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A Study of Stomatal Behaviour of Avocado (*Persea americana* Mill.) Leaves

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ABSTRACT

Immature expanding avocado leaves are relatively sensitive to water loss under highly evaporative environments due to the lack of stomatal control. Stomatal conductance (g_S) was determined on young expanding leaves of one-year-old avocado trees cv Hass growing in the glasshouse. The g_S measurement was made in controlled air temperature room of 25°C both in the dark and light during leaf growing. Fully expanded leaf size was reached by about 30 days after emergence. Similar behaviours of stomata both in the dark and light were observed, suggesting to be due to an overriding effects of low vapour pressure deficit (VPD) on g_S.

Key words : avocado, *Persea americana*, stomatal behaviour, water conductance

INTRODUCTION

Wilting often occurs visually on immature expanding flushes in avocado particularly under highly evaporative environments such as high irradiance and temperature, and low air humidity. This symptom actually reflects the excessive transpiration loss from the young expanding leaves while water can not have replenished that loss whereas mature expanded leaves are often capable of maintaining turgidity. Control of water loss within the soil-plant-atmosphere continuum in tree species is mainly by regulation of stomatal aperture (Raschke, 1975; Cowan, 1977).

It is hypothesized that the control of avocado stomata is a physiological function of leaf maturation since the young unfolded expanding leaves lack stomatal control over water loss (Scholefield and Kriedemann, 1979). On the other hand, for the mature expanded leaves, stomatal closure occurred to conserve water at high irradiance, temperature and vapour pressure deficit (VPD) around midday (Whiley *et al.*, 1988). In addition, in the morphological and anatomical studies on avocado leaves during their expansion, both the adaxial and abaxial surfaces are covered with wax-like deposits as leaves become more mature (Scholefield and Kriedemann, 1979;

The objective of this study was to report the behavior of avocado leaf stomata in response to light and dark periods during the course of leaf expansion to define the stomatal function in controlling water loss.

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MATERIALS AND METHODS

Five one-year-old avocado trees cv. Hass were grown in a glasshouse where air temperatures were 32+2°C and 23±2°C for the day and night, respectively. The first two leaves on new flushes from each of the five trees were tagged as they emerged from the shoot buds. Approximately five to ten days after the leaf emergence, its area was measured using a portable LICOR Model LI-3000 leaf area meter. Stomatal conductance (g_S) was also measured on the abaxial surface of the leaves using a LICOR Model LI-1600 steady state porometer. The g_S measurement was taken after the trees were transferred to acclimatize to the controlled air temperature room at 25°C where VPD was controlled at 0.6 to 0.8 kPa. The g_S measurement was made both in the dark and the light conditions. For the measurement in the light, the tree was placed under an artificial light source and a well-drained water bath was installed underneath the light source to reduce radiation heat to the tree. The photosynthetic photon flux densities (ppfd) of 800 to 1200-μmol quanta $m^{-2}s^{-1}$) were determined (saturating ppfd 500 μmol quanta $m^{-2}s^{-1}$, Scholefield *et al.*, 1980). All those measurements were made every four days until leaves stopped expanding (about 30 days after emergence).

Data were plotted from individual leaf and the best fitting regression curves were used for data projections. The experiment was conducted at Maroochy Horticultural Research Station, Nambour, Queensland, Australia during the period from December 1990 to February 1991.

RESULTS

Leaf growth increased exponentially for the

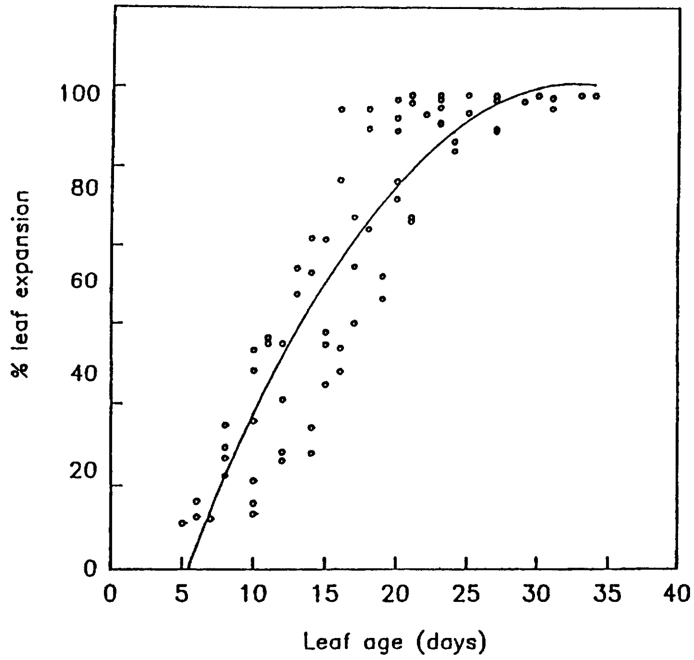

Figure 1 The relationship between age and expansion of avocado leaves (cv. Hass) represented by : $y = -44.66 + 9.03x - 0.138x^2$, $r = 0.91$.

first 20 days, reaching 50 percentages of full size at 15 days after emergence (Figure 1). A gradually diminishing rise of leaf growth was observed from day 20 onward and the full expansion was reached at around 30 days after emergence.

The g_S values measured both in dark and light periods varied considerably (Figure 2). The values tended to increase with leaf maturity from 50 percentages of full expansion to full size in both two conditions. There was no significant difference in the g_S values between dark and light periods throughout leaf growth and development (Figure 2). Therefore, stomatal function could not be described for the closing-opening transition of leaf age. From observations with an electron microscope on the abaxial surface of some mature expanded leaves, most stomata showed similar behaviour both in the dark and light. Stomata were still open in the dark.

g_S was likely to be responsive to VPD whether in the dark or light (Figure 3). The data were substantially variable. Although there was no relationship between VPD and g_S, the g_S values tended to be higher where VPD was relatively low.

DISCUSSION

A similar pattern of leaf growth was also demonstrated for the seven-year- old Quatemalan avocado trees cv. Hass growing in a commercial orchard at Nelspruit, South Africa (latitude 25°S, altitude 660m) (Whiley, 1990). Even studied on the small juvenile tree, leaves grew quickly and full expansion was reached after about 30 days. This result is similar to the reports on the mature bearing orchard in Quatemalan cv. Hass (Whiley, 1990)

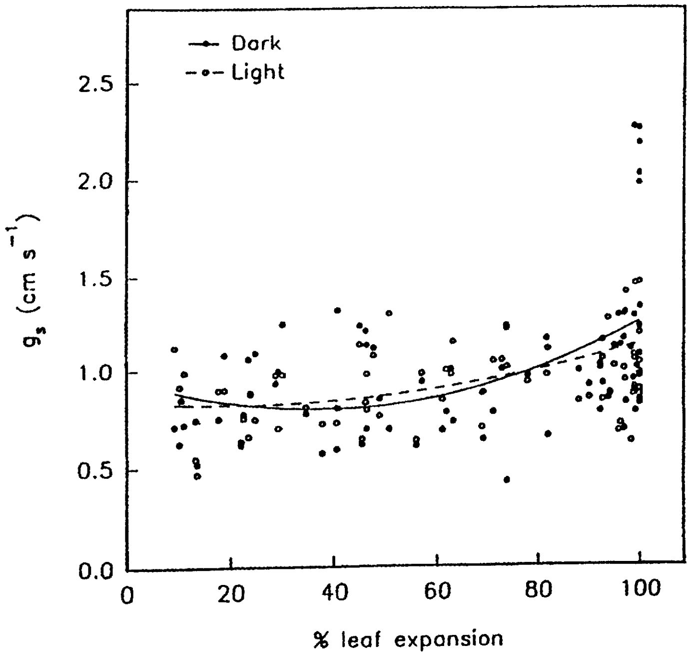

Figure 2 The relationship between stomatal conductance (g_S) and leaf expansion of avocado (cv. Hass) measured in the dark where $y = 0.95 - 0.08x + 0.0001x^2$, $r = 0.48$; and measured in the light where $y = 0.83 - 0.001x + 0.00004x^2$, $r = 0.30$.

and the West Indian cv. Peterson (Schaffer *et al.*, 1991). Although CO_2 assimilation was not measured in this study, the net gain in CO_2 assimilation was present at 80 percentages of full leaf expansion (25 days old), increasing to the maximum rate at 60 days (Whiley *et al.*, 1990; Schaffer *et al.*, 1991). That evidence obviously indicates the sink-source transition for photoassimilates of leaf age. This implication is really useful for manipulating the tree for optimum cropping since the sink-source competition for photoassimilates between young vegetative shoots and developing fruits often occurs during fruit set (Whiley, 1990). As this transition exists, stomata may have already developed and hence played an important role for gas-water exchange between leaf and atmosphere.

Unfortunately, the data in this study were not able to depict the initiation of stomatal control of gas-water exchange between leaf and atmosphere at any stage of leaf growth and development. Stomata behaved similarly both in the dark and light conditions from 10 percentages of full leaf expansion to fully expanded size over a narrow low range of VPD at 0.6-0.8 kPa. This results cause a discrepancy to the report by Scholefield and Kriedemann (1979) that stomata of fully expanded avocado leaves closed as it was dark. Different response of stomata in the dark may be attributed to other environmental effects especially VPD and/or air humidity. In the current study, it is likely to be an overriding effect of VPD on stomatal aperture. Over such low VPD range, stomatal opening was retained.

The sensitivity of stomata to VPD has been reported in some fruit trees such as lychee (Menzel and Simpson, 1986), custard apple (George *et al.*,

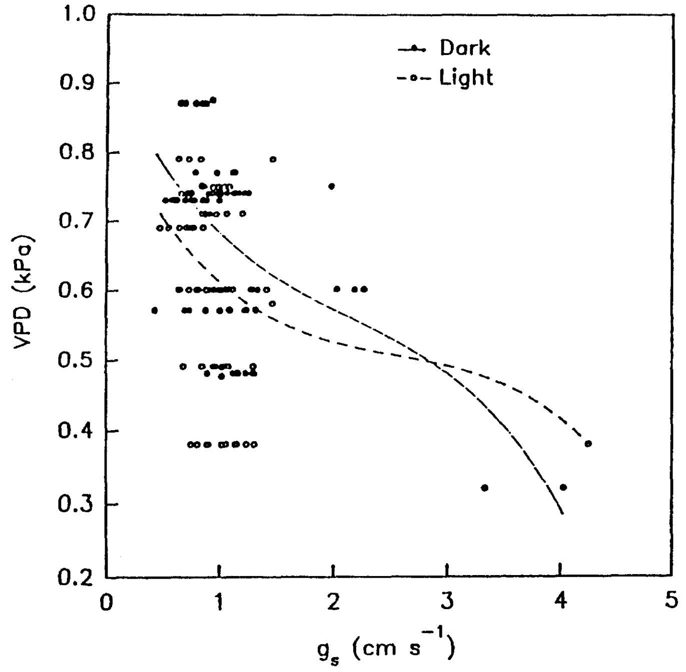

Figure 3 The relationship between vapour pressure deficit (VPD) and stomatal conductance (g_s) of avocado (cv. Hass) measured in the dark where $y = 0.93 - 0.349x + 0.124x^2 - 0.019x^3$, $r = 0.32$; and measured in the light where $y = 0.84 - 0.334x + 0.119x^2 - 0.016x^3$, $r = 0.32$.

1990) and mango (Pongsomboon, 1991). Furthermore, George *et al.*, (1990) reported that in custard apple stomata were highly sensitive to relative humidity and/or VPD at a much greater extent compared with other environmental factors including photon flux density, leaf temperature and wind speed. Likewise, it is possibly presumed that stomatal responses of avocado leaves are likely VPD-dependent, regardless of light and dark effects.

On the other hand, lychee stomata are open at night and relatively insensitive to changes in irradiance per se whereas air humidity has an overriding effect on g_S (Menzel and Simpson, 1986). Stomatal opening at night has also been reported in some species such as cotton, soybean, and kenaf (Muchow *et al.*, 1980) and *Piper hispidium* (Mooney *et al.*, 1983). These evidences reinforce the results of this study.

Further works are required to investigate the influence of VPD or humidity on stomatal response of avocado leaves in relevance to light and dark effects.

CONCLUSION

Stomatal development of avocado leaves is important for control of transpiration during new flush growing and reproductive growth especially when water deficit occurs. Despite the lack of significant stomatal response to light and dark effects, low VPD or high air humidity is likely to have an overriding effect on g_S. The interpretation is attained to question of what are the major environmental factors directly influencing stomatal behaviour. This should be sorted out by manipulating some specific environmental conditions for avocado trees. The interactions between those environmental variables influencing on g_S are of interest as mature bearing orchard trees are also responsive.

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