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# Biology, population built up and damage potential of Red spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) on marigold: A review

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**Abstract**
Marigold (*Tagetus* sp.) is a commercially exploited flower crop and is having a prominent place in ornamental horticulture. Agriculture is having a large impact on human economics and the emergence of red spider mite, *Tetranychus urticae* as a serious pest of marigold is a major concern. It leads to an economic yield reduction in crops depending on cropping seasons and agro- climatic conditions. Once it is established in an area, it is hard to get rid of it due to its high fecundity, dispersal techniques, short life cycles, rapid development of resistance to acaricides and adaptability to various ecological conditions. There is an urgent need to create awareness for this acarine and its behaviour for its timely management. This review gives a complete picture of the two spotted spider mite, *Tetranychus urticae*, including its pests, biology, population dynamics, effect of environment and the damage it causes to marigold crop. Awareness through this documentation will open new scope for its early detection on marigold crop.

**Keywords:** Marigold, *Tetranychus urticae*, pest, damage

## Introduction
Marigold is an important flower crop attacked by various pests including mites. *Tetranychus urticae* Koch is a polyphagous mite adapted to feed on a vast variety of hosts and is widely distributed [34]. It hampers the photosynthetic activity of the host plant by reducing the chlorophyll content of leaves. *T. urticae* punctures the leaf cells with its stylet, leading to a mechanical damage [73]. The damaged leaves initially dry and then drop out [1]. Webbing is made by this pest as it walks on leaves, twigs or flowers. This destroys beauty of the flower crops and finally there is let down of yield and price [14]. It is having various dispersal strategies [69] which are used when either the plant is complety destroyed or abundant population is there on a single plant which creates a need for a new infestation. *T. urticae* leads to stress responses in marigold plant and affects various physiological and biological processes [66]. The life time period of this pest ranges from 18.00 to 27.60 days [50]. Population dynamics of this mite varies with season. There is also correlation between *T. urticae* with external environmental factors like temperature, humidity, sunshine and wind speed [50]. Literature search has revealed that *T. urticae* is unique in its biology and behaviour and to understand this one must have the knowledge of studies carried out on spatial distribution and adaptations of *T. urticae*, its population buildup, the influence of environmental factors and damage potential of *T. urticae*. This would open up new scope to manage *T. urticae* during marigold cultivation.

## Pests of marigold
Marigold is one of the most important flower crops attacked by pests. A number of pests such as mites, aphids, leaf miner, white fly, mealy bug, Heliothis, other lepidopterans and thrips feed on marigold [4]. Among mites, *Eutetranychus orientalis* (Oriental red spider mite), *T. cinnabarinus* (Carmine mite) (synonym of *T. urticae*) and *T. urticae* (two spotted red spider mite) were recorded infesting African and French marigold [54]. Indirect effects of mite feeding may include decreased photosynthesis and transpiration. *T. urticae* can become a very serious pest late in a crop cycle because it spins webs over the flowers which interfere with pollination [23].

At increased population levels, whitefly *Trialeurodes vaporariorum* (Westwood) (Homoptera: Aleyrodidae), became a pest of marigold [68]. Shah *et al*. (2015) [31] reported that *Aphis gossypii* Glover (melon aphid) and *Myzus persicae* (Sulzer) (green peach aphid) (Homoptera: Aphididae) are a serious pest of marigold causing heavy damages to marigold crop. Both whitefly and aphids secreted honeydew on to which a sooty fungus was grown, the presence of whom on leaves interfere with photosynthesis rate of the plant [23].

Under heavy infestation of leaf miner, the seed production in marigold decreased [83], photosynthesis is reduced [30, 48, 74], plants may be stunted and they are reported to kill young plants [15]. Feeding by larvae of various lepidopterous species such as *Spodoptera exigua* (beet armyworm) and *Trichoplusia ni* (cabbage looper) (Lepidoptera: Noctuidae) can damage the foliage and flowers of marigold [23]. *Helicoverpa armigera* was noticed on the marigold crop from the fourth week of December (1.66 larvae / 5 plants) of year 2016 to the first week of February (3.33 larvae / 5 plants) of year 2017 [4].

Wahab *et al*. (2015) [77] reported that thrips on marigold were recorded from mid-April to late July (189.5 individuals/plant) and from early September to late December 2013 (143.6 individuals/plant). The lowest number recorded was 4.6 individuals/plant.

**Biology of *Tetranychus urticae* on marigold**

The population growth parameters of *T. urticae* such as developmental rate, survival, reproduction and longevity may vary in response to changes in temperature, relative humidity, host plant species resistance, nutrition, cultivar type, exposure to pesticides, phenological stage, etc. [2, 12, 27, 40, 59, 80, 82]. Diapausing females or eggs were found as the most common overwintering stage for tetranychids [76] in response to short day lengths and cooling temperatures [43]. During diapause, *T. urticae* do not feed or oviposit, and they generally seek shelter in crevices in the bark of trees and shrubs or in clods of dirt and in leaf litter [25]. One generation of *T. urticae* was found to complete in 10-14 days when the temperature was between 21-23ºC [41] and in 7 days when temperature is higher than 30ºC [22]. Jose and Shah (1989) [31] reported that nymphochrysalis period, teleochrysalis period, protonymphal period and developmental period of male and female varies at varying room temperature. Males develop early as compared to females [43].

Rishi and Rather (1983) [57] revealed that the egg laying by *T. urticae* continued for three days and each female laid 40 to 50 eggs. Patiladiti *et al*. (2016) [51] reported that the lifecycle of *T. urticae* on marigold consists of five different stages *viz*., egg, larva, protonymph, deutonymph and adults. Each of these feeding stages was found to be followed by a short period of quiescent stage termed as nymphochrysalis, deutochrysalis and teliochrysalis. The larval, protonymph, deutonymph period and adult period on marigold were reported as 02.84±0.80, 03.56±1.19, 03.04±0.84 and 09.88±1.45 days for male and 05.36±1.11, 04.52±1.11, 04.04±0.93 and 18.44±1.92 days for female, respectively. Total developmental period was 12.08 ± 1.77 days for male and 22.11 ± 2.43 days for female. Male to female ratio of bisexual reproduction was recorded as 1: 2.43 (70.90% females) while the sex ratio of parthenogenetically reproduced population was found to be 100 per cent male [51].

***Tetranychus urticae* population build up on marigold**

*T. urticae* cause extensive damage to marigold plants. Cloudiness on plant is caused by their webbing which in heavy infestation may cover foliage and flower [51]. It was found that the maximum build up of *T. urticae* population occurred from July-August at 30-32 °C while winter forms of mite generally developed at the end of October (15-20 °C) [57]. It was reported that in kharif crops the mite incidence was from middle of November to end of December [71].

Demirel and Cabuk (2008) [11] recorded that the population of *T. urticae* was higher in cotton fields adjacent to dusty roads than cotton fields adjacent to bitumen roads. Dutta *et al*. (2011) [13] while studying spatial distribution of mites in brinjal plant reported that *T. urticae* population was higher on the upper canopy of plant (44.24%) followed by middle (30.57%) and lower canopy (25.19%). But it was also reported that mature leaves are preferred over young leaves by *T. urticae* [65, 72].

Mahato *et al*. (2008) [39] at Nadia, West Bengal found that the population of the mite on marigold followed a typical increasing trend with the increase of weather parameters except relative humidity and total rainfall. A prolonged dry spell during the spring from third week of January to second week of March led the mite population to reach its peak which resulted in a sudden population outbreak of mite. Patiladiti and Ghetiya (2015) [50] at Navsari reported the activity of *T. urticae* on marigold throughout the year under field conditions and revealed that incidence of *T. urticae* started from the first week of April and increased gradually to reach its peak during fourth week of July (17.8 mites/cm$^2$ leaf area). The lowest population of mite was recorded in fifth week of January (0.4 mite/cm$^2$ leaf area).

Bhagat *et al*. (2018) [4] recorded *T. urticae* population on marigold crop at Chhattisgarh in the third week of November to first week of February. Mite population observed in the fourth week of November (2.67 mites / 10 plant) reached to its maximum during the first week of January (3.67 mites / 10 plants). Lower population (3.00 mites / 10 plants) was observed during the end of flowering period in the first week of February. Ganai *et al*. (2018) [16] at Jammu found maximum population on variety Puasa basanti (9.52 mites/leaf) of marigold in first week of March and the lowest population was recorded on second week of January (7.55 mites/leaf).

High density of *T. urticae* population during the summer months (when temperature is high) have been reported in past on many crops such as okra [17, 19], peach [56] and cucumber [33]. Sonika *et al*. (2017) [70] at Hisar, Haryana studied the occurrence of *T. urticae* on brinjal (*Solanum melongena* L.). It was found that mite showed a gradual increase in population build up from the first week of September until getting peak in the last week of September, 2014 and afterwards, a decrease in *T. urticae* population was recorded until November.

Poovizhiraja *et al*. (2017) [52] noted the effect of various irrigation levels with different watering frequency *viz*., on daily basis, once in a week, twice in a week with an untreated control on various preferred host plants of *T. urticae* like, okra, eggplant and tomato and revealed that daily irrigation is the most unsuitable moisture regime which supported a large number of number of *T. urticae* population by maintaining the turgor pressure of the cell and succulency of leaf which in turn encouraged the uninterrupted feeding process.

**Influence of environmental factors on *Tetranychus urticae* incidence on marigold**

Mahato *et al*. (2008) [39] reported that *T. urticae* population on

marigold increased with increasing temperature. Rise in mite population was reported in summer season [49]. Patiladiti and Ghetiya (2016) [51] recorded a highly significant association between mite population and minimum temperature (r = 0.876).

Significant association between *T. urticae* population and morning relative humidity (r = 0.415), evening relative humidity (r = 0.760) was recorded on marigold [51]. Pande and Yadav (1976) [47] reported positive correlation of mite build up with relative humidity.

The development of *T. urticae* on marigold was reached at its peak during brightest period of season [39]. It was shown that sunshine hours (r = -0.454) showed significant association with *T. urticae* population [51]. Hence, decreasing trend of bright sunshine hours showed increased trends of mite population in marigold.

Gulati (2004) [19] reported that rainfall and sunshine hours did not play any significant role in mite population build up but Pande and Yadav (1976) [47] recorded negative and positive correlation, respectively between mite population and rainfall. Sadana and Kumari (1987) [61] reported that low wind velocity favoured the population build up of tetranychid mites.

**Damage symptoms and quantitative losses caused by *Tetranychus urticae* on marigold**

Among the non- insect pests of marigold, *T. urticae* is probably the most notorious one whose mouthparts were found to be adapted for sucking plant sap. Stylet of the two spotted spider mite (*T. urticae*) penetrate about 100 µ depth of leaf [28]. Under high density, *T. urticae* reduced the photosynthetic activities and transpiration of the leaves [44] due to which the leaves and branches got wilted, defoliation occurred and the plants died [60]. It was observed that puncturing of cells by mite stylets and injection of saliva cause mechanical damage, changes in cell cytology, physiological and biochemical processes of punctured as well as non punctured adjacent cells [73]. The number of photosynthetically active leaf cells that were punctured and emptied per mite, were hundred cells per minute [7].

The *T. urticae* infestation resulted in loss of chlorophyll, appearance of stipplings and white spots where the green epidermal cells were destroyed, which later on turned yellow in colour [53]. Bronzing of foliage, twisting, curling, crumpling of leaves and stunted growth on carnation and chrysanthemum plant was also observed [36, 45, 38]. Silvering of foliage in marigold was observed due to feeding of leaf cells by *T. urticae*. The cloudiness on marigold plant was reported to be caused by the webbing of *T. urticae* (produced by protonymphs, deutonymphs and adults of *T. urticae*) which under heavy infestation was observed to cover foliage and flowers [51].

The Current-year damage depending on the duration, timing and severity, reduced levels of leaf nitrogen, caused premature leaf fall [3] , reduced shoot growth and trunk diameter [6], lowered fruit yields [3,8,21], fruit size and quality [24], titrate able acids, skin color and firmness [2].

After heavy infestation on the host plant, two-spotted spider mites congregate on the top leaflet apices of bean plants where they formed a 'ball' [26]. Due to the weight of the mites the leaf got directed downward and several mites got fallen from it, leaving a silk thread that was followed by mites forming another smaller 'ball' at end of the thread. Several mites dropped down from the ball, while others continued using the threads in their migration downward towards the ground. It was noted that the silken rope either swung like a pendulum until it reached a different plant to infest it or it lengthened until it reached the ground. Once it hit the ground, mites were dispersed towards the most brighten areas. *T. urticae* infestation can start as early as third true leaf stage and can result in yield losses of up to 30 percent [18, 58, 67]. In a greenhouse brinjal crop, *T. urticae* infestation resulted in a reduction of 28.08, 20.53 and 14.37 per cent in yield, fruit weight and number of fruits per plant, respectively [46]. Infestation by *T. urticae* was observed to cause 23-25 percent loss in okra, 20-30 percent loss in cotton, 5-11 percent loss in tea and 36 percent in pointed gourd [20]. *T. urticae* was responsible for causing reduction of the economic yield of fruits ranging from 20-45 percent [53] to 50–100 per cent [37] depending upon cropping season and agro-climatic conditions.

Cotton plants were infested with *T. turkestani* at bloom, three weeks after bloom, and eight weeks after bloom resulted in 63, 31, and 18 percent yield losses, respectively [29]. The studies revealed that early infestation of mites resulted in increased crop damage and yield loss [42, 55, 81, 82].

**Biochemical changes in marigold due to *Tetranychus urticae* infestation**

It was reported that when there is disturbance of water conduction, water-stressed plants undergo changes in the concentration of soluble sugars and amino acids and thus increasing their nutritional value to *T. urticae* [73, 79]. *T. urticae* was reported to close stomata of leaves which decreased $CO_2$ uptake [9, 63] that disturbed $CO_2$ gas exchange. Feeding by mite resulted in an increase or decrease in the production of certain secondary plant constituents due to occurrence of enzymatic reactions in response to *T. urticae*. It was found out by de Angelis *et al*. (1983b) [10] that the metabolic conversion of pulegone, a monoterpene to menthal isomers occured which resulted in an increased availability of soluble carbohydrates such as that of glucose-6-phosphate.

Watson (1964) [78] reported that reproduction and population growth of *T. urticae* also increased with phosphorus concentrations up to a certain concentration. *T. urticae* showed positive correlation with nitrogen level in plant as amino acids are essential for its development and reproduction [75]. It was reported by Sivritepe *et al*. (2009) [66] that fall in potassium, magnesium and calcium concentrations by *T. urticae* infestation in sultana cultivar of grapevine occurred. Kanika (2013) [32] also reported a decrease in levels of some minerals due to mite infestation on cucumber.

The phenol content of plant increased with increase in mite infestation [35].Twenty five cultivars of okra at Palayamkottai, Tamil Nadu were rated resistant, where the resistance level was based on low moisture and more phenol content against the phytophagous mite, *T. cinnabarinus* [62].

**Conclusion**

The two spotted spider mite is a polyphagous and cosmopolitan species. Its population fluctuates with abiotic factors and under optimum conditions it reaches its highest population density. The literature reviewed suggests that its presence on the crop leads to various physiological, morphological and biochemical changes in plant cells. Webbing on flower and leaves destroys asthetic beauty of flowers and finally leads to yield losses in crop. Hence *T. urticae* is a disastrous pest of marigold crop and must be controlled in early conditions.

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