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PHYSIOLOGICAL AND BIOCHEMICAL ASPECTS OF STOCK-SCION INTERACTION IN *HEVEA BRASILIENSIS*

P. Sobhana, Jayasree Gopalakrishnan, James Jacob and M.R. Sethuraj

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Rootstock-scion interaction effects on certain physiological and biochemical parameters were studied in five clones of *Hevea brasiliensis*. Photosynthetic CO_2 assimilation rate (A) and stomatal conductance (gs) were measured in 18-month-old polyclonal rootstock seedlings before budding and 18 months after budgrafting them with the scions. The photosynthetic CO_2 assimilation rate was found to be a clonal character. Existence of a strong positive correlation between A of the stock plants and scion indicated that A is also being influenced by the rootstock. No significant relationship existed between gs and instantaneous water use efficiency (A/gs) of the stock plants and scion. Very high CV was observed among plants within the scion clones in gs and A/gs, may be due to stock-scion interaction. The considerable CV observed between the individual plants within a clone in total soluble sugars, reducing sugars, phenol and amino acid contents, indicated the existence of stock-scion interaction.

Key words : *Hevea brasiliensis*, Photosynthetic CO_2 assimilation rate, Stock-scion interaction, Stomatal conductance.

P. Sobhana (for correspondence), Jayasree Gopalakrishnan, James Jacob and M.R. Sethuraj, Rubber Research Institute of India, Kottayam – 696 009, Kerala, India (Email: rrii@vsnl.com).

INTRODUCTION

Budgrafting, a well accepted practice of vegetative propagation in *Hevea brasiliensis*, has some definite advantages. This technique is an effective means of rapid and true to type multiplication of desired genotypes. But wider genetic differences between rootstock and scion could lead to incompatibility in the budgrafted plants. Rootstock-scion interaction is a complex phenomenon (Hartman and Kester, 1978; Andrews and Marquez, 1993). The influence of rootstock on scion cultivars is well documented in many plant species (Hartman and Kester, 1978; Singh, 1980; Lockard and Schneider, 1981; Rom, 1987).

Influence of rootstock or existence of rootstock-scion interaction on growth and yield in *Hevea* were reported by Templeton (1960), Buttery (1961), Ng *et al.* (1981), Seneviratne *et al.* (1996) and Sobhana (1998), but there are only very few reports on physiological and biochemical aspects of rootstock-scion interaction (Teng and Pushparaja, 1974; Sobhana *et al.*, 1980). The objectives of the present experiments were to evaluate the effect of rootstock/scion on gas exchange by leaves and on the biochemical composition of the scion leaves.

MATERIALS AND METHODS

Five clones of *Hevea brasiliensis viz.* RRII 105, RRII 208, RRIM 600, GT 1 and Gl 1 were selected for the present study. These clones were budgrafted on eighteen month old seedling rootstocks raised from heterogeneous polyclonal seeds in large cement pots containing about 40 kg soil. To avoid any possible plant-to-plant variation, buds were selected from a given budwood plant for each clone. After the grafts were properly established the stocks were cut off above the grafts.

Photosynthetic carbon dioxide assimilation rate (A) of leaves and stomatal conductance (gs) were measured using a portable photosynthetic system (LI 6200, Licor, USA) in fully expanded and mature leaves in the polyclonal seedlings just before budgrafting. Eighteen months after budding these measurements were repeated on fully expanded mature leaves of the scions. Gas exchange measurements were recorded between 08.30 and 09.30 h at saturating sunlight (1000 ± 200 $\mu mol/m^{-2}/s^{-1}$), with an ambient temperature of 27 ± 2°C and a relative humidity of approximately 60 per cent.

The total chlorophyll (Ozerol and Titus, 1964), reducing sugar (Nelson, 1944), total soluble sugars (Scott and Melvin,1953), phenols (Swain and Hillis, 1959) and amino acids (Moore and Stein, 1948) were measured in mature leaves as per the standard analytical techniques.

RESULTS AND DISCUSSION

Photosynthesis

Photosynthetic carbon dioxide assimilation rate (A) of 18-month-old budgrafted plants of the five clones and their corresponding rootstocks just before budding (18-month-old) are summarized in Table 1. There was a significant clonal variation in A. For both the rootstocks and the scions, coefficient of variation (CV) for mean A was fairly high suggesting a large variation. Among the scion clones, the lowest CV was observed in RRII 208 (9.8%) and the highest in RRIM 600 (27.6%).

Table 1. Mean and coefficient of variation in net CO_2 assimilation rate (A) before budding (18 month old stock seedlings) and 18 months after budding

Clone	A ($\mu molm^{-2}s^{-1}$) Before budding Mean	CV (%)	After budding Mean	CV(%)
RRII 105	9.3	16.8	13.1	24.4
GT 1	8.8	18.2	9.6	27.1
RRIM 600	10.6	31.0	13.2	27.6
GI 1	8.8	30.7	10.5	20.7
RRII 208	8.3	26.3	8.4	9.8
CD (P≤0.05)	2.80		3.18	

Regression analysis of A (Fig. 1) of the rootstocks with that of the scions showed a strong positive relationship (r=0.74, p ≤ 0.001). Moreover, considerably large CV observed among the individual plants within a clone also indicates a substantial stock influence. However, significant clonal differences noticed among the five clones suggested that A is a clonal character, as well. Thus, it appears that while A is a clonal character, it is also influenced by the heterogeneous rootstock.

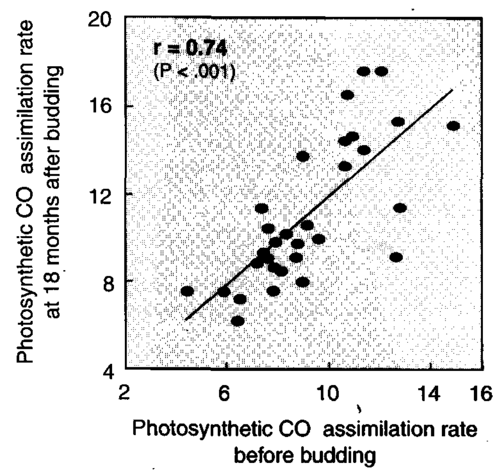

Fig. 1. Carbondioxide assimilation rate before and after budding in five *Hevea* clones

Influence of rootstock on A of the scion leaves has been reported earlier in other plant species (Lloyd *et al.*, 1990; Walt and Davies, 1995). Studies in young apple trees by Brown *et al.* (1985) showed that A of the scion leaf was influenced by the rootstock. Influence of rootstock on net photosynthesis in apple was also reported by Baugher *et al.* (1994) and in lemon by Sharma and Singh (1989).

Stomatal conductance (gs)

Stomatal conductance before budding did not vary much among the five groups of seedlings on which the five clones were budgrafted. But significant differences existed among the budgrafted plants (Table 2). A higher CV when compared to their corresponding stock plants was also observed. No significant relationship was noticed in the gs before budding and after budding (Fig. 2).

Table 2. **Mean and coefficient of variation in gs before budding (18-month-old polyclonal seedlings) and 18 months after budding**

Clone	gs			
	Before budding		After budding	
	Mean	CV (%)	Mean	CV(%)
RRII 105	0.12	42	0.66	41
GT 1	0.11	27	0.32	77
RRIM 600	0.13	39	0.74	100
Gl 1	0.14	37	0.17	54
RRII 208	0.12	50	0.29	89
CD($P \leq 0.05$)	NS		0.42	

The instantaneous water use efficiency (A/gs) was calculated in the plants before budding and 18 months after budding (Table 3). The CV was higher among budded plants of different clones than their corresponding seedling rootstocks. The mean values of A/gs were different only between RRII 105 and Gl 1 ($p \leq 0.05$). No significant relationship existed between A/gs before and after budding in these clones because of the lack of relationship between gs before and after budgrafting. The above results indicate that there was no rootstock influence on gs or A/gs of the scion in all the five clones studied. Very high CV observed among the budgrafted plants within clones in these two parameters may be due to rootstock-scion interaction.

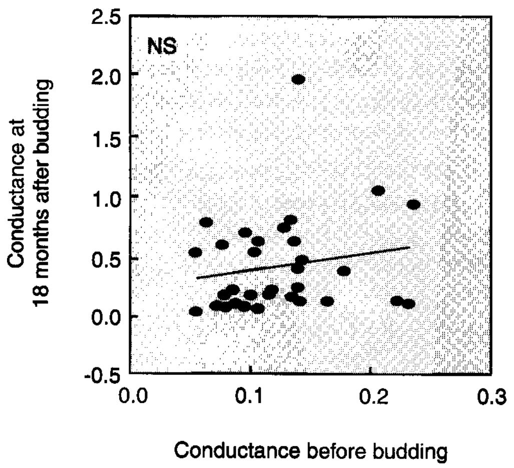

Fig. 2. Stomatal conductance before and after budding in five *Hevea* clones

Table 3. **Mean and coefficient of variation in A/gs before budding (18-month-old polyclonal seedlings) and 18 months after budding**

Clone	A/gs			
	Before budding		After budding	
	Mean	CV (%)	Mean	CV(%)
RRII 105	88.7	39	25.8	83
GT 1	84.6	24	60.0	80
RRIM 600	86.2	33	41.3	77
Gl 1	68.2	30	74.8	35
RRII 208	75.2	30	53.7	65
CD	NS		NS	

Chlorophyll content

Significant differences were observed in the mean chlorophyll contents and chlorophyll a/b ratio in the five scion clones. Total chlorophyll and cholorophyll a and b contents were found to be high in RRII 105 and Gl1 followed by RRII 208 (Table 4). Chlorophyll a and total chlorophyll did not show much variation among the plants within a clone in any of the five clones, but chlorophyll b showed high CV. The clones RRII 105 and Gl 1 showed similar values of chlorophyll a and b, the latter being mother parent of the former, similar pigment composition could be due to their genetic similarities. Korovin (1971) reported that compatible rootstock-scion combinations in apple had higher chlorophyll contents than those of non-compatible combinations. The low CV for the total chlorophyll content

Table 4. **Chlorophyll composition (mg/cm^2) of leaves in 18-month-old budgrafted plants**

Clone	Chlorophyll a		Chlorophyll b		Total chlorophyll		Chlorophyll a/b	
	Mean	CV(%)	Mean	CV(%)	Mean	CV(%)	Mean	CV(%)
GT 1	2.3	12.7	1.4	35.2	3.7	21.8	1.8	15.9
RRIM 600	2.4	7.9	1.4	14.8	3.8	10.5	1.7	6.7
RRII 105	2.8	1.8	2.2	14.7	5.0	7.2	1.3	12.4
RRII 208	2.7	6.3	1.9	27.1	4.6	14.8	1.4	21.0
Gl 1	2.8	1.4	2.3	15.5	5.1	8.6	1.3	13.4

among the individual plants of clones RRII 105 and Gl 1 indicate that stock has no profound influence on the pigment composition in *Hevea*.

Reducing sugar

Total reducing sugars in the leaves showed appreciable variation in the five clones studied (Table 5). Considerable CV was observed among plants within clones and the lowest CV was observed in the clone RRII 208.

Total sugar

The highest sugar concentration was observed in RRII 105 and was significantly different from the clone RRIM 600 only. All other clones showed no significant difference. Considerable CV was also observed among plants within each scion clone. Kul'tabaev (1985) reported that the accumulation of total sugar in different cultivars of apple depends on rootstocks. Brown *et al.* (1985) also reported the rootstock influence on carbohydrate contents in young apple trees. Starch content varied in different combinations of stock and scion and plants growing on their own roots of *Citrus* sp. (Kaplankiran *et al.*, 1985).

Phenols

Total phenol concentrations in the leaves of the five clones are shown in Table 5. The clones differed in their phenol concentrations. CV showed higher values in the clones RRII 208, RRIM 600 and GT 1.

Phenolic compounds are among the most widespread classes of secondary metabolites and play a significant role in the metabolic interactions of plant systems. These compounds also constitute an important group in rootstock-scion relations (Errea, 1998).

Changes in phenolic composition in the scion of *Jasminum grandiflorum* before and after budding on to *Jasminum officinale* was reported by Tahrouch-skouri *et al.* (1993). Schmid and Feucht (1985) reported that incompatibility symptoms were reflected through proteins, enzymes and polyphenols in plants of *Prunus avium / Prunus cerasus* graft combinations.

Amino acids

Amino acids also showed considerable variations among clones and plants within clones as shown in Table 5. High CV was observed in the amino acid concentration among the budded plants of different clones except GT 1.

Carbohydrates, especially sugars form the basic substrate for rubber biosynthesis. Hence sugar is considered as an important constituent related to yield in *Hevea*, the

Table 5. **Biochemical composition of leaf samples in 18-month-old budgrafted plants**

Clone	Reducing sugar (mg/g)		Total sugar (mg/g)		Phenols (mg/g)		Amino acids (mg/g)	
	Mean	CV(%)	Mean	CV(%)	Mean	CV(%)	Mean	CV(%)
GT 1	122.1	24.9	339	18.3	71.9	35.0	24.9	13.1
RRIM 600	105.8	25.6	308.5	18.8	39.0	34.6	20.4	42.2
RRII 105	100.0	23.8	388.9	18.1	55.2	18.5	18.7	47.1
RRII 208	146.3	10.8	336.1	44.3	47.0	37.2	15.6	55.7
Gl 1	80.3	27.7	335.6	30.2	47.0	16.5	10.8	23.1

intraclonal variations observed in the sugar content may contribute to the yield variations reported in monoclonal plantations. High sugar content is also associated with growth vigour of the plants. In the present study also, the observations of highest concentration of total sugars in the leaves of RRII 105 may be due to the greater growth vigour of this clone. Such a trend was exhibited by other clones also. Similar observations were reported by Brown *et al.* (1985) in apple trees.

Changes in the biochemical composition can be attributed to the differences in the metabolic activities of the plants which may be influenced by genetic and/or environmental factors. In the present study, significant differences existed among the five clones with regard to all the biochemical parameters studied *viz.*, reducing sugar, total sugar, phenol and amino acids. By budgrafting, two genetically different plants having different metabolic activities are combined together to form and function as a new single plant. The large intraclonal variation may be due to the genetic differences between the genetically heterogeneous rootstock and the homogeneous scion. In spite of the homogeneity of the scion materials of each clone, considerable CV observed for various parameters among the plants of each clone indicates the stock influence on the scion.

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