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Gas Exchange in the Avocado Leaves Under Water Stress and Recovery

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Abstract

Net photosynthesis, transpirations, water potential, and stomatal resistance were studied in avocado leaves during stress and recovery periods. The changes in leaf gas exchange seemed to be influenced more due to drastic changes in stomatal resistance than the leaf water potential. During the period of development of water stress and its initial recovery, the leaf water potential remained steady at the same level.

Introduction

Sterne *et al.,* (1977) reported the role of irradiance and humidity on leaf transpiration and xylem pressure potential of normal and stressed avocado trees. Bower *et al.,* (1977), studying the internal water status and stomatal water conductance under varying irradiance and temperature, concluded that the temperature optimum for photosynthesis was 20-24°C with an irradiance of approximately 300 Wm^{-2}. Water stress conditions affected leaf gas exchange through the drastic effect on leaf conductance. These results were confirmed by Kimelmann (1979). The diurnal fluctuation in leaf conductance and xylem pressure potential in avocado leaves have also been reported (Sterne *et al.,* 1978; Scholefield *et al.,* 1981, in press). The present study relates to effect of water stress and recovery on leaf gas exchange and water potential in avocado leaves.

Materials and Methods

Potted scion cultivar Fuerte grafted into Mexican seedling root stocks, in the second year of growing season, were used for the studies. Ten single potted young trees of uniform size were selected, and from each young tree at least two leaves of same maturity were used for gas exchange studies.

The net photosynthesis, stomatal resistance, and transpiration rate were measured simultaneously using a flow system consisting of infrared gas analyser (URAS II, Hartman and Brawn), H_2O analyser, temperature controlled leaf cuvette, and pre-calibrated light source off a Quartz halide lamp. The gas stream consisted of 300 PPM CO_2 and N_2 as reference gas off cylinders. The flow rate was maintained at 500 ml m^{-1} and the leaf temperature at 21°C throughout the studies.

The net photosynthesis and transpiration (T) were calculated off the chart readings. The stomatal resistance, r_s, was calculated using the

equation: $r_s = \Sigma r - r^a$

where Σr is the leaf resistance and r^a is the boundary layer resistance (Leopold and Kriedeman, 1975). The water potential was determined using the pressure bomb technique (Scholander *et al*., 1965).

The gas exchange measurements were made at hourly intervals for 6 hours in normal condition. Water potential measurements were also conducted simultaneously. Irrigation was withdrawn at this stage, and all the measurements done again at hourly intervals from 0-5 hours, 24 hours after the withdrawal of irrigation. The young trees had exhibited wilting of all leaves at this stage. The pots were rewatered and the measurements were resumed at 1 hour, 3 hours, 5 hours, and 16 hours after rewatering.

Results

The data (mean of two adjacent leaves from each experimental plant) are presented in Table 1. At normal condition, net photosynthesis ranged from 16.7 to 19.7 ng CO_2 $cm^{-2}s^{-1}$ at r_s ranging from 2.0 to 4.9 s cm^{-1}. The water potential ranging from -3,6 to -9.0 bar also was high. Twenty four hours after irrigation was stopped, the net CO_2 uptake decreased gradually from 0 to 5 hours, from 15.8 ng to 5.9 ng CO_2 $cm^{-2}s^{-1}$. The r_s recorded a steep rise during this period from 16.7 s cm-l to 47.7 s cnvl. The water potential, however, was steady at -12 or -13 bars.

One hour after re-watering, the r_s decreased by more than 50 percent from that at wilting of leaves, when net CO_2 uptake also recorded a rise. This inverse trend continued for the next 4 to 5 hours after re-watering, by which time the near normal values for these two factors were obtained. The water potential, excepting for drastic deduction from -5.0 bars at normal condition to -12 bar, 24 hours after irrigation was withdrawn, did not change further until about 16 hours after re-watering was done.

Discussion

The influence of water stress on net photosynthesis in plants has been reviewed recently (Hsaio, 1973). In several studies in the recent past—the recovery process after stress effect—that influence net photosynthesis has been discussed. It has been suggested that the major influence of recovery process on net photosynthesis was the rate of recovery of water potential (Brix, 1962; Bielori and Hopmann, 1975; Boyer, 1971).

In a study on *Panicum* grass, Ludlow *et al.,* (1980) observed greater influence of stomatal resistance rather than water potential on net photosynthesis.

In the present studies, the stomatal resistance showed a close relation with the gas exchange during development and recovery of stress, in avocado leaves. The water potential remained at -12 to -13 bars without any drastic change, during the stress and recovery periods. The water potential, although reduced considerably at the beginning of development of stress, recovered more slowly than the gas exchange rates or stomatal resistance. In this process it did not seem to exert its effect on net photosynthesis as much as the stomatal resistance, as has been observed by Ludlow *et al.,* (1980). However, unlike in *Panicum maximum* leaves, where the relationship between leaf water potential and net photosynthesis observed during the development of stress was different from those recorded during recovery, in avocado leaves the leaf water potential did not record any change at all during these periods. After the initial drop it remained steady when both gas exchange rates and stomatal resistances changed drastically during the drying and recovery periods.

TABLE I. Photosynthesis, transpiration, water potential, and stomatal resistance in avocado leaf under normal and stress conditions

	Hours of Measurement	Photosynthesis ng. CO_2 cm^{-2} s^{-1}	Transpiration µg H_2O cm^{-2} s^{-1}	Stomatal resistance S cm^{-1}	Leaf water potential bars
Normal condition	0	17.9	0.68	2.9	-9.0
	1	18.2	0.70	2.7	-6.3
	2	17.2	0.70	2.7	-7.0
	3	19.7	0.69	2.6	-5.0
	4	17.1	0.73	2.0	-3.6
	5	18.6	0.67	2.8	-4.0
	6	16.7	0.57	4.9	-5.0
24 hours after irrigation was stopped	0	15.8	0.25	16.7	-12.7
	1	11.9	0.25	16.7	-13.2
	2	8.7	0.22	20.0	-12.8
	3	7.9	0.13	39.2	-12.2
Wilting point	4	7.7	0.17	28.1	-13.0
	5	5.9	0.11	47.7	-13.0
	(After re-watering)				
Flow rate : 500 ml m^{-1}	1	9.6	0.20	24.1	-13.0
	3	11.4	0.22	11.3	-13.0
PHAR : 150 W m^{-2}	5	15.7	0.35	5.8	-13.0
	16	20.6	0.58	2.5	- 7.0
Leaf temperature : 21°C	16	19.9	0.54	3.2	- 9.0

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References

Brix, H. (1962). The effect of water stress on the rates of photosynthesis and respiration in tomato plants and loblolly pine seedlings. *Physiol. Plant*. 15,10-20.

Bower, J. P., Wolstenholme, B.N., and de Jager, J.M. (1977). Incoming solar radiation and internal water status as stress factors in avocado, *Persea Americana* (Mill.) C.V.

Edranol. Proceedings of Technical Committee, *South African Avocado Growers Association*, 1977: 35-40.

Bielorai, H., and Hopmanns, P.A.M. (1975). Recovery of leaf water potential, transpirations, and photosynthesis of cotton during irrigation cycles. *Agron. J.* 67: 629-32.

Boyer, J.S. (1971). Recovery of photosynthesis in sunflower after a period of low leaf water potential. *Plant Physiol*. 47: 816-20.

Hsiao, T.C. (1973) Plant responses to water stress. *Annu. Rev. Plant Physiol*. 24: 519-70

Kimelmann, R. (1979). The influence of different temperatures and light intensities on gas exchange of avocado leaves (*Persea americana* (Mill.)). M. Sc. Agri. Thesis. Hewbrew University of Jerusalem, Rehovot, Israel.

Leopold and Kriedemann, P.E. (1975). *Physiology of Plant growth and Development*. Academic Press

Scholander, R. R., Hammel, H.T., Bradstreet, E. D. and Hemmiegsen, E.A. (1965). Sap pressure in vascular plants. *Science* 148: 339-346

Scolefield, P.B., Walcott, J.J., Kriedemann, P.E. and Ramadasan, A. (1981), Some environmental effects on photosynthesis and water relations of Avocado leaves. *California Avocado Society, Yearbook* 1960.

Ludlow, M.M., Ng.,T.T., andC.W. Ford (1980). Recovery after water stress of leaf gas exchange in *Panicum maximum* var. trichoglume. *Aust. J. Plant Physioi.* 7: 299-313.

Sterne, R.E., Kanfmann, M.R., and Zentmeyer, G.A. (1977). Environmental effects on transpiration and leaf water potential in avocado. *Physiol.* Plant 41:1-6.

_______ (1978). Effect of *Phytophthora* root rot on water relations of avocado.
Interpretation with a water transport model. *Phytopathology* 68: 595-602.