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RESEARCH ARTICLE

Layla AH. Al-Shareef

IMPACT OF WHITEFLY, *BEMISIA TABACI* (GENNADIUS) INFESTATION ON CHLOROPHYL AND CAROTENE COCENTRATIONS, AS WELL AS MOISURE CONTENT IN SOME VEGETABLE PLANTS IN A GREENHOUSE

ABSTRACT:

Effect of the sweet potato whitefly, *Bemisia tabaci* (Gennadius), infestation on the mean content of plant pigments (chlorophyll a, chlorophyll b and carotene), as well as the percentage of moisture content were investigated in the leaves of three different plant varieties (cantaloupe, cucumber and zucchini) in a greenhouse. Results indicated that plant pigments (chlorophyll a, chlorophyll b and carotene) differed significantly in their contents in the plant varieties. In general, mean content of chlorophyll a was significantly higher than chlorophyll b, which was higher than carotene. Plant varieties differed significantly in their content of pigments. The highest mean content of total plant pigments significantly was in cucumber, then cantaloupe followed by zucchini. Infestation with *B. tabaci* reduced mean content of each plant pigments (chlorophyll a, chlorophyll b and carotene) in all plant varieties. Feeding of the whitefly decreased total percentage of moisture content in all plant varieties as well.

KEY WORDS:

Bemisia tabaci, chlorophyll a, chlorophyll b, carotene, moisture content

CORRESPONDENCE:

Layla AH. Al-Shareef

Faculty of science for girls, King Abdul Aziz University, Jeddah, Saudi Arabia

E-mail: Layladr@hotmail.com

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INTRODUCTION:

The sweet potato whitefly, *Bemisia tabaci* is a major pest all over the world especially in tropical and subtropical regions (Toscano *et al*., 1994; Denholm *et al*., 1996). It spreads on many vegetable crops including cucumber (Shibuya *et al*., 2010), cantaloupe (Castle, 2006) and zucchini (McAuslane *et al*., 2004). Feeding of whitefly by sucking plant sap reduces plant vitality and productivity (Palumbo *et al*., 2000), deformation of leaves, flowers and fruits (Lin *et al.,* 1999). Whitefly secrets honeydew on the leaf surface, which stimulates the growth of sooty mold fungi, leads to reduce the efficiency of leaves in respiration and photosynthesis (Byrne *et al.*, 2003). It was found that the infestation of *B. tabaci* reduced chlorophyll pigments and moisture content in many plant leaves such as tomato (Buntin *et al*., 1993), cucumber (Shannag and Freihat, 2009). In addition, other sucking plant sap insects like aphids decreased concentration of chlorophyll pigments (Ni *et al*., 2001; Ni *et al*., 2002; Heng-Moss *et al*., 2003) and moisture content in plant foliage (Petitt and Smilowitz, 1982). Nagaraji *et al*. (2002) found that green bug causing reduction in chlorophyll content and photosynthetic rate in sorghum plant. As well as, herbivorous insects in soybean resulted water loss in the infested leaves (Aldea *et al*., 2005). The present study was conducted to examine the effect of whitefly, *B. tabaci* infestation on plant pigments (chlorophyll a, chlorophyll b and carotene) and moisture content in three plant cultivars that were cantaloupe (*Cucumis melo* L.), cucumber (*Cucumis sativus* L.) and zucchini (*Cucurbita pepo* L.) in a greenhouse.

MATERIAL AND METHODS:

Greenhouse plantation:

A greenhouse (size 24 × 10 m^2) was planted with three varieties: cantaloupe (*Cucumis melo* L.), cucumber (*Cucumis sativus* L.), and zucchini (*Cucurbita pepo* L.). Every variety was planted in an area of 8 × 10 m^2 at 75 cm longitudinal lines apart. The experiment laid out in a Randomized

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Complete Block Design with four replications. The study conducted between April 5 to July 8, 2008 at the Agricultural Research Station in Hada Al Sham, located 120 km northeast of Jeddah, western part of Saudi Arabia.

Estimation of plant pigments content:

The data was collected from five randomly selected plants for each of non-infested (control) and infested varieties with *B. tabaci* (five leaves from each plant) after six weeks of transplanting. 5 ml of dimethyl formamide was added to 0.05-0.1 g of each leaf of the plants in small vial and was covered immediately with Aluminum foil, and then they were placed in fridge at 4º C for 24 hours. A spectral absorption apparatus (spectrophotometer, uv-1601) was used to estimate each of chlorophyll a, b, and carotene at wavelengths 664.5 nm, 647 nm and 452.5 nm, respectively. The pigments estimated in mg/g wet weight of a plant leaf (according to Lichtenthaler, 1987).

Estimation of moisture content:

The leaves were picked up randomly from five plants for each variety that non-infested and infested with *B. tabaci* (five leaves from each plant) after six weeks of transplanting. The leaves immediately weighted using a critical balance to determine the wet weight. Each leaf was dried in an oven at 75ºC for 48 h to determine the dry weight. The percentage of moisture content for the plant leaf was estimated according to AOAC, (1980) using the equation:

% of moisture = [(Wet weight – dry weight) / (Wet weight)] × 100

Statistical analysis:

The data are subjected to statistical analysis according to Watson and Croft (1993).

RESULTS:

The study was conducted in spring season, the minimum and maximum of the temperature and relative humidity were 20.75 ± 0.25ºC, 33.76 ± 0.25ºC and 56.17 ± 0.6%, 67.22 ± 0.54%, respectively. Results showed that there were highly significant differences in the mean content of plant pigments resulted from *B. tabaci* infestation, plant varieties, as well as the differences in the kind of pigment.

Table 1 shows that there were significant differences in the mean content of pigments in different plant varieties, and the most mean content of pigments was in cucumber (1.61), then cantaloupe (1.00) followed by zucchini (0.79). From the same table it is clear that mean content of each pigments were differ significantly in all plant varieties, and they were in descending order starting with chlorophyll a (1.64), chlorophyll b (1.00) and carotene (0.76).

Table 1 also demonstrates that in cantaloupe, chlorophyll a was the highest mean content significantly (1.69), then chlorophyll b (0.82), followed by carotene (0.50). In each of cucumber and zucchini, chlorophyll a was the most content significantly (1.90 and 1.32), but chlorophyll b and carotene were not differ significantly in each plant (1.55, 1.36, and 0.63, 0.43).

The mean content of chlorophyll a was differ significantly in plant varieties, and they were in descending order starting with cucumber (1.90), then cantaloupe (1.69) followed by zucchini (1.32). For each of chlorophyll b and carotene, the highest mean content of each pigment significantly was in cucumber (1.55 and 1.36), and then cantaloupe (0.82 and 0.50) and zucchini (0.63 and 0.43) which were not differ significantly from each other (Table1).

Table 1. Mean content of plant pigments in the leaves of three plant varieties.

Plant varieties	Plant pigments			Means
	Chlorophyll a	Chlorophyll b	Carotene	
Cantaloupe	1.69 B a	0.82 B b	0.50 B c	1.00 B
Cucumber	1.90 A a	1.55 A b	1.36 A b	1.61 A
Zucchini	1.32 Ca	0.63 Bb	0.43 Bb	0.79 C
Means	1.64 a	1.00 b	0.76 c	1.13

Different letters mean that there are significant differences between the mean values (Duncan's Multiple Range Test, (Duncan, 1955).

Capital letters are present in the vertical comparison

Small letters are present in the horizontal comparison

Table 2 shows that mean content of pigments in control plants (1.42) was more significant than infested plants (0.85). In all varieties (cantaloupe, cucumber and zucchini), the mean content of pigments in control plants (1.13, 2.09 and 1.05) were more significant than infested plants (0.87, 1.12 and 0.54). In control plants, the mean content of pigments was more significant in cucumber (2.09) than each of cantaloupe (1.13) and zucchini (1.05) which were not differ significantly from each other. However, in infested plants the most content of pigments was in cucumber (1.12) which was more significant than cantaloupe (0.87) followed by zucchini (0.54).

Table 2. Mean content of total plant pigments in the leaves of three plant varieties that non-infested and infested with *B. tabaci*

Plant varieties	Control (non infested) plants	Infested plants	Means
Cantaloupe	1.13 B a	0.87 B b	1.00 B
Cucumber	2.09 A a	1.12 A b	1.61 A
Zucchini	1.05 B a	0.54 C b	0.79 C
Means	1.42 a	0.85 b	1.13

Different letters mean that there are significant differences between the mean values (Duncan's Multiple Range Test).

Capital letters are present in the vertical comparison

Small letters are present in the horizontal comparison

Table 3 shows that control plants were significantly higher than infested plants in the mean content of each chlorophyll a (1.84 and 1.43), chlorophyll b (1.38 and 0.63) and carotene (1.053 and 0.48). The mean content of chlorophyll a was higher than each of chlorophyll b and carotene in control (1.84, 1.38, and 1.053) and infested plants (1.43, 0.63, and 0.48).

Table 3. Mean content of plant pigments in control and infested plant leaves with *B. tabaci*

Means	Plant pigments			Plant case
	Chlorophyll a	Chlorophyll b	Carotene	
Control	1.84 A a	1.38 A b	1.053 A b	1.42 A
Infested	1.43 B a	0.63 B b	0.48 B b	0.85 B
Means	1.64 a	1.00 b	0.76 c	1.13

Different letters mean that there are significant differences between the mean values (Duncan's Multiple Range Test)

Capital letters are present in the vertical comparison

Small letters are present in the horizontal comparison

Table 4 demonstrates the interaction between three factors; mean content of each pigment (chlorophyll a, chlorophyll b and carotene), different plant varieties (cantaloupe, cucumber and zucchini) and the infestation with *B. tabaci*. It is clear that the highest mean content of pigments was in control cucumber leaves (2.09) followed by each of control cantaloupe (1.13), infested cucumber (1.12) and control zucchini (1.05) which were not differ significantly from each other, but significantly more than infested cantaloupe (0.87) followed by infested zucchini (0.54).

Table 4. Mean content of plant pigments in control and infested leaves with *B. tabaci* for three plant varieties.

Plant varieties	Plant case	Chlorophyll a	Chlorophyll b	carotene	Means
Cantaloupe	Control	1.82 A a	1.054 B b	0.53 B c	1.13 B
	Infested	1.56 A a	0.59 CD b	0.47 B b	0.87 C
Cucumber	Control	1.99 A a	2.13 A a	2.13 A a	2.09 A
	Infested	1.81 A a	0.98 B b	0.59 B b	1.12 B
Zucchini	Control	1.71 A b	0.95 BC b	0.49 B b	1.05 B
	Infested	0.94 B a	0.31 D b	0.36 B b	0.54 D
Means		1.64 a	1.00 b	0.76 c	1.13

Different letters mean that there are significant differences between the mean values (Duncan's Multiple Range Test)

Capital letters are present in the vertical comparison

Small letters are present in the horizontal comparison

Results from statistical analysis showed that there were highly significant differences in the mean percentage of moisture content between control and infested plants with *B. tabaci*, but there were no significant differences between plant varieties. From figure 1, it is clear that in cantaloupe, mean percentage of moisture content in infested plants (82.833) were lower than control plants (91.709) significantly. However, for cucumber and zucchini there were no significant differences in the mean percentage of moisture content in control and infested plants (89.78, 87.78, 89.456, and 87.93, respectively). For control plants, there were no significant differences in the mean percentage of moisture content. In infested plants the mean percentage of moisture content in cantaloupe was lower than each of cucumber and zucchini significantly which were not differ from each other.

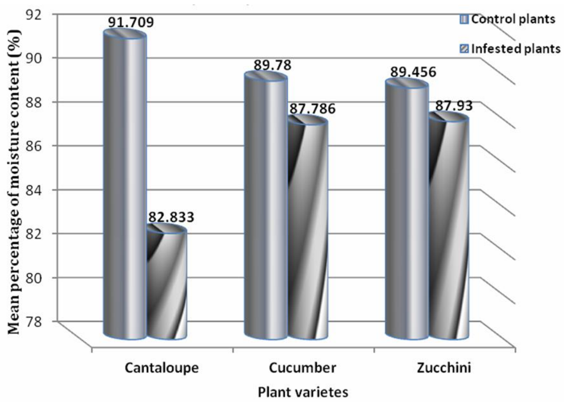

Fig. 1. Mean percentage of moisture content in three plant varieties that non-infested (control) and infested with *B. tabaci*

DISCUSSION:

Results of the present study show that feeding of the whitefly, *B. tabaci* reduced content of plant pigments (chlorophyll a, chlorophyll b and carotene) and moisture in all plant varieties. Direct sucking of plant sap, which contains plant pigments and water, may cause this. The currently results agreement with Walsted *et al*. (1973) who proved that chlorosis in pine leaves resulted by feeding whitefly on phloem sap which contains water and many important nutrients for plants, thus destroy chlorophyll and reduction moisture content in the leaf. However, some of water in infested leaves may be loss by absorbing through egg pedicel, Paulson and Beardsley (1985) reported that *B. tabaci* egg pedicel insert directly with the leaf tissue. Whereas, Buntin *et al*. (1993) proved that larval and adult stage injury of *B. tabaci* reduced chlorophyll content and photosynthetic capacity per unit of remaining chlorophyll in tomato *Lycopersicum esculentum* Mill leaves. Jimenez *et al*. (1995) found that feeding of whitefly *B. tabaci* biotype A on squash plant (*Cucurbita pepo* L.) caused chlorosis and decreasing chlorophyll content. Furthermore, *B. tabaci* causing significant reduction reached to 9.7 % and 65.9 % in each of chlorophyll content and photosynthesis rate, respectively in eggplant leaves (Touhidul Islam and Shunxiang, 2009). Whereas, Shannag and Freihat (2009) stated that *B. tabaci* infestation in cucumber leaves caused

30% reduction in the photosynthetic rate at 14 days after whitefly release, and the rate of water loss from infested leaves was 3-32% greater than control plants. In addition, Aldea *et al*. (2005) found that herbivorous insect causing water loss in soybean plant reached to 45% after 6 days feeding, these due to injuries the cuticle as well as cut edges, and the water evaporated from the apoplast of the damaged leaves. Histological studies of feeding *B. tabaci* showed that the phloem was the primary feeding site, and the stylet penetration through the parenchyma usually was intercellular (Walker, 1985). In cotton, *Gossypium hirsutum* L., Pollard (1955) proved that *B. tabaci* sometimes caused plasmolysis in parenchyma cells adjacent to the stylet, but the parenchyma cells generally remained intact.

Some insects feeding in the same way of the whiteflies causing the same effect, Petitt and Smilowitz (1982) found that aphid, *Myzus persica* (Sulzer), feeding decreased the moisture content in infested potato leaves. Nagaraji *et al*. (2002) proved that green bug infestation interval of 1, 2, 3, and 4 days reduced significantly both chlorophyll content and photosynthetic rate. In addition, aphids *Diuraphis noxia* and *Rhopalosiphum padi*, noticeably declined the amount of chlorophyll a and b and carotenoids, and increased chlorophyll degradation enzyme of infested wheat leaves (Ni *et al.*, 2001; Ni *et al*., 2002). In addition, Walter (1989) stated that leaves of barley (*Hordeum vulgare* L.) plant that infested with wheat Aphid, *Diuraphis noxia* Mordvilko, had lower relative water content than corresponding leaves from non-infested plants.

The present study also shows that there were significant differences in the mean content of chlorophyll in three plant varieties, and this result agreement with Ilyas *et al*. (1991) who found that in different types of cotton cultivars there were significant differences in morphological (hair length, hair density, leaf thickness) and physiological characters (pH value, Nitrogen and chlorophyll content), and this caused differences in *B. tabaci* incidence which fed on plant sap.

Feeding of whitefly on chlorophyll and carotene explained whitefly's performance for the plants which have higher content of these pigments. Shibuya *et al*. (2010) found that there were significantly fewer whitefly *B. tabaci* (36%) on the cucumber seedlings which grown under fluorescent lamps (FL) than on that grown under metal-halide lamps (MLs) (64%), due to higher chlorophyll content and thicker leaves in seedlings of FL cucumber than ML.

Few studies stated that the reduction in chlorophyll content in infested plant with *B. tabaci* might be caused by presence tomato yellow mosaic virus, thus causing reduction in photosynthesis rate (Marco, 1975; Leal and Lastra, 1984). Others, confirmed that the reduction in chlorophyll content was not caused by viruses; McAuslane *et al*. (2004) conducted experiments on two different genetic types of zucchini that tolerance to sliverleaf disorder virus and one susceptible, they found that all genotypes had reduced in chlorophyll a + b and carotenoids reached to 66% in petioles at the infestation level of 30 pairs of whitefly and their progeny, whereas these pigments in leaf blades declined at the average 14-15% with the infestation of 90 pairs of the whitefly and their progeny. This means that tolerance to silverleaf disorder did not protect against the loss of pigments and photosynthetic induced by feeding of *Bemisia argentifolii*, and the reduction in plant pigments was caused by feeding whitefly not by the infestation of sliverleaf virus.

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تأثير الإصابة بالذبابة البيضاء *Bemisia tabaci* (Gennadius) على محتوى الأصباغ النباتية في بعض نباتات الخضر في البيوت المحمية

ليلى عودة الشريف

كلية العلوم للبنات- جامعة الملك عبد العزيز

تمت دراسة تأثير الإصابة بالذبابة البيضاء *B. tabaci* (Gennadius) على محتوى الأصباغ النباتية (كلوروفيل أ، كلوروفيل ب والكاروتين) وكذلك النسبة المئوية للمحتوى الرطوبي في أوراق ثلاثة أنواع مختلفة من نباتات الخضر (الكنتالوب، الخيار، الكوسا) في البيت المحمي. وقد أوضحت النتائج اختلافا معنوياً لمحتوى الأصباغ النباتية من نبات لآخر. وبشكل عام فإن محتوى كلوروفيل أ هو أعلى معنوياً عن كلوروفيل ب والذي بدوره أعلى معنوياً عن الكاروتين. وكذلك فإن أصناف النباتات تختلف عن بعضها معنوياً في محتواها من الأصباغ. وقد كان أعلى محتوى لمجمل الأصباغ النباتية معنوياً كان في نبات الخيار ثم الكنتالوب يليه الكوسا. كما أن الإصابة بالدبابة البيضاء قللت من متوسط محتوى كلاً من الأصباغ النباتية (كلوروفيل أ، كلوروفيل ب والكاروتين) في جميع الأصناف النباتية. وأيضاً فإن تغذية الذبابة البيضاء قلل من إجمالي النسبة المئوية للمحتوى الرطوبي معنوياً في كل الأصناف النباتية.

المحكمون:

أ.د. نعيم محمد عيسى قسم علم الحشرات، علوم القاهرة

أ.د. عبد الرؤوف سلام قسم علم الحيوان، علوم المنصورة