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Alterations in The Photosynthetic Pigments of *Cinnamomum Verum* (Presl.) Due to Infestation by The Gall Mite, *Aceria Doctersi* (Nalepa, 1909) (Acari: Eriophyidae)

KEYWORDS: *Aceria doctersi*, *Cinnamomum verum*, galls, chlorophyll depletion

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ABSTRACT *Aceria doctersi is a highly host specific eriophyid mite, infesting and inducing varying numbers of pouched galls on the leaves, leaf petioles, inflorescence and the young shoots of Cinnamomum verum, one of the most economically important spice and medicinal crop. In the present study, the feeding impact of a gall forming eriophyid mite viz. A.doctersi on the photosysthetic pigments of its host plant, C. verum was studied by analyzing chlorophyll a, chlorophyll b, total chlorophyll (a+b) and carotenoid contents of infested and uninfested leaves. The results of the study revealed a significant reduction in amounts of chlorophyll a, b, total chlorophyll and carotenoid pigments, thereby elucidating the potential of the mite in hindering the photosynthetic efficiency of the host plant.*

INTRODUCTION

Eriophyid mites represent an exclusively phytophagous group exhibiting high host specificity (Keifer, 1982), (Weis, et al. 1992), inducing diverse types of abnormalities like galls , blisters, erinea, big buds, leaf rolling, stem and foliar deformation, russetting, silvering and bronzing of leaves etc. on their respective host plants (Castagnoli,1996). Neoplastic formations developed in the form of galls involve parasitism and are believed not to benefit the host plants (Armstromg 1995; Silva et al. 1996). The gall formers have been regarded as phloem parasites (Fay et al. 1996). The affected host plants respond to herbivore attack by altering photosynthetic rate which in turn would partly determine the resource base for defenses, changes in food quality, or compensatory growth (Larson, 1998).

A. doctersi (Fig:1b) is an eriophyid species which feeds exclusively on *C. verum*, an important economic crop of multiple utility in medicine as astringent, antiseptic, carminative and stimulant and its use against Type 2 diabetes, (Lu, T et al. 2012) colds, diarrhea and various problems of the digestive system. In addition, Cinnamon essential oil has significant antioxidant and antimicrobial properties as well (Priyanga et al. 2013). A.doctersi while sucking the sap from the leaves, inflorescence and tender stem of *C. verumm*, stimulates the formation of innumerable number of pouched galls of varying dimensions. Quite often, individual galls become fused to form complex, irregular, massive structures, covering the entire leaf lamina including the midrib, veins and vein lets. This in several occasions results in severe distortion and subsequent drying up of leaves.(Fig:1c)

Considering the medicinal and nutritional importance of *C. verum*, the present work was taken up to understand the severity of damage induced by *A. doctersi* on the photosynthetic rate of the plant, by assessing the alterations induced by the mite on the photosynthetic pigments like chlorophyll a, b total chlorophyll and carotenoids.

MATERIAL AND METHODS

Collection of plant samples:

Leaf samples for pigment analysis such as the galled and uninfested leaves were collected from naturally growing plants of *C. verum* having a height of six feet in the Calicut university Campus area in Malappuram district, Kerala during April-May, 2013. For rating the degree of damage, four categories of fresh leaf samples were considered: (A) Uninfested control leaf; (B) Leaf tissue around gall; (C) Galled leaf tissue; (D) Mature gall tissue.

Analysis of photosynthetic pigments:

Chlorophyll a, chlorophyll b, total chlorophyll and carotenoids were extracted from one gram each of fresh normal healthy leaf tissue and mite infested leaf tissue in 80% acetone and measured spectrophotometricallyand calculated based on the formula by Arnon, 1949. The amount of the various pigments were expressed in µg/g of dry mass basis.

Statistical analysis

The data obtained on the quantitative analysis of photosynthetic pigments were analysed using ANOVA (SAS software, version 9.0.) Descriptive analysis was done by using SPSS, version 16.0.

RESULTS

Mite infested leaves and leaf galls collected from *C. verum* growing in various localities of Calicut University Campus appeared highly distorted, bearing pouch like galls, both on the abaxial and adaxial surfaces (Fig:1a). Results of quantitative analysis performed on the photosynthetic pigments revealed a drastic reduction in both a and b contents as well as carotenoid pigments (µg/g DW) when compared to the fresh uninfested, control leaves (Table:1). As shown in Table 1, mature galls showed significantly lower concentrations of chlorophyll a (405.4±4.1µg−1 DM) and chlorophyll b (336.3±3.5µg g−1 DM)), total chlorophyll (777.5±3.06 µg−1 DM) and carotenoid pigment (346.4±11.65µg g−1 DM) when compared to the control leaf tissue [chlorophyll a (2236.388±44µg−1 DM), chlorophyll b (1205.3±38µg g−1 DM)), total chlorophyll (3344±28µg−1 DM) and carotenoid pigment (4006.392± 34µg g−1 DM).

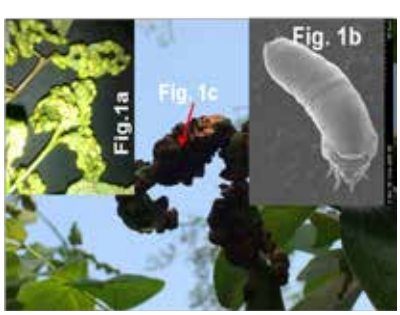

Fig: 1a. - Pouch like galls on the leaf of *C. verum* covering

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entire leaf area
Fig: 1b. - Scanning Electron Micrography of *A. doctersi* of *C. verum*.
Fig: 1c. - Completely dried leaf due to infestation by *A. doctersi* on *C. verum*.

However, results of analysis of chlorophyll pigments present immediately around the galled tissue was found comparatively higher [chlorophyll a (1336.08 ± 24.5µg−1 DM) and chlorophyll b (679.5±5.5µg g−1 DM; total chlorophyll (2085.63± 37.7µg−1 DM) and carotenoid pigment (2241.1±35.4µg g−1 DM) respectively), than that of the intact gall tissue alone (Table:1). Heavily infested galled leaf presented significantly lower concentrations of chlorophyll a (584.2±4.25 µg−1 DM) and chlorophyll b (475.03 ± 4.4 µg g−1 DM)), total chlorophyll (1094.4±30.7 µg−1 DM) and carotenoid pigment (695.4±17 µg g−1 DM) when compared to the normal uninfested tissue (control). The above data when subjected to statistical analysis (ANOVA) were found significant at 0.0001 levels.

Table: 1 – Amount of Chlorophyll a, Chlorophyll b , Total Chlorophyll, and carotenoid contents (in µg−1 DW) in the normal and mite infested leaf samples of *C. verum* (Mean± SEM (n=9).

Samples	Chl.a-µg−1 DW Mean ± SEM	Chl.b-µg−1 DW Mean ± SEM	Total Chl - µg−1 DW Mean ± SEM	Carotenoid - µg−1 DW Mean ± SEM
Control	2236.388±44	1205.3±38	3344±28	4006.392± 34
Tissue around gall	1336.08 ± 24.5	679.5±5.5	2085.63± 37.7	2241.1±35.4
Galled leaf	584.2±4.25	475.03 ± 4.4	1094.4±30.7	695.4±17
Gall tissue	405.4±4.1	336.3±3.5	777.5±3.06	346.4±11.65
F value	1234.56	507.95	1692.36	3867.93
P	<.0001	<.0001	<.0001	<.0001

During the present study, a remarkable decrease was observed in the mean per cent of chlorophyll a and b contents, as well as carotenoid pigments in the intact gall tissue (79.2%, 72% and 81% respectively) (Fig.2). As presented in Fig.2, the mean per cent loss of chlorophyll a, b and carotenoid pigments in heavily mite infested galled leaves could be observed as 66.3%, 55% and 75.6% respectively. The leaf tissue present immediately around the gall also showed a significant reduction in the photosynthetic pigments and the mean % loss was observed as 39.67% (chlorophyll a), 43.67 % (chlorophyll b), 40% (carotenoids) respectively as compared to the normal, uninfested tissue (100%).

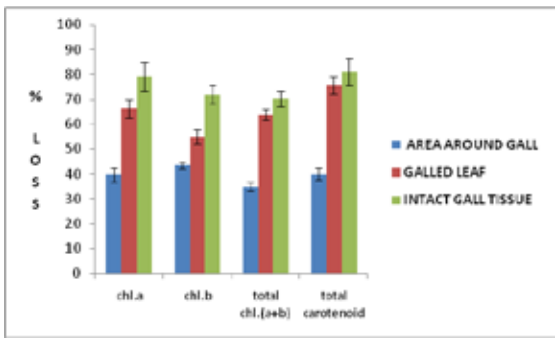

Fig: 2 - Mean± SEM (n=9) Percent loss in chlorophyll(a, b & total) and carotenoid contents due to infestation by *A. doctersi* on *C.verum*.

DISCUSSION

It is generally accepted that the biochemical and physiological characteristics of neoplastic tissues are quite different from those of the normal host plant tissues (Vereecke et al. 1997; Hartley 1998; Schonrogge et al. 2000; Konno et al. 2003). A depletion in chlorophyll contents was reported earlier in galls induced by aphids (Miles,1968 ; Purohit , 1979). This very clearly indicates that the gall formers would drastically affect the photosynthetic activity of plants, in turn leading to a reduction of biomass and thereby affecting their growth as reported earlier in *P. pinnata* (Sahadev et al, 2009). Presence of galls, would not only reduce the photosynthetic rate of infested leaves, but also impair the rate of photosynthesis in adjacent ungalled leaves of the shoot as well (Larson, 1998). Insect induced galled leaves of plants like *Eucalyptus, Tilia cordata, Ulmus glabra, Ulmus laevis* etc. also were reported to show a significant reduction in chlorophyll 'a,' 'b', and carotenoid pigments (Khattab and Khattab, 2005, Agnese et al. 2005). Eriophyid mite induced leaf galls also would result in a decrease in chlorophyll a, chlorophyll b, and total carotenoid pigments as observed in *Acer sacharinum* (Agnese et al. 2005) thereby supporting the results of the present study . The present findings were also supported by earlier studies of Castro et al. (2012) who demonstrated that insect induced extra laminar horn-shaped galls on *Copaifera langsdorffii* showed lower chlorophyll content, but acted as a sink of nutrients.

CONCLUSION

Drastic reduction of chlorophyll and carotenoid contents as evidenced during the present study revealed the negative impact of the gall mite, *A. doctersi* on the general health of the host plant, *C. verum*, by affecting the rate of photosynthesis. This would substantially lead to a reduction in the growth rate, leaf area, biomass etc. of the plant and thus reducing the economic utility of the plant in the preparation of ayurvedic medicines.

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