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BIOCHEMICAL AND IONIC COMPOSITION OF LATEX INFLUENCING YIELD ATTRIBUTES AND PRODUCTIVITY IN *HEVEA BRASILIENSIS*

Molly Thomas, Jayasree Gopalakrishnan, P. Prasannakumari, Joshua Abraham, R. Krishnakumar and James Jacob

Rubber Research Institute of India, Kottayam - 686 009, Kerala, India

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Natural rubber (cis-1, 4-polyisoprene) is synthesised as rubber particles suspended in latex, which constitutes the cytoplasm of latex producing cells. In the present study, sucrose, thiols and ionic composition of latex were correlated with flow characteristics and yield in seven *Hevea* clones. Thiols in the latex showed significant positive correlation with total latex volume and significant negative correlation with plugging index. Level of sucrose showed significant positive correlation with initial flow rate, total volume and yield of the latex. Among the ionic components, inorganic phosphorus (Pi) showed significant positive correlation with initial latex flow rate, total volume and yield while calcium (Ca) showed significant negative correlation with total volume and yield. The biochemical or inorganic ions present in the latex did not show any significant correlation with the physiological disorder namely tapping panel dryness (TPD).

Keywords: *Hevea brasiliensis*, Latex ionic composition, Tapping panel dryness.

The two major factors influencing the yield in *Hevea brasiliensis* are latex flow characteristics and *in situ* regeneration of latex between two successive harvesting dates (Sethuraj, 1981). It was shown that biochemical and biophysical properties of latex govern its flow and *in situ* regeneration (Jacob *et al.*, 1989). The role of biochemical factors such as sucrose and thiols and their importance as yield components in *H. brasiliensis* had been established (Eschbach *et al.*, 1984; Jacob *et al.*, 1986). Sucrose is the primary precursor for rubber biosynthesis (isoprene) and its higher concentrations in the latex indicate either an increased supply (Tupy and Primot, 1976) or low metabolic utilisation in the laticiferous tissues (Prevot *et al.*, 1984) during isoprene synthesis. Thiols present in latex scavenge the reactive oxygen species (ROS) produced during cell metabolism. Thiols can also activate some key enzymes such as invertase and pyruvate kinase that increase the metabolic activity of isoprene synthesis in the laticiferous tissues and thereby influencing the regeneration of latex (Jacob *et al.*, 1986).

Mineral ions play an important role in the latex formation in laticiferus tissues (Hamzah *et al.*, 1975). They alter the latex flow characteristics, act as cofactors of enzymes involved in rubber biosynthesis and influence the latex regenerative pathway.

Correspondence: Molly Thomas (Email: molly@rubberboard.org.in)

Inorganic phosphorus (Pi) is an essential mineral for ADP phosphorylation during ATP synthesis that is required in the biosynthesis of rubber in fairly large amounts. Magnesium (Mg) is known to activate some of the key enzymes related to isoprene synthesis (d'Auzac, 1965) and also inhibit a few other enzymes (Tupy and Primot, 1976) during the synthesis of latex. Ribaillier (1968) and Ribaillier and d'Auzac (1970) had established an inverse relationship between Mg content and latex flow time. Higher concentration of Mg and Mg/Pi ratio in latex are reported to be associated with premature latex coagulation in the tapping panel (Beaufils, 1957). It had been observed that clones with low Pi/Mg ratios in the latex tend to have higher plugging index (Yip and Gomez, 1980). Potassium (K), an activator of tonoplast pyrophosphatase and pyruvate kinase (Jacob *et al.*, 1989), present in the latex in high levels (40 to 100 mM) maintains the latex osmoticum. Copper (Cu), manganese (Mn), iron (Fe) and zinc (Zn) are also important as cofactors of different isozymes of superoxide dismutase and oxidases in the laticifers.

Tapping panel dryness (TPD) in *Hevea* trees is a major productivity constraint encountered in natural rubber plantations. Variations in the intensity of TPD had been attributed to genetic variations (Sivakumaran *et al.*, 1988), nutritional imbalance (Pushpadas *et al.*, 1975), intensity of harvesting (Vijayakumar *et al.*, 1991), *etc.* The levels of sucrose, thiols and ionic elements in the latex of different *H. brasiliensis* clones and their influence on TPD have not been studied in detail. The effects of mineral elements on latex regeneration and flow characteristics have also not been studied in detail. The present study deals with the relationship between biochemical and ionic compositions of latex with yield attributes and productivity in seven *H. brasiliensis* clones.

The experiment was carried out in the farm of Rubber Research Institute of India (RRII), Kottayam District, Kerala. Eleven-year-old *Hevea* clones *viz.* Gl 1, RRII 105, RRII 38, RRII 308, GT 1, Tjir 1 and RRIM 600, opened for harvesting latex (BO-1 panel) in 1999 under S/2 d2 tapping system were used for the study. Twelve trees of comparable girth from each clone were selected at random for the following analyses. Latex samples were collected during October and November in the fourth year of tapping and

Table 1. **Concentrations of sucrose and thiols in the latex and yield attributes in different clones**

Clone	Sucrose (mg/100 g latex)	Thiols (mg/100 g latex)	Initial flow rate (ml/min.)	Total volume (ml)	Plugging index	Yield (g/t/t)	TPD (%)
Gl 1	366.30	07.07	2.62	61	5.82	24.22	16.7
GT 1	412.35	13.55	3.58	152	2.50	66.09	08.3
Tjir 1	198.07	07.31	3.18	53	9.30	20.29	16.7
RRIM 600	386.04	08.52	4.08	96	4.90	40.60	08.3
RRII 38	448.07	08.17	3.78	117	4.20	48.52	-
RRII 308	588.33	11.26	5.82	177	4.04	76.18	25.0
RRII 105	507.31	07.01	5.30	159	4.05	79.81	25.0
CD (P = 0.05)	154.47	1.73	1.32	48.6	2.10	21.63	-

the concentrations of sucrose, thiols and ions were determined. The trees were monitored for the occurrence of TPD at monthly intervals. Plugging index and dry rubber yield were determined as reported earlier (Thomas *et al.*, 2000) based on the observations made during the peak yielding period (October to January).

The latex was extracted with 2.5 per cent trichloroacetic acid and aliquots were used for estimating sucrose, thiols and inorganic phosphorus (Thomas *et al.*, 2000). K, Ca, Mg, Cu, Fe, Mn and Zn in dry rubber were estimated after ashing thin films in a muffle furnace at 550 ^{0}C for 3 h. K was estimated by flame photometry. Ca, Mg, Cu, Fe, Mn, and Zn were estimated by atomic absorption spectrophotometry (RRIM, 1973).

The levels of sucrose and thiols in the latex, initial latex flow rate, total latex volume, plugging index, dry rubber yield (g/t/t) and the TPD incidence of different clones studied are summarised in Table 1. The differences in the concentrations of sucrose and thiols were significant among the clones as reported earlier (Nair *et al.*, 2001). Under S/2 d2 system of tapping in the BO-1 panel, the highest incidence of TPD was observed in clones RRII 105 and RRII 308 and no incidence of TPD was observed in clone RRII 38 during the period of study. No consistent pattern was observed for the sucrose and thiols contents in the latex with TPD per cent in different *H. brasiliensis* clones. The high initial flow rate and low plugging index in RRII 105 and RRII 308 might have resulted in over-harvesting of latex (more than the inherent capacity) from these clones. The incidence of TPD was positively correlated with rubber yield and over–harvesting of latex (Sethuraj, 1988; Premakumari *et al.*, 1991).

Variations in ionic components in the latex of different *H. brasiliensis* clones are shown in Table 2. The differences in the concentrations of ionic components were significant among the clones as reported earlier (George *et al.*, 2006). Among the *H. brasiliensis* clones, the highest yielding clone RRII 105, showed the highest level of Pi in the latex and that may be related with the higher latex ATP levels reported (Sreelatha *et al.*, 2004). Zn level was comparatively low in this clone, where high incidence of TPD was also observed. The highest content of Mn and the lowest content of Mg were noticed in clone RRII 38, which showed the lowest incidence

Table 2. **The ionic components in the latex of different clones**

Clone	Pi (mg/100g latex)	K	Ca	Mg	Cu	Zn	Fe	Mn
		mg/100 g dry rubber			µg/100 g dry rubber			
Gl 1	14.39	415.4	2.98	213.40	99.20	92.56	138.31	60.06
GT 1	30.23	560.6	2.33	88.60	526.15	562.50	780.73	164.30
Tjir 1	26.35	276.0	2.96	132.70	475.90	557.00	876.20	133.30
RRIM 600	31.00	628.0	3.79	212.80	619.70	700.20	1004.20	151.80
RRII 38	26.81	306.8	3.15	41.78	274.20	353.05	390.84	186.10
RRII 308	32.12	519.8	2.37	153.65	265.10	85.60	491.60	71.09
RRII 105	42.40	330.0	1.97	141.20	141.90	57.70	195.15	141.22
CD (P = 0.05)	8.40	93.75	0.99	39.31	145.49	90.47	204.55	35.44

of TPD. Mn as cofactor of the ROS scavenging enzymes such as super oxide dismutase and oxidase has a protective role in oxidative stress. Higher concentrations of Mg have been reported to associate with premature latex coagulation in the tapping panel (Beaufils, 1957). No consistent pattern was observed between the latex ionic components and TPD per cent in different *H. brasiliensis* clones.

Table 3. **Relationship between biochemical and ionic composition of latex with flow characteristics and yield in different clones**

Biochemical and ionic components	Initial flow rate	Total volume	Plugging index	Yield
Thiols	0.06	0.33*	-0.42*	0.30
Sucrose	0.37*	0.40*	-0.29	0.49**
Pi	0.63**	0.58**	-0.26	0.67**
K	0.04	0.13	-0.30	0.13
Ca	-0.32	-0.39*	0.10	-0.47**
Mg	0.01	-0.26	0.19	-0.20
Cu	-0.20	-0.11	0.06	-0.21
Zn	-0.31	-0.27	0.15	-0.32
Fe	-0.17	-0.16	0.15	-0.22
Mn	-0.07	-0.06	-0.22	0.08

* Significant at P < 0.05: ** Significant at P < 0.01

The relationship between metabolites such as sucrose, thiols and inorganic ions of latex with flow characteristics and yield (g/t/t) was computed for all the seven clones (Table 3). Thiols in the latex showed significant positive correlation with total latex volume and significant negative correlation with plugging index. Sucrose content in the latex showed significant positive correlation with initial flow rate, total latex volume and dry rubber yield. Positive correlation between latex sucrose content and yield was reported earlier (Tupy, 1973). Sucrose being the primary precursor molecule for the formation of numerous metabolic byproducts including rubber, its role in the formation of latex in *H. brasiliensis* is therefore pertinent.

The inorganic phosphorus content in the latex showed significant positive correlation with initial flow rate, total latex volume and dry rubber yield. However, Ca content in the latex showed significant negative correlation with total latex volume and dry rubber yield. The inorganic phosphorus content indicates the energy metabolism of latex through its role in the phosphorylation of ADP to ATP. For the conversion of sucrose into rubber, the requirement of ATP is high. Direct correlation between Pi content of latex and yield has been reported (Eschbach *et al.*, 1984; Thomas *et al.*, 2000). Though no relationship between yield and other ionic components could be observed, other indirect influences of these ions are evident. Hamzah *et al.* (1975) observed that N, P, K and Mg are essential for bark regeneration and Fe, Mn, and Zn have major role in latex vessel formation. The beneficial effect of Pi and K in the stability of latex has also been reported (Philpot and Garth, 1953; Karyudi, 2004; Gopalakrishnan *et al.*, 2008).

To achieve sustainable crop production, it is essential to have a balanced situation between the amount of crop harvested and the ability of the tree to replenish, not only the crop harvested but also the amount of elements lost in the latex. The biochemical and ionic components investigated in the present study indicated that sucrose, thiols and inorganic phosphorus in the latex have significant positive correlation with dry rubber yield while latex calcium content has a significant negative correlation with dry rubber yield. No consistent pattern was observed for the biochemical and ionic components in the latex with the development of disorders like TPD in *H. brasiliensis*.

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