0.28
51	3.21	4.49	2.47	4.12	1.94	3.73	2.54 ± 0.64	4.11 ± 0.38
52	6.63	7.66	8.47	9.18	3.92	4.58	6.34 ± 2.29	7.14 ± 2.34
1	8.42	11.48	9.94	10.92	4.73	5.93	7.70 ± 2.68	9.44 ± 3.06
2	7.58	9.36	11.25	11.57	5.64	6.08	8.16 ± 2.85	9.00 ± 2.76
3	12.46	18.14	14.86	15.26	8.25	9.91	11.86 ± 3.35	14.44 ± 4.18
4	14.61	20.1	16.44	16.14	8.86	11.34	13.30 ± 3.96	15.86 ± 4.39
5	17.19	21.49	18.39	18.48	10.54	13.62	15.37 ± 4.23	17.86 ± 3.97
6	16.43	22..53	20.61	17.23	15.26	14.69	17.43 ± 2.81	15.96 ± 1.80
7	22.14	23.41	22.12	19.45	18.33	17.17	20.86 ± 2.19	20.01 ± 3.16
8	26.36	27.34	25.88	19.71	18.78	18.93	23.67 ± 4.24	21.99 ± 4.65
9	27.17	29.48	32.93	20.83	19.14	19.78	26.41 ± 6.93	23.36 ± 5.32
10	39.54	30.45	34.86	27.88	21.29	20.61	31.90 ± 9.48	26.31 ± 5.10
11	48.82	32.67	42.81	34.46	27.43	21.22	39.69 ± 11.03	29.45 ± 7.18
12	50.29	39.59	44.35	36.19	29.91	26.94	41.52 ± 10.48	34.24 ± 6.55
13	55.67	48.13	45.61	41.65	41.33	33.85	47.54 ± 7.36	41.21 ± 7.15
14	65.71	45.34	51.83	43.12	35.24	27.69	50.93 ± 15.26	38.72 ± 9.61
15	51.39	39.62	41.87	36.31	26.45	22.87	39.90 ± 12.59	32.93 ± 8.87
16	48.56	30.84	33.26	27.46	19.83	18.53	33.88 ± 14.38	25.61 ± 6.36
17	41.43	17.48	21.49	15.64	11.54	10.85	24.82 ± 15.22	14.66 ± 3.42

SMW: Standard Meteorological Week, SD: Standard Deviation

Table 3

Weather parameters as per standard week wise

SMW*	Temperature (℃)		Relative humidity		Rainfall	
	Temp.Max	Temp.Min	RH.Max	RH.Min		
50	28.5	25.5	72	58	19.0	5.8
51	27.5	23.8	75	41	0.0	6.2
52	30	26.5	70	43	0.0	7.8
1	30.2	27.5	71	46	16.6	5.4
1	28.6	25.8	73	48	0.0	6.5
3	30.3	27.1	72	45	0.0	8.1
4	31.2	28.6	69	48	0.0	8.6
5	31.5	28.5	70	44	0.0	6.9
6	32.7	28.8	68	50	0.0	7.3
7	33	29.5	69	48	0.0	5.0
8	32.8	28	60	49	0.0	7.6
9	33	27.9	60	45	0.0	8.6
10	32	27.5	65	48	0.0	8.7
11	35.5	29.1	68	38	0.0	8.2
12	36.8	28.7	65	34	1.0	6.1
13	35.8	29.6	66	37	0.0	8.2
14	36.5	27.1	68	31	8.2	8.6
15	33.4	27	63	30.2	4.3	3.0
16	32.6	26.3	71	56	30.5	8.7
17	30.7	25.5	75	53	1.0	8.2

* SMW: Standard Meteorological Week

Table 4

Correlation of *T. urticae* with weather parameters

	Max. temp	Min. temp	Max. RH	Min. RH	Rainfall	Sunshine hours
Mean nymph/adults	0.932^{**}	0.571^{**}	-0.606^{**}	-0.628^{**}	-0.090^{NS}	0.168^{NS}
Mean eggs	0.917^{**}	0.457^{*}	-0.528^{*}	-0.579^{**}	-0.017^{NS}	0.196^{NS}

*Significant at 5 % (*p*=0.05), ** significant at 1 % (*p*=0.01), NS: Non-Significant, Temp: Temperature and RH: Relative Humidity.

Table 5

Regression analysis of nymph and adults of *T. urticae* (X) and weather parameters (Y)

	Coefficients	Standard Error	t Stat	Significant
Nymph/Adults				
Intercept	-47.224	41.296	-1.144	0.273^{NS}
Temp. Max (°C)	3.630	0.910	3.991	0.002**
Temp. Min (°C)	-0.831	1.170	-0.710	0.490^{NS}
RH. Max %	-0.289	0.312	-0.925	0.372^{NS}
RH. Min %	-0.244	0.236	-1.033	0.321^{NS}
Rainfall	0.071	0.165	0.428	0.676^{NS}
Sunshine hours	0.548	0.795	0.689	0.503^{NS}
Eggs				
Intercept	-84.066	52.146	-1.612	0.131^{NS}
Temp. Max (°C)	6.701	1.149	5.834	0.000**
Temp. Min (°C)	-3.743	1.477	-2.534	0.025*
RH. Max %	-0.123	0.394	-0.311	0.761^{NS}
RH. Min %	0.009	0.299	0.030	0.976^{NS}
Rainfall	-0.011	0.208	-0.053	0.958^{NS}
Sunshine hours	1.596	1.388	1.150	0.269^{NS}

*Significant at 5 % (*p=0.05*), ** significant at 1 % (*p=0.01*), NS: Non-Significant, Temp: Temperature and RH: Relative Humidity.

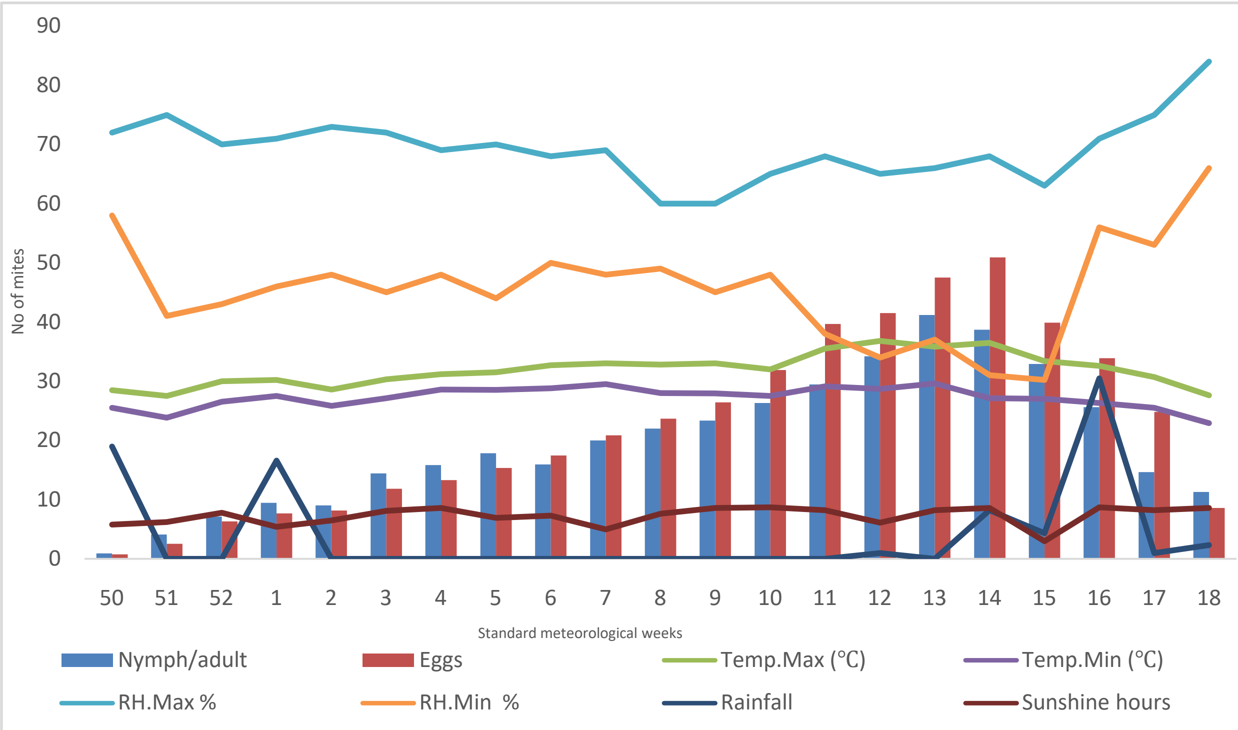

Figure 1: Correlation of *T. urticae* in cucumber under protected cultivation during 2021-2022

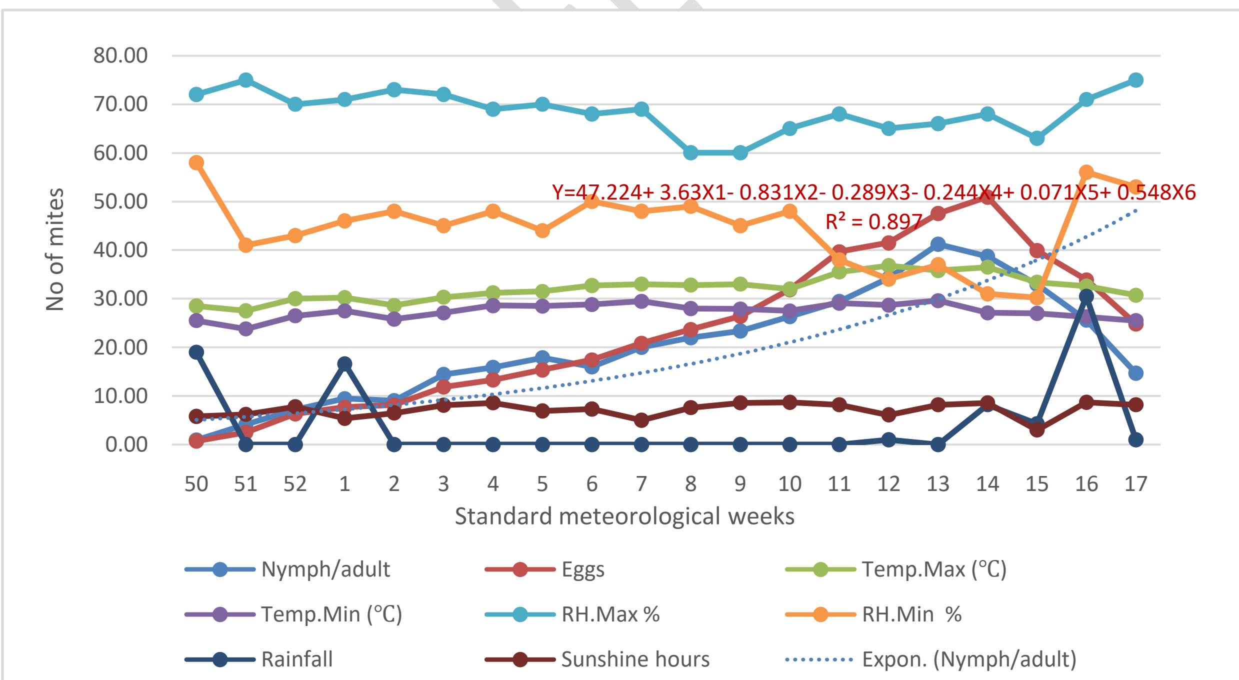

Figure 2: Regression of *T. urticae* in cucumber under protected cultivation during 2021-2022

4. Discussion

The growth and development of *T. urticae* were observed to be completed within 6.47 days and this might be due to the variation in the environmental parameters under protected conditions compared to the open field condition. According to Krishna (2014), the total development period of two spotted spider mites was recorded to be completed within 6.76 and 7.5 for males and females respectively [19]. The occurrence of *T. urticae* was predominant in strawberry cultivar, wherein the development of mites was found to be completed within 9.03 days [20]. The developmental period of *T. urticae* has been shortened by the influence of elevated temperature and condensed relative [1].

The incidence of *T. urticae* was found to be more dynamic in cucumber under protected cultivation compared to open field conditions. This might be due to variation in the weather parameters in protected compared to open field conditions. The accessibility of prey by natural enemies was found to be disabled in the closed cultivation, while open field cultivation consents activities of natural enemies and allows them to contribute to the pest population maintenance. The minimum and maximum temperature significantly increase the growth and development of *T. urticae* positively, while maximum and minimum relative humidity considerably decrease the mites population [21]. The current studies indicated that maximum and minimum temperature under protected cultivation tremendously increased the mite population and regression analysis showed that temperature significantly increased the mite population under protected conditions. Similarly, Desai (2017) observed maximum and minimum temperature increases in the mite population, while relative humidity decreases the mite population under the protected cultivation of rose [22]. The mites were negatively correlated with rainfall causing a sudden decrease in the mite population. Similarly, Ghongade (2020) reported that temperature drastically increases the mite population under protected cultivation in cucumber, while relative humidity substantially decreases the mite population in closed conditions [23]. The population dynamics of two spotted spider mite were recorded on the strawberry plants showed that mites occurrence was started from November onwards and peak was achieved at march month and highest population were found on the top leaves of plants [24]. The present studies also revealed that same population pattern have observed in this study and peak population were entertained during March month. Hollingworth (1982) reported that at lower mites densities, mites were distributed throughout the plant and subsequently as the population build up mites were aggregated on the top leaves of the plant and performed dispersion [25].

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5. Conclusion

The biology and population dynamics of *T. urticae* was highly specified and varied in protected cultivation compared to open field condition because of elevated weather parameters. Nowadays the cultivation of cucumber under protected conditions is well adopted and their successful cultivation is threatened by a vast range of pests, of which two spotted spider mites achieved a major pest status and caused significant yield loss. The studies on the biology and population dynamics of mites revealed mites have developed the potential to be plentiful in closed conditions and their shortened development constituted the quick establishment within short period of time.

6. References

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