LEAF WATER POTENTIAL AND STOMATAL CONDUCTANCE OF RUBBER (Hevea brasiliensis) AS INFLUENCED BY SOIL MOISTURE AND LEAF AGE

BY

LALANI SAMARAPPULI

ABSTRACT

Stomatal conductance and transpiration and leaf water potential of rubber (Hevea brasiliensis), clone PB 86, subjected to water stress were measured with a steady-state porometer and a pressure bomb, respectively. In well watered plants young leaves showed a higher stomatal conductance than mature leaves. In water stressed plants young leaves always exhibited a lower stomatal conductance than mature leaves. Increase in soil dehydration reduced the leaf water potential, stomatal conductance and the rate of transpiration.

INTRODUCTION

A uniform annual distribution of rainfall is regarded as favourable for growth of Hevea plants (4). In several regions of the world, dry spells of between one and ten days are common in most months. Prolonged draught periods also occur in regions with distinct dry seasons. These lead to soil moisture stress of differential magnitude affecting adversely the growth of young rubber. (5) It has recently become a common practice with the rubber industry during draught periods to irrigate young rubber plants in the nurseries as well as field planted rubber in the initial establishment stages.

Leaf water potential and stomatal conductance were reported to have good correlations with the soil water potential (6). Water potential is one of the most important properties to measure the soil-water-air system (7). Water potential is a measure of the internal water status of a plant and is a direct measure of the negative pressure or tension of the sap in the system by which a suction force develops to draw water. It is connected with the water deficit of a plant and hence is directly proportional to the turgidity of a cell which influences the growth of the plant. Shinn and Lemon (1968) reported that leaf-water potential decreased in maize with an increase in soil water tension (9). Jordan *et al.* (1975) found that cotton plants subjected to soil-water stress showed an increase in stomatal resistance and a decrease in leaf-water potential (3). The stomatal conductance was found to vary with the age of the leaf (10). It was reported that stomatal conductance of peach was significantly correlated with both leaf water potential and net photosynthesis. Hsiao (1973) attributed the reduction of CO_2 assimilation to stomatal closure during exposure to water stress. Stomatal closure was reported as the limiting factor in photosynthetic activity, which is directly proportional to the growth of a plant (2).

It is therefore generally accepted that water stress induce a progressive reduction in growth of a plant. The aim of this experiment is to study some effects of water stress situations on leaf water potential, stomatal conductance and transpiration of *Hevea* plants.

MATERIALS AND METHODS

Seven young (6 month old) and uniform seedlings of *Hevea brasiliensis* were followed during a drying cycle experiment done in a growth chamber at the University of California, Davis on 4th June 1987.

Air temperature in the growth chamber was 29.4°C and relative air humidity around 80% where the day time considered was 12 hrs which is assumed to be comparative to natural tropical condition.

The rubber plants were raised from seeds of clone PB 86 in polyethylene pots. The potting medium was a commercial potting mixture commonly used in the USA. Plants were supplied with half strength Hoagland solution at weekly intervals.

Prior to the commencement of experimental treatments, Hevea plants were watered daily, upto field capacity. Thereafter different levels of moisture stress situations were induced by withholding water application for 0, 1, 2, 3, 4, 5, and 6 days.

Stomatal conductance and transpiration were measured with a steady state porometer, while leaf water potential was measured with a pressure bomb on the same young and old leaves on each plant. Young leaves used for the determination of stomatal conductance, tianspiration and leaf water potential refer to the seccnd leaf and old leaves to the fourth or fifth leaf from the apical bud.

RESULTS

Stomatal conductance and transpiration rates measured with the steady state porometer on young and old leaves of each of the seven treatments, are given in table 1.

Table 1. **Effect of moisture stress on stomatal conductance and transpiration in Hevea brasiliensis seedlings**

Days without water	*Parameters* *Stomatal conductance cm sec*		*Transpiration g cm sec*	
	Young	*Old*	*Young*	*Old*
0	0.289	0.279	4.961	4,072
1	0.270	0.234	4.888	4.109
2	0.246	0.231	4.520	4.278
3	0.210	0.190	4.502	3.658
4	0.130	0.150	2.723	3.225
5	0.080	0.092	1.551	1.707
6	0.040	0.060	1.004	1.252

The stomatal conductance was consistantly higher in the well watered treatments compared with that in the stress treatments (Table 1, Fig. 1), irrespective of leaf age. In the stressed plants, stomatal conductance and transpiration in young leaves were lower compared to older leaves (Table 1).

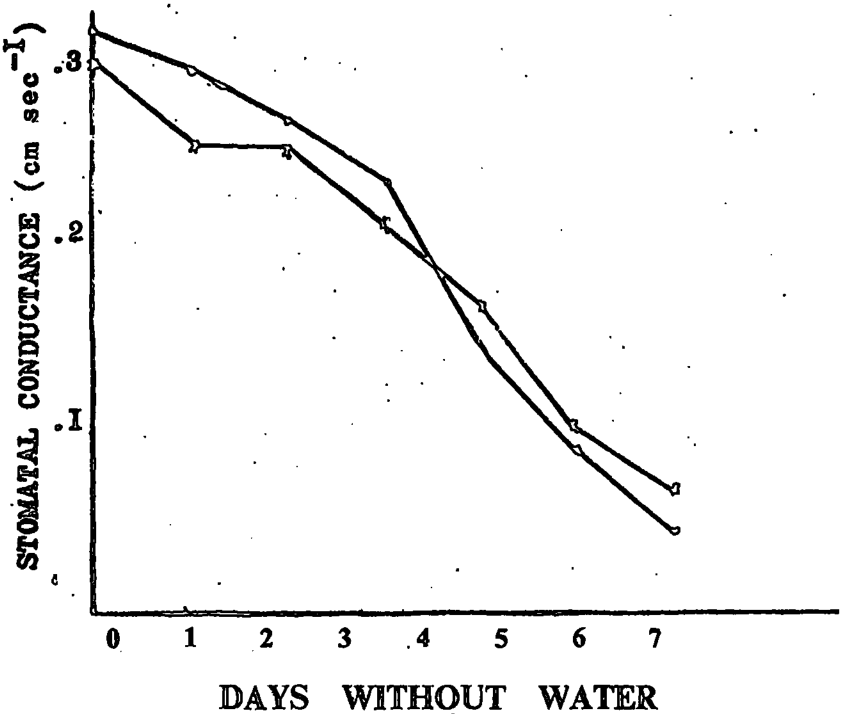

Fig. 1 Changes in stomatal conductance in young and old leaves of *Hevea brasiliensis* at different stress conditions.

The leaf stomatal conductance decreased sharply with a decrease in leaf water potential up to about — 11.00 bars and gradually thereafter (Table 1 and Fig. 2).

The leaf water potential was also consistantly higher in the well watered treatments compared with that in the stress treatments, irrespective of leaf age (Table 2).

Table 2. **Leaf water potential in young and old leaves of Hevea brasiliensis at different stress conditions**

Days without water	*Leaf water potential bars*	
	Young	*Old*
0	9.0	8.6
1	10.0	9.0
2	11.0	10.2
3	11.6	11.3
4	11.8	11.6
5	15.6	14.8
6	20.2	20.0

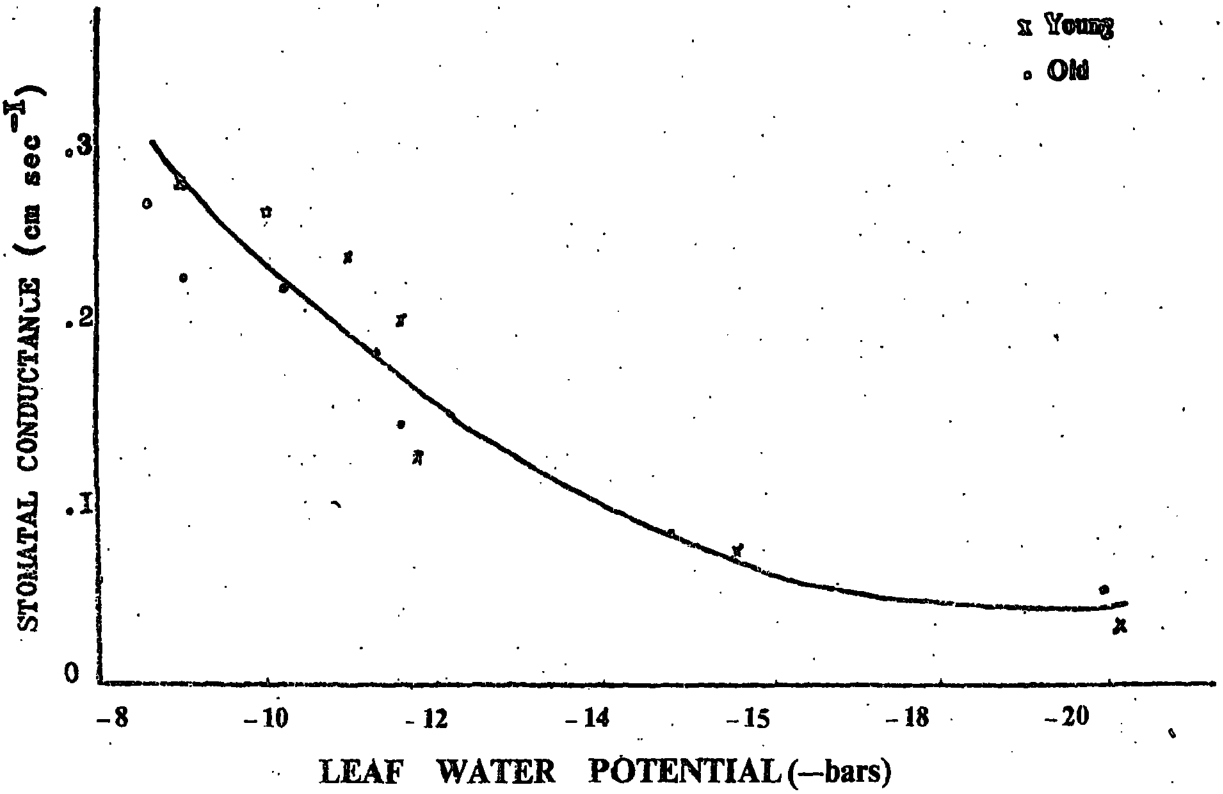

Fig. 2 Relationship between leaf water potential and stomatal conductance in *Hevea brasiliensis*.

DISCUSSION

The stomatal conductance of each individual leaf may be uniquely related to its own water potential as modified by age and stress conditioning (3). In such diverse plant species as cotton, sorghum, maize, beech and birch, older leaves have been associated with low stomatal conductance as compared with that of young leaves (1). This age dependent difference in stomatal conductance has generally been attributed to low irradiation or senescence. However, stress induced stomatal closure, which occurred earlier in the older leaves than in the young leaves of cotton was reported to be independent of radiation differences or senescence (3). In the present experiment old rubber leaves consistently showed a lower diffusion resistance (high stomatal conductance) than young leaves on the same plant under water stress. Similar results have been reported for tea (8). The lower stomatal conductance recorded in young leaves compared with that in old leaves cannot be explained in terms of light effects or senescence. This age dependent response of stomatal to water stress could be due to a difference in the stomatal density, the morphology of the stomatal apparatus and stomatal physiology associated with ageing. It therefore appears that the age dependent response in stomatal conductance may be due either to a partial loss in stomatal functioning with age or a change in stomatal physiology.

It was also evident from visual observations made in the absence of quantitative assessment that in water stressed plants young leaves wilted earlier than old leaves. This may be due to the close proximity of old leaves to the source in the water transport pathway resulting in a higher water potential in the old leaves compared with that in young leaves. This may be one of the reasons for the higher diffusion resistance (lower stomatal conductance) recorded in water stressed young leaves compared with that in old leaves. Leaf flaccidity due to water stress may also be due to the relative amounts of structural tissue per unit area. This may be higher in old leaves. Additionally, a higher rate of cuticular transpiration in young leaves compared with that in old leaves, leading to earlier desiccation of young leaves may be another cause.

It appears from the present experiment that there is a relationship between stomatal conductance and leaf water potential (Fig. 2) with scatter in the data possibly being due to the dependence of stomatal conductance on leaf temperature, relative humudity and radiant flux density.

Results discussed here are from an unreplicated experiment, but done in a growth chamber under controlled conditions, and was done merely to test whether this type of investigations could be done with *Hevea brasiliensis* plants. This study will be continued with more detailed replicated experiments before any firm conclusions are made.

ACKNOWLEDGEMENT

I thank Dr N. Yogaratnam, the Assistant Director for his suggestions in the revision of this manuscript and Mr S. Dimantha, Head, Land Use Division for his critical comments on the original draft.

REFERENCES

GEE, G. W. and FEDERER A. (1972). Stomatal resistance during senescence of hardwood leaves. *Water Resour. Res. 8* : 1356 - 1360.

HSIAO, T. C. (1973). Plant responses to water. *A. Rev. Pl. Physiol. 24* : 591 - 670.

JORDAN, W. R. BROWN, K. W., and THOMAS, J. C. (1975) Leaf age as a determinant in stomatal control of water loss from cotton, during water stress. *Pl. Physiol. 56* : 595 - 599.

POLHAMAS, L. G. (1962). Rubber London. Lenard Hill.

PUSHPARAJAH E. and HARIDAS, G. (1976). Developments in reduction in immaturity period of Hevea in Peninsular Malaysia. *Rubb. Res. Inst Sri Lanka Centenary Conf.* 1976.

RASCHKE, K. (1970). Stomatal responses to pressure change and interruptions in the water supply of detached leaves of Zea mays *L. Pl. Physiol 5* . 415 - 423.

SALISBURY, E. B. and ROSS, C. (1969). Plant Physiology pp 32 - 37. Wadsworth publishing Co. Inc. Belmont, California, U.S.A.

SANDANAM, S. GEE, G. W. and MAPA R. B. (1981). Leaf water diffusion resistance in clonal tea. *Ann Bot. 47* : 339 - 349.

SHINN, J. H. and LEMON, E. R. (1968). Photosynthesis under field conditions XI. Soil-plant water relations during draught stress in corn. *Agron. Jl. 69* : 231 - 233.

TURNER, N. C. (1970). Concurrent comparisons of stomatal behaviour, water status and evaporation of maize. *Pl. Physiol 5* : 932 - 936.