Net Photosynthesis, Transpiration, and Stomatal Conductance of Avocado Leaves Infested by Avocado Red Mites

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Abstract. Net photosynthesis, transpiration, stomatal conductance, and damage rating were determined at 14 day intervals for leaves of potted avocado trees (*Persea americana* Mill. cv. Waldin), manually infested with avocado red mite (*Olygonichus yothersi* McGregor). Damage rating increased linearly over each 14 day period. Net photosynthesis decreased 28 days after mite infestation. There was no decrease in transpiration or stomatal conductance of infested leaves at this time. Transpiration decreased 42 days after infestation, presumably due to a decrease in stomatal conductance.

Resumen. La rata de transpiración, la activadad fotosintética y la actividad de los estomas fueron determinadas en plantas de aguacate (*Persea americana* Mill.) variedad Waldin, las cuales fueron infestadas previamente con el ácaro rojo del aguacate (*Olygonichus yothersi* McGregor). El daño causado por estos ácaros se incrementó linearmente durante un periodo de 14 días. La rata fotosintetica se redujó a los 28 días depués de la infestación con el acaro. No hubo sin embargo, disminucion en la transpiración o en la actividad de los estomas en hojas de aguacatas infestadas con el acaro. La transpiración decreció a los 42 días depués de iniciar la infestacion.

Introduction

The avocado red mite, (*Olygonichus yothersi* McGregor) is a pest of avocados (*Persea americana* Mill.) in Florida and California (4,6). The avocado red mite is often found on the upper leaf surface and causes severe defoliation in late fall and winter (4,7)

Previous studies have shown that feeding damage caused by different mite species decreased the net photosynthetic (Pn) rate of apple (5), strawberry (9), almond (1), and avocado (8). Sances et al. (8) observed a reduction in chlorophyll content of the upper mesophyll layer of avocado leaves caused by the feeding damage of the avocado brown mite (*Oligonychus punicae*). Chlorophyll content of the lower spongy parenchyma cells, however, was unaffected by mite damage. Stomatal conductance (g_s), transpiration (Tr) and Pn of leaves of the avocado variety Hass, was negatively correlated with brown mite feeding damage. Pn rates decreased by 56% when feeding damage on the upper leaf surface was 100% (8). Previous studies with the avocado brown mite were conducted in southern California where winter temperatures and humidity are considerably lower than in southern Florida. In addition, there may be differences in phyisological responses of avocado leaves to mite feeding between California and Florida, since the studies in California utilized a different mite species and the avocado varieties grown are different.

This study was designed to determine the effect of red mite feeding damage on Pn, Tr, and g_s of potted avocado trees in southern Florida.

Materials and Methods

Avocado plants (Persea americana cv. Waldin) were planted in a mixture of 3 parts muck:1 sand:1 horse manure (by volume) in 7.5 liter plastic pots. Scions cv. Waldin were grafted on 3-month old 'Waldin' rootstocks 18 months prior to the beginning of this experiment. Plants were fertilized monthly with 6 g/pot of a 8N-3P-9K soluble fertilizer. In addition, plants were fertilized weekly with a 20N-8.7P-16K soluble fertilizer at a rate of 6 g/pot. Plants were divided into 2 treatments: those with the entire plant manually infested with avocado red mite in early February, 1986, and those left uninfested (control). Each treatment consisted of six single-plant replications in a completely randomized design.

Prior to infesting plants with mites, 2 leaves of each plant were tagged. Tagged leaves were approximately the same age for each plant. Net photosynthesis, Tr, and g_s were determined for these leaves prior to mite infestation and at 14-day intervals for 42 days following mite infestation. The number of mites, as well as the damage rating per tagged leaf, was determined at 14-day intervals following infestation. To eliminate additional uncontrolled infestation, leaves of the control plants were inspected and mites were manually removed. The damage rating for each tagged leaf was determined by comparing the percentage of damaged leaf area with a previously constructed rating scale (Fig. 1).
Actual mite days were calculated by the formula (3):

$$\text{Mite days} = \frac{M1 + M2}{2}$$

where M_1 and$_2$ are the number of mites cm^{-2} on observation day 1 and 2 respectively. Mites cm^{-2} was determined by counting the number of mites per leaf and dividing by the leaf area which was determined with a leaf area meter (LiCor

Instruments, Inc.). Cumulative mite days was determined by the formula:

$$\text{Cumulative mite days} = \frac{M1 + 2}{2} + \frac{M2 + M3}{2}...$$

Net photosynthesis was determined by enclosing leaves in a Parkinson's leaf chamber attached to a field portable CO_2 analyzer (Analytical Development Do., Inc., Haddesdon Herts. England). The chamber contained thermocouples for leaf and air temperature measurements, a humidity sensor and a selenium photocell for determination of photosynthetic photon flux density (PPFD). All Pn determinations were conducted under saturating PPFD levels. Transpiration rates and g_s were calculated as described by Schaffer and O'Hair (10).

Net photosynthesis, Tr, and g_s of infested leaves were calculated as the % of the rates for uninfested (control) plants throughout the experiment.

Results

After infesting plants with mites, cumulative mite days and damage ratings increased every 14 days throughout the experiment (Table 1). Actual mite days increased up to 28 days after infestation and then began to decrease (Table 1). Cumulative mite days was positively correlated with damage rating ($r^2 = .82$).

Prior to infesting plants with mites, mean Pn, Tr, and g_s rates were 5.1 umol $CO_2 m^{-2}s^{-1}$, 5.6 mmol $H_2O\ m^{-2}s^{-1}$, and 382 mmol $m^{-2}s^{-1}$ respectively. These rates were fairly constant for the uninfested (control) plants throughout the experiment except 42 days after infestation. At that time, leaves exhibited chlorosis and other visual signs of senescence. Pn of the control plants decreased to half of the original rate while Tr and g_s were only slightly lower than the original rate. The majority of tagged leaves of both controls and infested plants were shed as a result of normal senescence between 42 and 56 days after infestation.

There was no significant change in Pn (expressed as % of control) of infested leaves 14 days after infestation. Net photosynthesis of the infested leaves significantly decreased 28 days after infestation (Fig. 2). This corresponded to a leaf damage rating of 2.6 (Fig. 2). Net photosynthesis of leaves of infested plants 42 days after infestation was similar to rates observed 28 days after infestation, although the leaf damage rating increased to 3.7 (Fig. 2). Transpiration and g_s of infested leaves (expressed as percentage of control) decreased sharply 42 days after infestation (Figs. 3 and 4). Transpiration was linearly correlated with g_s ($r^2 = .98$).

Discussion

The Results of this study are in agreement with the observations of others that mite feeding damage causes a decrease in Pn, Tr, and g_s (1,5,8,9). Net photosynthesis decreased prior to a significant decrease in g_s. Since mites feed primarily on the upper leaf surface of avocado (4,7), cell injury resulting from feeding damage presumably resulted in the reduced Pn rates. Sances et al. (7) found that the reduced chlorophyll content of the upper leaf surface of avocado, caused by brown mite feeding, led to a decrease in Pn. We observed no additional decrease in Pn after g_s was significantly reduced, which was contrary to what would be expected. This may have been due to the fact that the leaves began to senesce and became slightly chlorotic at the end of the study. Thus, the decreased chlorophyll content may have confounded the results during the last week of the experiment. Another confounding factor may have been the ambient temperature, which fluctuated considerably during the experiment. Previous reports have determined that the optimum ambient temperature for Pn of avocado leaves is 28°C (11). It was also determined that the optimum leaf temperatures for Pn of avocado is 20-24°C (2). Average ambient temperature during our study were lower with a maximum of 22°C and a minimum of 11°C.

Stomatal conductance showed a sharp decline 42 days after infestation. This decline was not due to leaf senescence, since g_s of the leaves of control plants decreased only slightly. Therefore, mite feeding damage resulted in decreased g_s 14 days after decreased Pn was observed. The decreased Tr rate was presumably a direct result of the decreased g_s since there was a high positive correlation between g_s and Tr.

From this study, it was determined that red mite feeding damage negatively affected the physiology of avocado leaves within a few weeks after infestation. These results, however, are based on one season. Also, it is difficult to extrapolate results from potted plants to responses in a grove. Therefore, a similar experiment should be conducted in the field, incorporating yield data.

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Table 1. Mean number of mite-days, cumulative mite days, and damage rating for leaves of potted avocado plants infested with avocado red mite.

Days after infestation	Actual mite-days	Cumulative mite days	Damage rating
0	0.0 c[1]	0.0 d	0.0 d
14	10.5 b	10.5 c	1.7 c
28	19.9 a	30.4 b	2.6 b
42	13.3 b	43.2 a	3.7 a

[1]Mean separation within columns by Tukey's studentized range test (P = .05).

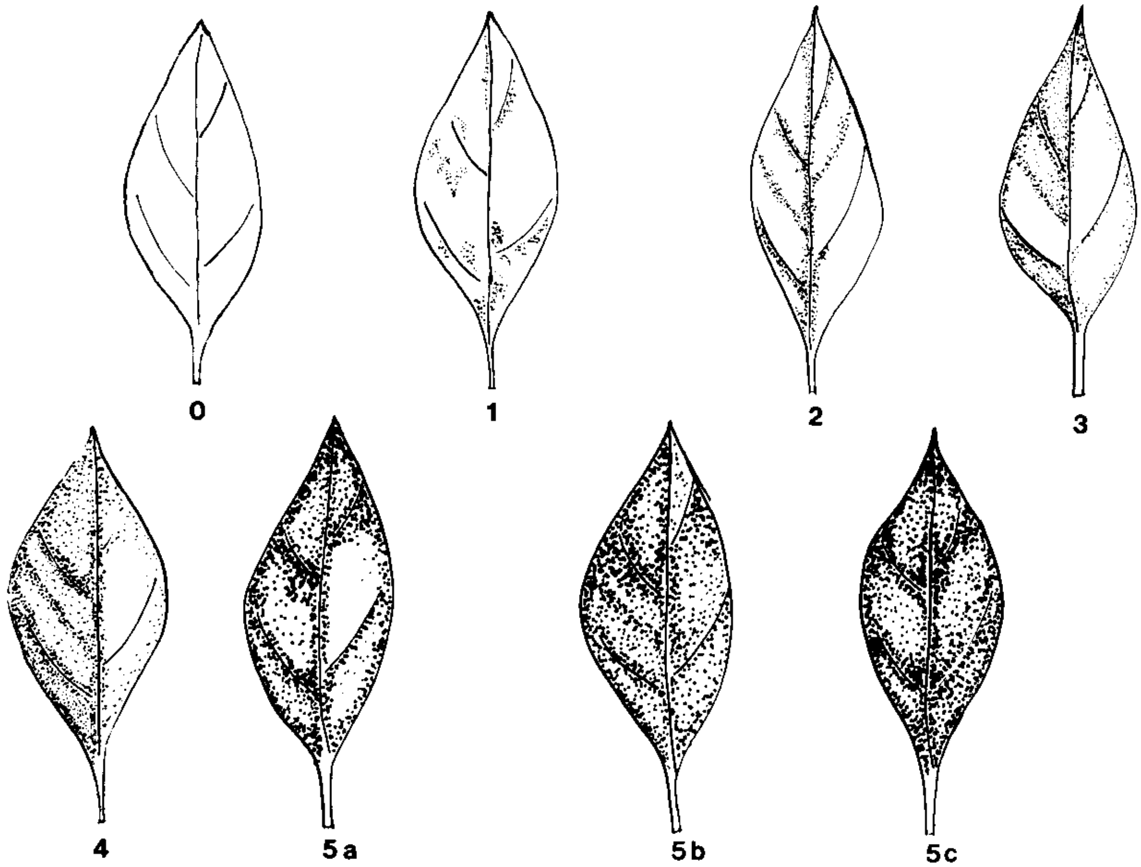

Figure 1. Diagramatic representation of red mite feeding damage rating scale on avocado leaves.

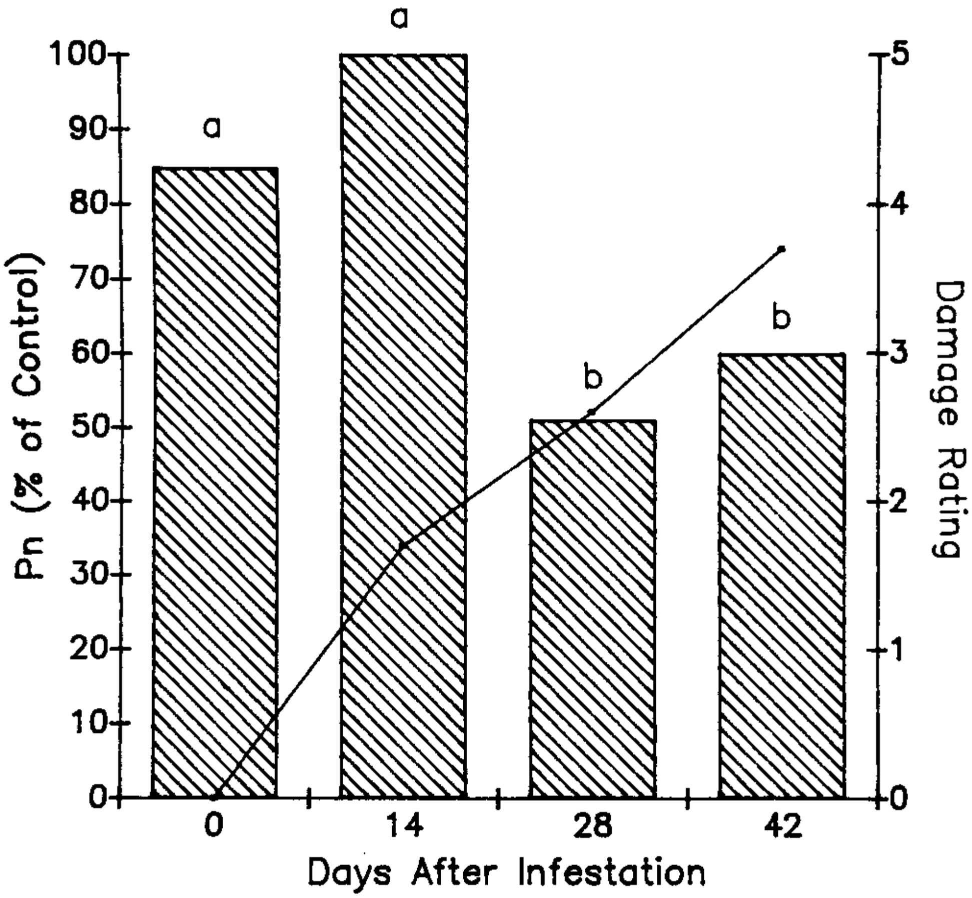

Figure 2. Net photosynthesis (Pn) and damage rating of avocado leaves infested with avocado red mites. Bars represent Pn, line represents damage rating. Mean separation by Tukey's studentized range test (P = 0.5).

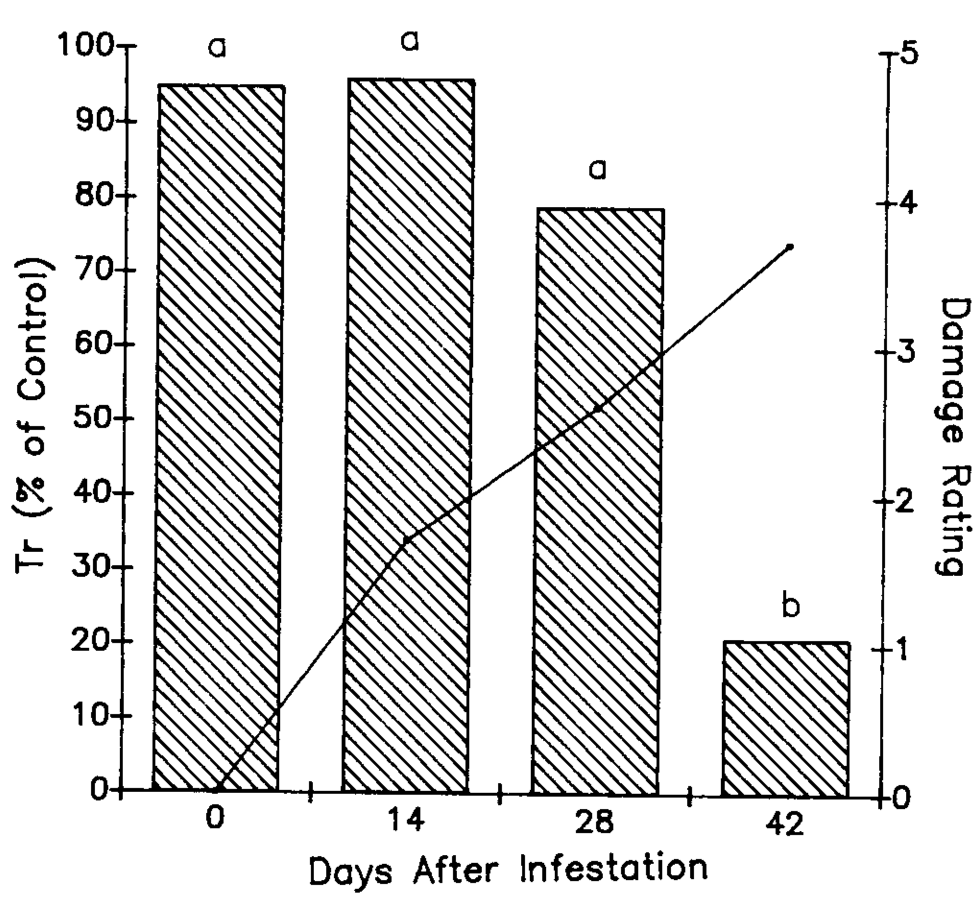

Figure 3. Transpiration (Tr) and damage rating of avocado leaves infested with avocado red mites. Bars represent Tr, line represents damage rating. Mean separation by Tukey's studentized range test (P = 0.5).

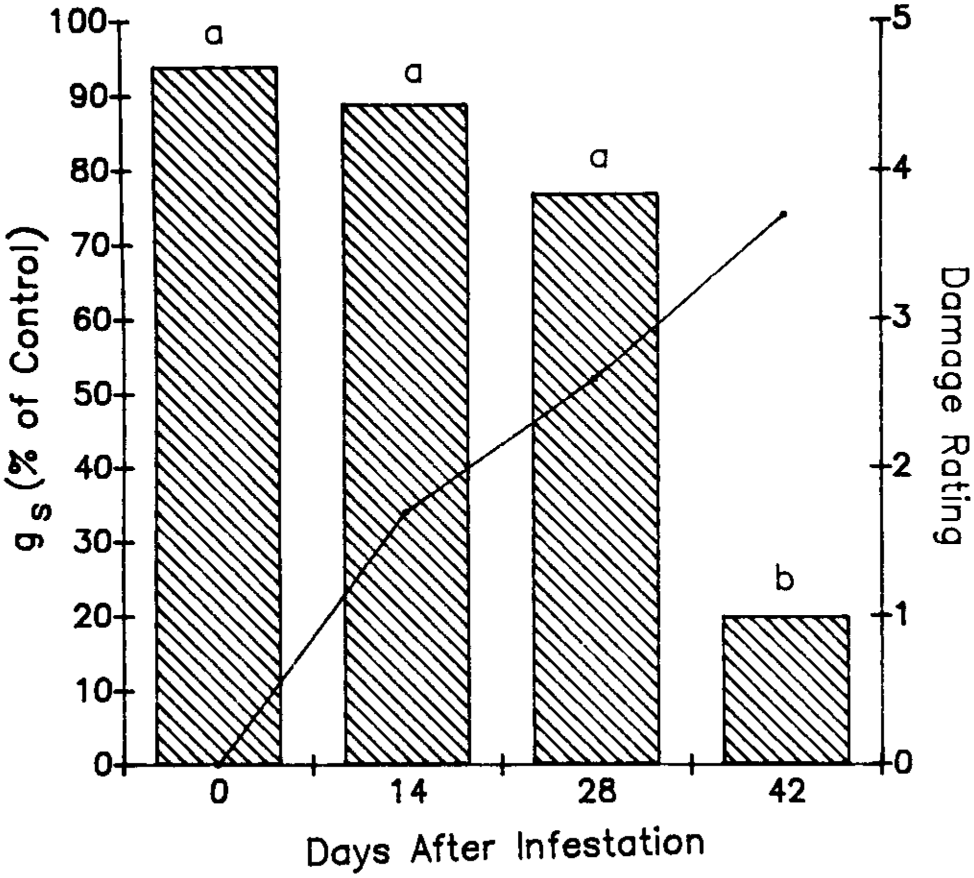

Figure 4. Stomatal conductance (g_s) and damage rating of avocado leaves infested with avocado red mite. Bars represent g_s, line represents damage rating. Mean separation by Tukey's studentized range test ($P = .05$).