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Impact of Spider Mite Infestation on the Photosynthetic Pigments of Indian Thorny Bamboos

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ABSTRACT

Spider mites coming under the family tetranychidae, are the most common mite pests and among the most ubiquitous of all pests in the garden. The present study elucidates the damage potential of these mites on the photosynthetic pigments of the leaves of Bambusa bambos (L) Voss. The results showed that an increase in the number of mites could lead to a decline in the total chlorophyll (77%) content of this plant. The feeding activity of the mites on the leaves of B. bambos induced drastic reduction in the levels of chlorophyll a (75%), chlorophyll b (85.03%) and carotenoids (47.8%). Results of statistical analysis of the data gathered on quantitative loss of chlorophyll due to the feeding activity of spider mites (using t-test) were proved highly significant at 0.01 level, thereby establishing spider mites as a potential pest of bamboos in India.

KEYWORDS : Spider mites, Tetranychidae, Chlorophyll, Carotenoids

Introduction:

Spider mites induce common pest problems on many plants. Injury is caused as they feed, bruising the cells with their small, whip-like mouthparts and ingesting the sap. Damaged areas typically appear marked with many small, light flecks, giving the plant a somewhat speckled appearance. Many spider mites produce webbing, particularly when they occur in high populations. This webbing gives the mites and their eggs some protection from natural enemies and environmental fluctuations. Spider mites feed primarily on leaf surfaces, often occurring in higher numbers on the underside than on the upperside of leaves (Jeppson *et al*., 1975)

Bamboo spider mites are cosmopolitan and found virtually everywhere bamboos exist and are easily recognized by their characteristic webbing, primarily found on the underside of bamboo leaves. These web nests are large and densely woven. Identification of individual bamboo spider mite species, however, is much more difficult and based on the location and length of minute dorsal setae. The effects of these mites on the leaf level photosynthesis have not been studied much.

Chlorophyll is an extremely important biomolecule, critical in photosynthesis, which allows plants to absorb energy from light. Spider mite infestation causes alterations to the stomatal apparatus and internal damage to the mesophyll (Bondada *et al*. 1995) which in turn would lead to reduction in photosynthesis (Welter, 1989). However, the levels in which these changes occur and how this varies with different mite densities, nature and intensity of damage have not been clarified previously. The aim of the present investigation was to determine the effects of different levels of spider mite infestation on the photosynthetic machinery of the Indian thorny bamboos.

Materials and Methods

Uninfested and infested middle-aged leaf samples were collected randomly from the Indian thorny bamboo, grown in the Calicut University Campus during the period November 2012 to October 2013. On the basis of the nature of infestation the leaves were grouped under four categories:- Uninfested leaf, Lightly infested (1-3 webnests per leaf), Moderately infested (7-10 webnests per leaf) and Heavily infested (> 17 webnests per leaf).

The amount of chlorophyll was estimated following the procedure of Arnon (1949). One gram of leaf tissue from each category was taken separately and ground to a fine pulp in a mortar by adding 20 ml of 80% acetone. The pulps were then centrifuged at 5000 rpm for 10 minutes, and the supernatants were transferred into volumetric flasks and made up to 100 ml with 80% acetone. The procedure was repeated until the residue became colourless. The absorbance of the solution was measured at 645, 663, 470 and 750 nm against the solvent blank in a UV–Vis spectrophotometer.

The amount of chlorophyll a per gram of tissue was calculated as

$12.69\ (A_{663}\text{-}A_{750}) - 2.69(A_{645}\text{-}A_{750}) \times V/\ (W).$

The amount of chlorophyll b per gram of tissue was calculated as

$22.9(A_{645}\text{-}A_{750}) - 4.68(A_{663}\text{-}A_{750}) \times V/\ (W),$

Total chlorophyll per gram of the leaf tissue was calculated by

$20.12\ (A_{645}\text{-}A_{750}) + 8.02\ (A_{663}\text{-}A_{750}) \times V/\ (W)$

The Carotenoid in the leaf sample was calculated by the formula:

$1000 \times A_{470} + 3.27\ (\text{Chl a} - \text{Chl b}) \times V/\ W \times 229$

where A is the absorbance at specific wave length (nm), V is the final volume of chlorophyll extract in 80% acetone (ml), and W is the fresh weight of tissue extracted (g). The percentage loss was calculated for each category and represented in the tabular form. Statistical analysis of the data on chlorophyll loss was carried out using t-test to evaluate the significance.

Results and Discussion

Results of field studies revealed spider mite infestation mostly on the lower surface of the leaves of bamboos, near the midrib or veins. The infested leaves collected from the field disclosed the presence of large number of white chlorotic spots due to the feeding activity of the mite. The feeding punctures were often found coalesced to form light brown coloured areas.

Sangeetha and Ramani (2011) reported that mite infestation initially results in white spots at the points of feeding. Continuous sucking would resulted in formation of large chlorotic patches. Mites feeding also induces mechanical injury to epidermal and mesophyll tissue and hence heavy water loss from the leaf tissues. According to Jayasinghe and Mallik (2010), feeding of mites causes destruction of chloroplasts which leads to physiological changes in host plants. They also reported that the mite injures individual leaf cells which ultimately causes reduction in total chlorophyll and net photosynthetic rate of leaves. This also alters carbon allocation patterns of plant organs.

The percentage loss of chlorophyll due to the mite infestation was higher for heavily infested leaves when compared to the lightly infested leaves. In the present study, an increase in the number of mites was found to result in a decline in the total chlorophyll (77%) content of *B. bambos*. The feeding activity of these mites caused a reduction of 11.06% in chlorophyll 'a' content of lightly infested category and a reduction of 35% in moderately infested leaves whereas it showed a decrease of 75% in heavily infested leaves. The amount of chlorophyll b also disclosed a similar decreasing pattern with least damage to lightly infested category (26%) followed by moderately (45%) and heavily infested category (85%) (Table 1). The results were found highly significant at 0.01 level.

Carotenoids are organic pigments that are found in the chloroplasts and chromoplasts of plants. They serve two key roles in plants by absorbing light energy for use in photosynthesis, and protecting chlorophyll from photodamage. In the present study, carotenoids showed a decrease of 19% in lightly infested leaves, 23% in moderately infested and 47% in heavily infested leaves (Fig1).

	Chlorophyll a	Chlorophyll b	Total Chlorophyll	Carotenoids
Lightly Infested	11.6067 ± 0.3134	26.1633 ± 0.0956	18.4667 ± 0.1299	19.243 ± 0.0689
Moderately Infested	35.09 ± 0.3703	45.21 ± 0.2103	38.53 ± 0.2261	23.553 ± 0.0578
Highly Infested	75.3867 ± 0.0949	85.033 ± 0.1782	77.54 ± 1.0457	47.8 ± 0.2052

Table 1: The effect of spider mites feeding on the chlorophyll pigments in the leaves of *Bambusa bambos* (L) Voss
Values are given as mean ± SE of five replicate

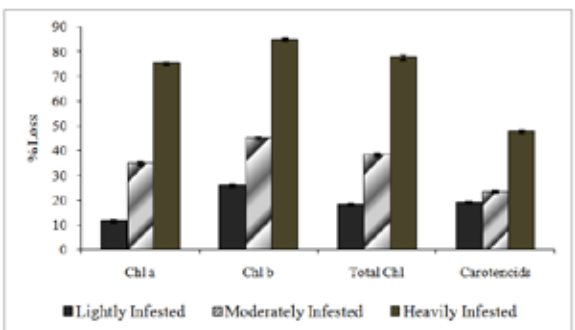

Fig 1: Quantitative difference in chlorophyll content (mg/gm tissue) of *B. bambos* leaves due to infestation by spider mites.

Damage by mites initially starts around the petiole and basal area of the leaves, impairing the transport of nutrients, hormones and water from the rest of the plant to the distal leaf portion owing to damage of the vascular tissues (Reddall *et.al.* in 2004). This in turn would lead to water stress in undamaged leaf portions and progressive closure of stomata and ultimately affect photosynthesis. There may also be a hormonal component as changes in abscissic acid (ABA) concentrations in particular can affect stomatal mechanics and leaf gas exchange; ABA is widely known to regulate stomatal aperture (Franks and Farquhar, 2001).

The decrease in chlorophyll content, as observed during the present study was correlated with the duration of the feeding period and the population density of various species of spider mites on other plants (De Angelis *et al*. 1983). The decrease in the chlorophyll content in leaves can also be attributed to the changes in the chloroplast content of cells adjacent to those damaged by the mites (Tomczyk and Kropczynska, 1985). Similarly, Tehri *et. al.* (2014) reported that the feeding by *T. urticae* results in enormous loss in the total photosynthates of the plant. According to Nyoike and Liburd (2013), removal of chloroplasts results in a decrease in the use of radiant energy with consequent reduction in vegetative growth and yield.

Conclusion

The effects of feeding of spider mites on the photosynthetic machinery of bamboo leaves were investigated in the present study. The results showed a drastic reduction in chlorophyll a, chlorophyll b, total chlorophyll and carotenoids in the Indian thorny bamboo due to the spider mites infestation. The natural occurrence of all stages of the mite species on the plant indicates their ability to complete its life cycle in the plant and thus could be considered as a natural enemy of bamboos.

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