Brown Bast and Nutrition: a case study

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ABSTRACT

GG1 seedings planted in 1966 in an estate in Kerala, were fertilized during its immature phase using NPK mixtures having a high proportion of potassium and phosphorus in relation to nitrogen. When the trees were brought under tapping on a S/2. d/3 system *in September, 1971, an unusually high yield, two to three* times the normal, was obtained and late-dripping was also noticed. Within a few months, incidence of brown bast became evident. It would appear from the manurial history and the results of analysis of soil, leaf and latex samples that unbalanced nutrition of the tree may be responsible for the unhealthy symptoms. The study shows that high intensity of tapping or frequency of the wounding process **per se** is not the cause of the type of brown bast observed in the estate. The process of long duration of flow or withdrawal of a large quantity of latex resulting in the loss of a critical quantity of materials from the trees in a relatively short period appears to be a pre-condition for the development of this type of brown bast.

The yield potential of **Hevea brasiliensis** may be considered to be dependent mainly on two factors: (i) the rate of biosynthesis of rubber and (ii) the rate and duration of latex flow on tapping. The first factor is mainly a genetic one and is maximum under optimum conditions of nutrition and other ecological factors. The second factor also appears to have a genetic component (Milford **et al.**, 1959), but it is definitely amenable to manipulations by external factors like stimulation (Boatman, 1966; Rubber Research Institute of Malaya, 1961 a) or alteration in soil moisture regime (Sethuraj and George, 1973). Under a normal exploitation system a very short duration of flow signifies an attenuated yield, and a much prolonged duration usually heralds the onset of brown bast. Though there has been no detailed and systematic study of the effect of fertilizers on rate and duration of latex flow, there are reports (Beaufils, 1957; Bolton and Shorrocks, 1961; Pushparajah, 1966; Rubber Research Institute of Malaya, 1967; Collier and Lowe, 1969; Pushparajah, 1969) of the influence of mineral nutrients on stability of latex or latex flow, which indicate a possible relationship between nutrition and latex flow. The mineral nutrition of the tree is thus intimately connected with its health and productivity. In this paper an attempt has been made to report and discuss a disorder of **Hevea brasiliensis** in South India, which appears to be related to nutrition.

MATERIALS AND METHODS

GG1 seedlings planted in 1966 in an estate in Kottayam district of Kerala State were fertilized during immaturity using NPK mixtures containing a higher proportion of K and P in comparison to the fertilizer recommendations of Rubber Board. In Table-1 is given a comparative statement of the fertilizer practice followed in the affected area of the estate and the fertilizer recommendations of Rubber Board.

Table – 1

Fertilizer schedule followed in the estsate and fertilizer recommendation of Rubber Board

Period of application	Nutrients supplied through fertilizers in g/tree						
	As per practice followed in the estate			As per Rubber Board's recommendation			
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	Mg O
1966 September	22	31	26	22	22	9	3.4
1967 March – April Sept. - Oct.	68	97	81	90	90	36	13.5
1968 March – April Sept. – Oct.	90	129	108	110	110	44	16.5
1969 March – April Sept. – Oct.	112	160	134	90	90	36	13.5
1970 March - April Sept. - Oct.	180	257	216	90	90	36	13.5
1971 March – April * Sept. – Oct.	41	28	120	90	90	36	13.5
	513	702	685	492	492	197	73.9
1972	No manuring						

* In the estate, application was done in one single dose.

Note: In the estate N was applied as urea and/or ammonium sulphate, P_2O_5 as rock phosphate and K_2O as muriate of potash.

In September, 1971 the trees were brought under tapping on a S/2. d/3 system. An unusually high yield, two to three times that normally recorded for such planting material in the area, was obtained, and late-dripping was noticed in many of the trees. Within about three months a number of trees had gone partially or completely dry, and within a year many more of the late-dripping trees became dry, and the symptoms associated with brown bast were clearly evident.

On 12th October, 1972 soil, leaf and latex samples were collected from the affected area. Leaf samples were collected from apparently normal, late-dripping and brown bast-affected trees, ten in each group. Latex samples were also collected from each tree in the apparently normal and late-dripping groups. Bark samples were collected in June, 1972 from tapped and opposite sides of brown bast-affected, late-dripping and apparently normal trees in the affected area.

Soil and leaf samples were analysed following the methods described by Pushpadas **et al**. (1972) with the exception that Ca and Mg were determined in a Hilger & Watts Atomic Absorption Spectrophotometer using strontium chloride as releasing agent. Latex analysis for dry rubber content, total solids and nitrogen was carried out as per the methods of Indian Standards Institution (1966). K in latex was estimated flame-photometrically using a modified method of Gyss and Menon (1960). The method due to Tunnicliffe (1955) was followed for determination of P in latex, and Mg was estimated in an acid extract of the ashed sample using Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

Results of analysis of soil, leaf and latex samples are given in Tables-2, 3 and 4 respectively. Details of the output of nutrients through latex are given in Table-5.

Table - 2

Results of analysis of soil samples from the affected area

Depth of soil sampling in cm	Available nutrients in mg/100 g soil				pH
	P	K	Mg	Ca	
0-30	M 1.3	L 2.5	M 1.1	4.3	5.0
30-60	L 0.2	L 2.1	L 0.5	0.5	5.1

L – Low, M - Medium

The heterogeneity of the planting material in the area and the fact that samples of soil, leaf and latex were collected one year after the opening of the trees vitiate the interpretation of results. It is also noteworthy that the trees were not manured in 1972. Nevertheless, it can be seen from Table–2 that available P and Mg in the soil are low to medium and available K low. Available calcuim in soil remains low in spite

Table – 3

Results of analysis of leaf samples from the affected area

(Average values of samples from 10 trees, expressed on dry matter basis)

Condition of the trees	N%	P%	K%	Mg%	Ca%	K/Ca	K/P	N/K
Apparently normal	M 2.99	M 0.24	L 0.81	H 0.33	1.19	0.68	3.38	3.69
Late-dripping	H 3.51	M 0.23	M 1.09	H 0.31	0.84	1.30	4.74	3.22
Dry	H 3.43	M 0.23	L 0.95	H 0.37	0.79	1.20	4.13	3.61

L – Low, M – Medium, H – High

of the fairly heavy application of rock phosphate. Table–3 shows that eventhough there has been considerable drainage of nutrients through latex, (Table–5), the N and K values of the leaf samples from late-dripping trees are higher than those from the apparently normal trees. According to the interpretation of nutrient ratios in leaf (Beaufils, 1957), the K/P and N/K ratios of leaf samples from late-dripping trees indicate abnormality due to excess K. This is in agreement with the high rate of K application in the affected area (Table–1) But it is rather strange that, in spite of the heavy K application, Mg content of the leaf samples remains high, and stranger still is the fact that there is no concomitant increase in the latex Mg. The difference between the K/Ca ratios of leaf samples from normal and late-dripping trees is also remarkable. Results obtained by Sulochanamma (1973) on anatomical studies of bark samples show that in the case of bark from brown bast-affected trees the latex vessels are irregular in shape and a good number of them, both on the tapping and opposite sides, are ruptured. Reddish brown colouration around latex vessels, meristematic zone and nodule formation are also noticed. The bark samples from late-dripping and apparently normal trees are free from ruptured vessels, eventhough reddish brown colouration is noticed particularly in samples from late-dripping trees. However, in the case of bark sample from one late-dripping tree which became dry within a few months, latex vessels in the bark sample from the tapping side (but not in the sample from the opposite side) are seen ruptured.

Regarding the properties of latex reported in Table-4, it is difficult to delineate genetic differences from those, if any, generated by late-dripping. Moreover, the properties of latex during the initial period of tapping are not known, and as such it is not possible to conclude whether the observed differences in properties between the two latices are the cause or consequence of late-dripping But it can be seen that the latices from trees in the affected area, whether from apparently normal or late-dripping trees, are in general low in Mg content and high in P and K contents in comparison with the values reported in literature (Institut des Recherches sur le Caoutehouc en Indochine, 1956; Paardekooper, 1965; Lowe, 1968; Chai Kim Chun **et al.** 1969; Collier and Lowe, 1969; Pushparajah, 1969 and Bealing and Chua, 1972).

Collier and Low (1969) reports that phosphate fertilization increases phosphate content and decreases Mg content of latex. K application is reported to increase stability of latex by lowering Mg and increasing P contents of latex (Pushparajah, 1969). Beaufils (1957) has established a significant negative correlation between the ratio K/Ca in leaf and latex Mg. Philpott (1951) found a positive correlation between stability of latex and its K content. According to Tupy (1973) under the actual conditions of **Hevea** exploitation, the production of latex is limited by sucrose supply to latex vessels, and fertilization with K improves production through its beneficial effects on sucrose translocation. It would thus appear that the high rates of application of phosphatic and potassic fertilizers in the affected area of the estate has resulted in an enhancement *in the production as well as stability* of latex. Delayed plugging seems to be yet another result of the manuring programme. But as the physiology of latex vessel plugging is still enshrouded in mystery, it can only be assumed that the nutrition of the tree has in some way adversely affected the synthesis and or operation of the 'plugging principle'. Late-dripping and high yield of latex in the affected area are thus the ultimate consequence of all the above factors.

It is a common observation that high intensity tapping usually results in late-dripping and incidence of brown bast, and that seedlings are especially prone to this disorder. Chai Kim Chua **et al.** (1969) and Bealing and Chua (1972) have studied the problem of high intensity tapping in relation to the composition and properties of latex and incidence of brown bast. The latter authors have examined the problem in great detail and have concluded that tapping results in a diminished permeability of latex vessels, and that the effect is directly proportional to the tapping in*tensity and can be regarded as one as*pect of wound response. The hypothesis of diminished or altered permeability has many features to commend itself. But the contention that the diminution in permeability is directly proportional to the tapping intensity and is one aspect of wound response does not hold good at least in the case of the brown bast reported in this paper, as it is associated with a low intensity of tapping (S/2. d/3). Another conclusion of the above authors that the origin of brown bast is not related to material losses through latex is also open to doubt. This conclusion seems to be based on the data obtained long after the yield of S/1. d/1 trees declined to a level lower

Table - 4

Results of analysis of latex samples (Average of samples from 10 trees)

Condition of tree	T. S	D. R. C.	mg N per 100 g			mg P per 100 g			mg K per 100 g			mg Mg per 100 g		
	%	%	T. S.	Latex	Serum	T. S.	Latex	Serum	T. S	Latex	Serum	T. S.	Latex	Serum
Apparently normal	38.9	35.8	887	343	194	258	94	117	561	215	304	32.2	12.9	13.2
Late - dripping	33.2	30.5	1025	337	199	290	97	116	725	245	318	60.0	19.4	20.8

T. S. — Total solid. D. R. C. — Dry rubber content

Note: — The nutrients were estimated in total solid and dry rubber only.

Values in latex and serum are calculated from values in dry rubber using D. R. C. %

Table – 5

Output of nutrients in latex per tapping (Average output of 10 trees in one day's tapping)

Condition of tree	Yield of latex in one tapping (g)	Nutrient output in mg/tree/tapping			
		N	P	K	Mg
Apparently normal	109	385	111	243	15
Late-dripping	218*	730	224	553	33

* Yield obtained during the first three hours of tapping only. The trees were still dripping at the rate of 5 tc 50 drops in a minute.

than that of S/2. d/2 trees. Their yield data show that S/1, d/1 trees give considerably higher yeild than S/2. d/2 trees during the first few months of tapping, and therefore material losses during this period must have been much higher in the case of S/1. d/1 trees. The same deduction can be arrived at from the data of Chai Kim Chun **et al.** (1969). In the present study also the output of nutrients through latex is found to be greater in the case of late-dripping trees (Table-5). Thus the important pre-condition for the type of brown bast referred to here seems to be the delayed plugging and consequent long duration of latex flow or withdrawal of an unusually large quantity of latex resulting in the loss of a critical quantity of materials from the tree in a relatively short period. Therefore, the possibility that the fulfilment of this pre-condition may trigger the processes leading to deminished or altered permeability of latex vessels appears to merit consideration. The decreased or altered permeability may curtail the supply of sucrose and other essential materials, thereby leading to progressive degeneration of latex vessels and subsequent dryness of tree.

In this investigation lower Ca level and higher K Ca ratio have been obtained for leaf samples from late-dripping trees. Lower Ca content in leaf of d/1 tapped trees compared to d/3-4 tapped trees has been reported by Chai Kim Chun **et al.** (1969). Bealing and Chua (1972) reports lower Ca and Mg contents in latex of S/1. d/1 trees. In all the above investigations latex from intensively tapped or late-dripping trees contains higher level of K. Ca content of latex is reported to be much reduced by stimulation especially with ethrel, eventhough the levels of N, P, K, Mg and Cu do not change greatly (Rubber Research Institute of Malaya (1971 b). The data of Bealing and Chua (1972) show that even though the levels of mineral and other constituents of latex from S/1. d/1 trees are lower as compared to S/2 d/2 trees, the reverse is true in the case of bark constituents. This phenomenon is perhaps comparable to the observation in the present study that latex magnesium remains low in spite of the fact that leaf Mg is high. A major proportion of Ca in latex is found to be located in the lutoids (Rubber Research Institute of Malaya, 1966) and lutoids are implicated in the plugging of latex vessels during tapping (Southern, 1969). Bangerth (1973), investigating calcuim related physiological disorders of fruit crops, puts forth the hypothesis that the physiological disorder may be caused by a Ca replacement and/or chelation in the plasma membrance by K, Mg, H and certain organic acids, the process leading to either an alteration in the permeability of the membrance or the degeneration of the membrane itself. Higinbotham (1973) points out the importance of Ca in the structural integrity of cell membrane aud in the electropotentials of plant cells. All these observations would suggest that the position of Ca and its relation to Mg and K deserves detailed investigations **vis-a-vis** the 'plugging principle' and the 'permeability factor' of latex vessels as well as the incidence of brown bast.

While discussing the permeability of latex vessels, Bealing and Chua (1972) have referred to the existence of gummy materials accumulating in the intercellular space near the latex vessels of brown bast-affected trees, and have speculated on its relation with the critical failure of latex vessel permeability. In the present study it has been observed that the total solids obtained from latices of many late-dripping trees adhered to the glass container used for evaporation. Whether this sticking property is due to the presence of gummy materials in latex, or whether the reddish brown colouration noticed around latex vessels has anything to do with this material remain to be elucidated.

CONCLUSION

The unbalanced fertilizer schedule followed in the affected area of the estate appears to have been instrumental in enhancing the stability as well as production of latex and in delaying the process of latex vessel plugging. These factors have caused late-dripping and high yield of latex which might have set in motion the processes leading to the development of brown bast. The fact that some trees in the affected area remain apparently normal may be due to genetic differences in yield potential latex flow characterestics or response to fertilizers applied. The process of long duration of flow a withdrawal of a large quantity of latex resulting in the loss of a critical quantity of materials from the trees in a relatively short period appears to be a pre-condition for the development of this type of brown bast.

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