

THE EFFECT OF TAPPING ON THE CO₂ ASSIMILATION RATES OF *HEVEA BRASILIENSIS* MUELL. ARG. LEAVES

By

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ABSTRACT

The CO₂ assimilation rates at leaf level were compared in tapped and untapped trees of two *Hevea brasiliensis* genotypes. In both genotypes, the CO₂ assimilation rates of the leaves in the upper stratum were lower in tapped trees. Similarly, in young microtapped plants the CO₂ assimilation rates were lower than in the untapped plants. The decrease in CO₂ assimilation rates due to tapping cannot be attributed to an increase in either stomatal or mesophyll limitations. Tapping increases the sink demand for photo assimilates, but it also results in the loss of water, inorganic nutrients and proteins from the plant. Loss of water, inorganic nutrients may result in lower CO₂ assimilation rates of the tapped trees. In the long-term this could result in lower sucrose content in the latex. This may be a probable cause for the physiological disorder, tapping panel dryness in rubber.

INTRODUCTION

Hevea brasiliensis Muell. Arg., plantations are grown for their latex which is synthesised in the latex vessels. Latex is synthesised from sucrose, provided by the adjacent phloem vessels (Tupy, 1985). Sucrose supply to latex vessels is an important factor limiting latex metabolism and yield. This is especially true, under high intensities of tapping and when environmental conditions are unfavourable for photosynthesis or sucrose translocation (Tupy, 1985). The modern high yielding *Hevea brasiliensis* clones exhibit a retardation of vegetative growth during exploitation. Thus it is evident that tapping increases the demand for photoassimilates. Accumulation of photoassimilates in the leaf results in lower light saturated CO₂ assimilation rates (Azcon-Bieto, 1983). In this study the effect of latex removal on the CO₂ assimilation rates were investigated using tapped and untapped trees of two *Hevea* genotypes.

MATERIALS AND METHODS

Plant material

Mature plants

Stands of two genotypes, i. e. PB 86 and RRIC 100, planted in 1976 on the Eladuwa State Plantation, Payagala, 15 km away from the laboratories were

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selected. The two stands were adjacent to each other in the plantation. An area consisting of 120 trees, avoiding the boundary trees, was chosen from each genotype to examine the gas exchange characteristics of their canopies. Six plants were selected from a genotype randomly and were divided (randomly) into two groups, three in each. In both genotypes tapping was discontinued for a month in plants belonging to one group. Following this gas exchange measurements were made using leaves detached from upper (18-22m), middle (14-18m) and lower (10-14m) strata of the canopy. Twigs were cut from different canopy positions, i. e. upper, middle and lower strata with a sharp knife. Leaflets were detached from the twigs and were cut across the lamina under water about 2 cm above the leaf base. A further cut was made after ca. 2 minutes, severing about 1mm to remove any latex which had coagulated at the cut ends.

Young plants

Six potted plants (three whorl stage) from each of the two genotypes, i. e. PB 86 and RRIC 100 were selected for the study. The selected plants of a genotype were divided randomly into two groups, 3 in each. In both genotypes one set of plants were micro-tapped, once daily for 2 weeks. Following this, gas exchange measurements were made using attached leaves at different times of the day, i. e. 8-11 am. 11-2 p.m. and 2-5 p.m.

Gas exchange measurements

The CO₂ assimilation rates and related gas exchange parameters were measured under controlled environmental conditions in an open gas exchange system (Long and Hallgren, 1985.) Atmospheric air from roof level (30M) was drawn into the system through a 25 l tank to buffer short term fluctuations in atmospheric CO₂ concentration, by a gas handling system (Series WA 161, ADC Ltd., UK). A variable amount of air, was passed through a magnesium perchlorate column to maintain a relative humidity of around 65%. The flow rates of analysis and reference air streams were controlled and maintained at 500 ml/min., using air flow meters and controllers in the gas handling system (Series WA 161, ADC Ltd., UK).

A leaf section chamber (LSC, ADC Ltd., UK) was used for both cut leaf sections and, by modification, for attached leaves. The area of the leaf exposed to light was constant, at 10 cm². When leaf sections were used for measurements, water was passed around the cut ends of the leaf by gravity flow, to prevent desiccation. The leaf temperature was measured with a copper-constantan thermocouple pressed against the lower surface of the leaf and monitored

with an electronic thermometer (Series 2001, Cu/Con, Comark Electronics Ltd.,) The temperature in the leaf chamber was maintained at $30 \pm 1.5^{\circ}\text{C}$, in all experiments.

A quartz-iodide light source (Model 250H, Scholly Fiberoptik, Denzlingen, FRG) was used to illuminate the leaf chamber. A 250 ml round bottom flask filled with water was placed between the light source and the leaf chamber to focus light on the leaf surface. Photosynthetic photon flux density at the position of the leaf was determined with a quantum sensor (LI - 190SR, Li-Cor Ltd., Lincoln, Nebraska, USA) placed below the chamber window in the position normally occupied by the leaf. The net fluxes of CO_2 and water vapour at saturating light levels were determined using an infra - red gas analyser (IRGA) (Series 225/2, ADC Ltd., Hoddesdon, Herts, UK), capacitance humidity sensors and temperature probes (Series DHL 40, Lee-Integer Ltd., Kettering, Northants UK) respectively. The IRGA, capacitance humidity and temperature probes were calibrated as described by Jarvis and Sandford (1985) and Day (1985) respectively. CO_2 assimilation rates (A), transpiration rates (E), stomatal conductances (gs) and internal leaf CO_2 concentration (ci) were calculated using equations described by Long and Hallgren (1985).

RESULTS

Effect of tapping mature plants on their gas exchange parameters

It seems that there is no evidence to show that tapping influences the gas exchange parameters, i. e. CO_2 assimilation rate (A), internal leaf CO_2 concentration (ci) and stomatal conductance (gs) of mature *Hevea plants*. However, with regard to CO_2 assimilation rates, there is a tapping leaf position interaction (Table 1). Thus, there is an influence of tapping on A, which varies with the position of the leaf in the canopy.

Table 1. Details of the Analysis of Variance (ANOVA) table to show the effect of conventional tapping of mature plants on their gas exchange rates.

SOV	df	A	Mean Square c i	gs
Clone (C)	1	42.8***	6115***	.0005
Tapping (T)	1	5.7	747	.0005
C*T	1	.006	3.7	.00002
Leaf Position (LP)	2	6.2	351	.0002
C*LP	2	2.2	351	.0002
T* LP	2	9.3*	690	.0009
C* T* LP	2	2.2	209	.0002
Error	24	2.3	311	.0006

***p < 0.0001, *p < 0.05

Effect of micro-tapping on gas exchange parameters of young *Hevea* plants

It is evident that the mean daily CO₂ assimilation rates and transpiration rates are lower in micro-tapped plants. This is true for both genotypes tested (Tables 4 and 5). Stomatal conductance and internal leaf CO₂ concentration are not affected by micro-tapping.

Table 4. Details of the ANOVA table to show the effect of micro tapping on gas exchange parameters.

SOV	df	Mean Square			
		A	E	gs	ci
Clone (C)	1	308***	.00002***	.032**	9360***
Tapping (T)	1	54.5*	.000004*	.008	1470
C*T	1	4.6	.0000009	.002	190
Error	8	11.2	.0000006	.003	309

***p < 0.001 **p < 0.01 *p < 0.05

Table 5. Mean daily CO₂ assimilation rates (A, $\mu\text{mol m}^{-2} \text{s}^{-1}$) and transpiration rates (E $\text{mol m}^{-2} \text{s}^{-1}$) of micro-tapped and untapped rubber plants grown in pots.

Treatment	Mean daily	
	A	E
Untapped	11.1	.0051
Tapped	8.7	.0045
Difference	2.5*	.0006*

*p < 0.05

DISCUSSION

Tapping of *Hevea brasiliensis* trees decreases the level of latex sucrose (Tupy, 1984), resulting in an increase in the sink demand for sucrose, the end product of photosynthesis. It is apparent that inspite of this increase in sink demand, tapping lowers the CO₂ assimilation rates of leaves in the upper stratum of a *H. brasiliensis* tree. This observation is true for all the light levels tested, excepting the lowest, i. e. 200 $\mu\text{mol m}^{-2} \text{s}^{-1}$. The CO₂ assimilation rates of the leaves in the middle and lower strata are not significantly affected by tapping. Micro-tapped young *H. brasiliensis* plants also behaved similarly, i. e. their CO₂ assimilation rates and transpiration rates are significantly lower than those of untapped plants. For other plant species it is reported that an increase

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in sink demand, i. e. during flowering, fruiting etc., exhibits elevated CO₂ assimilation rates (Fuji and Kennedy, 1981). Further, the commonly observed decline in CO₂ assimilation rate, later in the day, is further delayed in plants with a higher sink demand (Downton, et al., 1987).

Latex of *H. brasiliensis* is an aqueous suspension with ca. 30-35% rubber, protein systems and plant micro and macro nutrients. Though tapping increases the sink demand for photoassimilates the plant loses inorganic nutrients, eg. Mg⁺⁺, Ca⁺⁺, K⁺⁺ and also proteins and water. The activity of Ribulose biphosphate carboxylase / oxygenase (Rubisco), the enzyme that catalyses the primary carboxylation reaction in the photosynthetic carbon reduction cycle, is dependent on the available Mg⁺⁺ (Brooks and Farquhar, 1985) Thus a deficiency of Mg⁺⁺ will retard the activity of Rubisco, decreasing the assimilation rates. K⁺ plays an important role in phloem transport and also in enzyme activities. Lower phloem transport rates will result in accumulation of photoassimilates in the leaf. This could also lead to lower CO₂ assimilation rates (Azcon-Beito, 1983). A decrease in plant water status may also lower the leaf CO₂ assimilation rates (Day, 1981).

Measurements of stomatal conductance and internal leaf CO₂ concentration simultaneously with CO₂ assimilation rates show that both are not significantly affected by tapping. Thus, the decrease in A of tapped trees cannot be attributed to either an increase in stomatal or mesophyll limitations. The decrease may be due to both of these factors as reported in other instances (von Cammerer and Farquhar, 1981).

In both genotypes only the leaves in the upper stratum was affected. The proportion of the leaf area index (LAI) in the upper stratum is ca. 80 and 90% for genotypes RRIC 100 and PB 86 respectively (Nugawela, 1989). Thus tapping will cause a significant decrease in canopy photosynthesis and may result in lower levels of sucrose in the latex. It is observed that tapping panel dryness in rubber is associated with more or less continuing low levels of sucrose in the latex (Tupy, 1984). Thus, the decrease in A due to tapping may result in the physiological disorder, i. e. tapping panel dryness. Nevertheless, more studies are necessary to arrive at definite conclusions.

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