South African Avocado Growers' Association Yearbook 1998. 21:36-38

Effect of Photo-inhibition on Fruit Growth and Development in Hass Avocado

I. Bertling & A.K. Cowan
Department of Horticultural Sciences, University of Natal, Pietermaritzburg, Scottsville 3209.

ABSTRACT

Avocado (*Persea Americana* Mill.) is indigenous to the mezo-american rainforests, an environment with only slight fluctuations in daily and annual temperatures, with similar light intensities throughout the year and constant high humidity. In South African orchards, however, trees are subject to low and high temperatures and high radiation which might result in a reduction in photosynthetic efficiency, in photo-inhibition at times crucial for fruit growth and development. This reduction in photosynthesis could affect fruit size negatively. Leaf temperature, light intensity and plant photosynthetic efficiency was measured on a sunny winter, spring and summer day. Highest temperature and light intensity readings were found on the East and North side of trees. The impacts of these environmental conditions on tree productivity and fruit growth are discussed.

INTRODUCTION

Worldwide, avocado is cultivated under environmental conditions which differ from its habitat of origin, the mezo-american rain forests. In South Africa avocado orchards are, in comparison to their natural habitat, subjected to lower and higher temperature, water stress and higher irradiation. These environmental conditions might be expected to adversely affect photosynthetic efficiency. The decrease in photosynthetic capacity, due to exposure of photosynthetically active tissue to high fluxes of photosynthetically active irradiation, is termed photo-inhibition. In most cases photo-inhibition is a reversible phenomenon and photosynthetic rates can thus be restored after a lag-period when the leaves are exposed to less intense irradiance. However, a temporary decrease in photosynthesis is likely to result in a general reduction in carbon available for fruit growth and development. Besides high or low temperature, other stresses can also trigger photo-inhibition and thus influence fruit growth.

Photo-inhibition has been reported in avocado in Eastern Australia during the winter months (Whiley 1994). The minimum temperature curve for this region resembles one of the KwaZulu-Natal-midlands growing areas. Hence, inhibition of photosynthesis could also occur under SA growing conditions due to cold temperature stress. Potentially photo-inhibition might also occur under high temperatures during summer months and as a result of stress during fruit set when intense vegetative and reproductive growth occurs. How severely the photosynthetic system is affected by excess light energy depends on the intensity of radiation and on the physiological condition of the plant.

Since incident irradiation upon leaves differs from the aspect of the tree (i.e. direction-dependant) we decided to investigate the phenomenon of photo-inhibition in Hass avocado in relation to aspect of the tree (and fruit size). In addition, since younger leaves might not have developed mechanisms of photo-protection it was important to consider photosynthetic efficiency of leaves of different ages in assessing the contribution of photo-inhibition to fruit development.

The aim of the present study was to establish whether photo-inhibition occurs in Hass avocado cultivated in the KwaZulu -Natal Midlands and whether it can be correlated with particular periods of the season. Secondly, photo-inhibition reduces the amount of photosynthates for fruit growth and since small fruit size is a particular problem in Hass avocado, an attempt was made to correlate fruit size with photosynthetic efficiency of different aspects of the tree.

MATERIAL AND METHODS

Mature Hass avocado trees on Duke 7 rootstock, grown on Everdon Estates in the KwaZulu-Natal Midlands, were selected for this investigation. North, East, South and West aspects were marked and leaf temperature and incident light intensity recorded with a quantitherm light meter/thermometer (Hansatech, U.K.). Furthermore measurements of chlorophyll fluorescence, expressed as the ratio of variable over maximal fluorescence (Fv/Fm ratio), an indirect measure of photo-inhibition (Osmond 1994) were recorded with a Plant Efficiency Analyser (Hansatech, U.K.). Chlorophyll fluorescence, a measure of plant productivity, was determined for each of four leaves from each of the four aspects and for leaves of two different seasons (i.e. the present and the previous flush). Measurements of light intensity, temperature and chlorophyll fluorescence were taken hourly from 7hOO to 17hOO on clear, sunny days in winter (15.06.1997), spring (22.10.1997) and summer (10.2.1998).

Fruit size, determined as length for fruit from each of the four aspects from five trees at a height between 0.5 and 2 m was measured with a digital caliper in spring (22.10.1997) and summer (10.2.1998).

RESULTS AND DISCUSSION

Tree aspect and diurnal leaf temperature

During the winter season temperature was 4°C for all aspects at 7h00 (sunrise). Over the course of the day temperatures increased to a maximum of 18 to 20°C at midday. Thereafter leaf temperatures declined and by 17h00 temperatures had dropped to 6°C (East) to 8°C (West).

Leaf temperatures during spring (22.10.1997) were 26°C for the Eastern aspect by 7h00 and 20°C for the other aspects. Temperatures rose to a maximum of 32.5°C at midday on the Northern and Western aspect and 30.5°C for the Southern and Eastern aspect, and then declined to 22°C by 17h00 for all aspects. Leaf temperature on the Eastern aspect was distinctly higher than on all others in the morning. Leaf temperatures during the day of 10.02.1998 were at 20-22°C reaching a maximum of 36°C for the Northern

aspects at midday. Leaves on the Eastern aspect reached 34°C while those in the West and South increased to 33°C at 14h00.

Temperature measurements were taken at an above ground height of 1.5m where leaves are seldomly exposed to full sunlight. Much higher temperatures might prevail in the unshaded part of the tree and adversely effect photosynthesis, especially at midday or when light intensity is at maximum.

Tree aspect and changes in diurnal light intensity

The highest light intensity was measured on the Eastern aspect during spring and summer (figure 2). Over the course of the day light intensity declined on the Eastern aspects and increased on the Northern aspects. However, the light intensity at the top Northern, unshaded part of the tree might be higher at midday than those recorded for the Eastern aspect in the morning.

Tree aspect and diurnal plant productivity

Plant productivity was measured on 18.06.1997 for leaves from the current season (young leaves) and for those from the previous season (old leaves) and results showed values as low as 0.63 and 0.66 for the Northern and Eastern aspects. Similarly old leaves on the Eastern and Northern aspects showed lower productivity than the Western and Southern aspects. During October values for leaves of different ages were lowest on the Eastern aspect. The Northern aspect leaves differed only slightly from leaves on the Western and Southern aspects.

Plant productivity values below 0.6 are regarded as photo-inhibitory (Demmig-Adams *et al.* 1993). Hence, though there was a tendency towards stress in leaves on the Eastern and Northern aspects measurements did not indicate inhibition of photosynthesis.

Tree aspect and fruit size

Determination of fruit length in October revealed differences in fruit size between the four aspects: in October fruit size on the Eastern aspect was greater than on the Northern aspect followed by the Western aspect (figure 4). Fruit on the Southern aspect were smallest. By February, fruit on the Northern aspect had attained an average of 75 mm while those on the Southern aspect were only 66 mm long. Hence the relatively higher light intensities and temperatures on the Northern and Eastern aspects did not affect fruit development negatively.

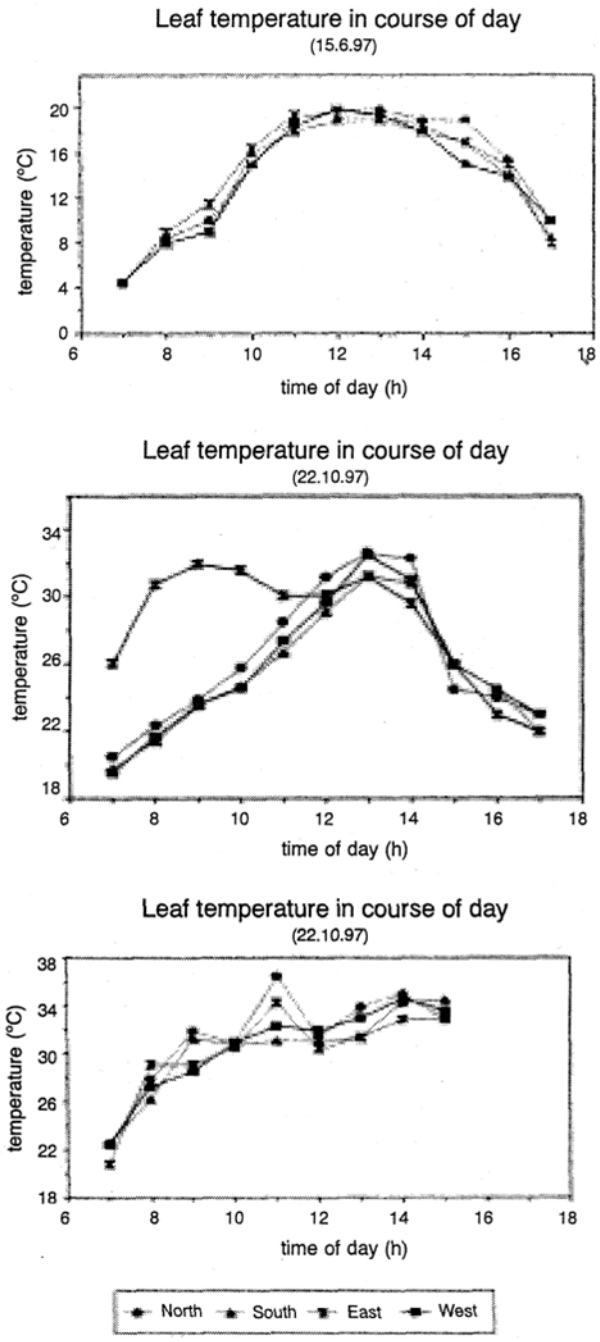

Figure 1: Diurnal leaf temperature of Hass avocado in winter, spring and summer

CONCLUSION

Our results show that leaves of Hass avocado trees endure differences in environmental conditions depending on aspect. Higher temperatures and light intensities at the Eastern and Northern aspects might be one of the reasons for a decrease in plant productivity over the course of the day. However, this reduction in

plant productivity does not seem to have a negative affect on fruit growth. Fruit size measurements at the Northern and Eastern aspects showed that fruit growth is not correlated to a decrease in plant productivity. Nevertheless, photo-inhibition measured as a reduction in plant productivity, might occur either under more stressful conditions (i.e. higher light intensity, higher temperature) or in less well managed orchards.

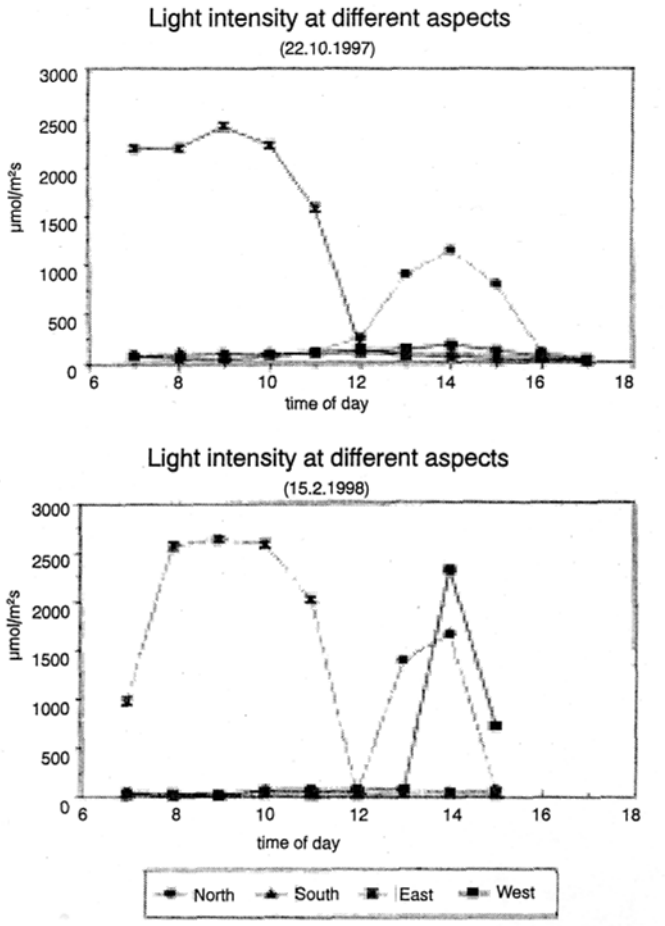

Figure 2: Light intensity at different aspects of Hass avocado trees

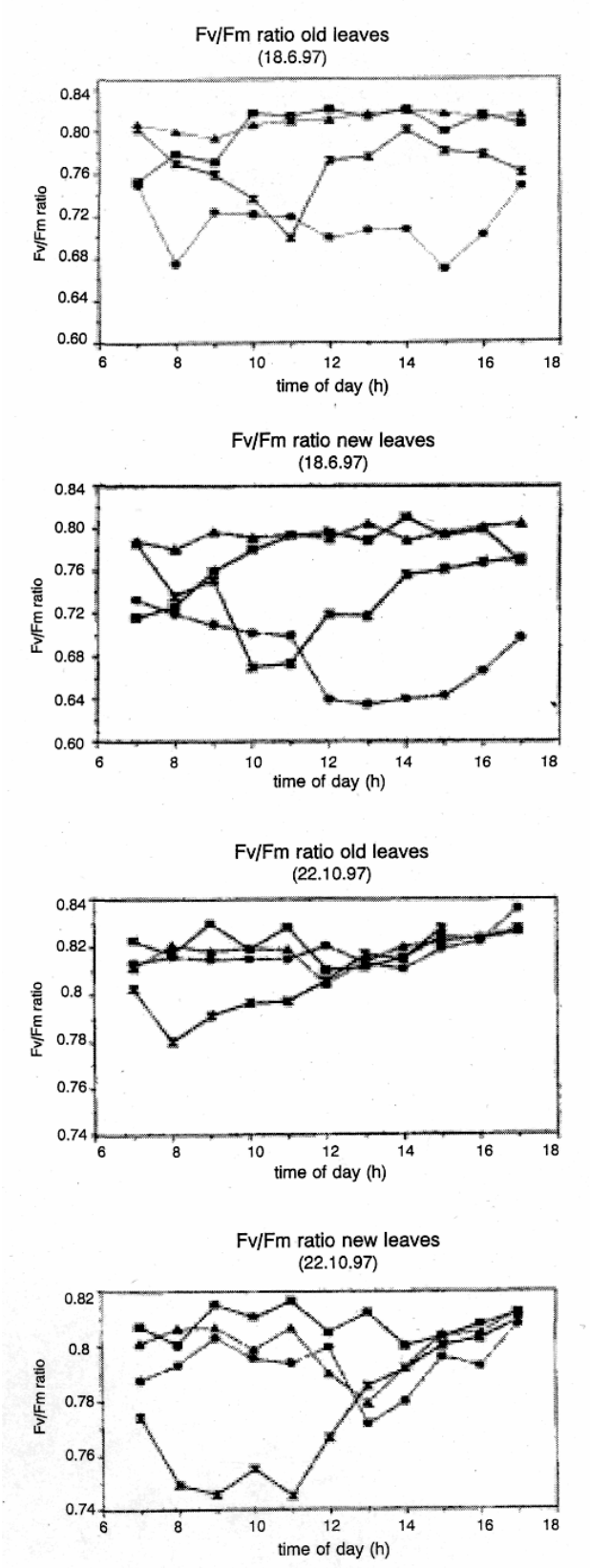

Figure 3: Plant productivity of leaves of different ages of Hass avocado trees

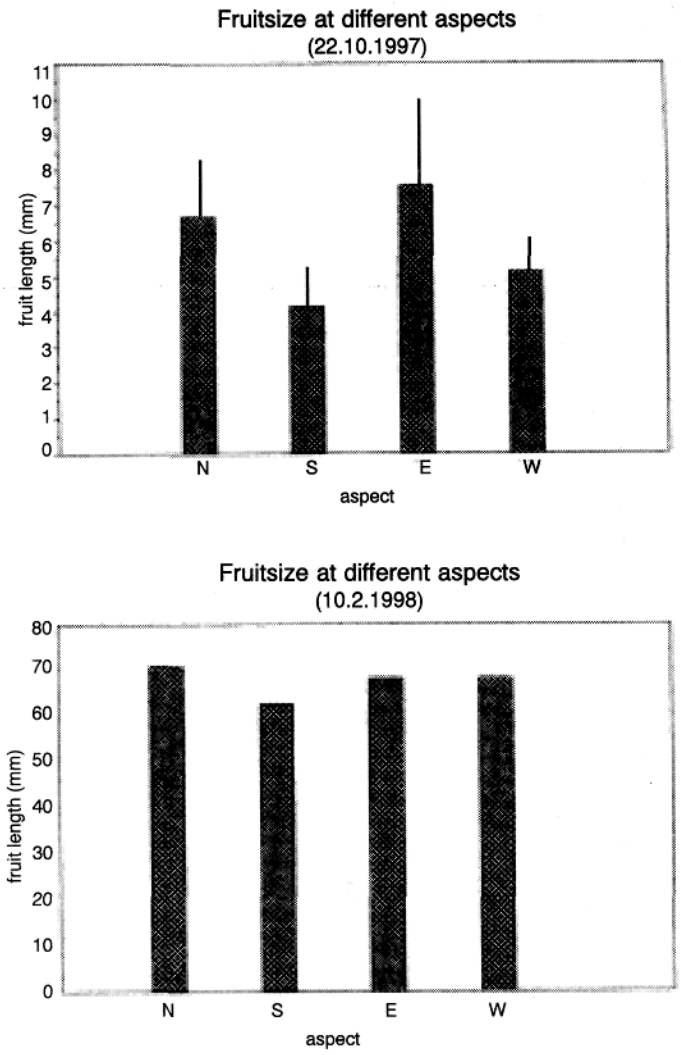

Figure 4: Fruit size of different aspects of Hass avocado trees

REFERENCES

DEMMIG-ADAMS, B., ADAMS, W.W., WINTER, K., MEYER, A., SCHREIBER, U., PEREIRA, J.S., KRUEGER, A., CZYGAN, F.C., LANGE, O.L. 1989 Photochemical efficiency of photosystem II, photon yield of O_2 evolution, photosynthetic capacity, and carotenoid composition during the midday depression of net CO_2 uptake in *Arbutus unedo* growing in Portugal. *Planta* 177:377 - 387,

OSMOND, C.B. 1994 What is photo-inhibition? In: Photo-inhibition and photosynthesis from molecular mechanisms to the field, NR Baker and J. Bowyer, Bios scientific publishers.

WHILEY, A.W. 1994 Ecophysiological studies and tree manipulation for maximisation of yield potential in avocado *(Persea Americana* Mill.), PhD thesis, University of Natal.