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ROOT DEVELOPMENT IN *HEVEA BRASILIENSIS*

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This paper provides an over view of root development in rubber plants, with reference to tap root, lateral roots and feeder roots. Also, an attempt is made to ascertain the process of root development in relation to changes in the environment and management practices. Finally these information are used to suggest some implications on the method of fertilizer application for rubber at different growth stages.

The rubber tree possesses an extensive root system, which accounts for about 15-25 percent of the total dry weight of a mature rubber tree. The root system consists of a well developed tap root, several whorls of lateral roots and large numbers of fine rootlets (feeder roots). These roots are capable of exploiting a large volume of soil to enhance the tree's absorptive capacity for both moisture and nutrients.

Tap root

The growth of the tap root depends to a large extent on soil properties. For instance, on deep soils, without impediments to root growth, the length of the tap root of 3 years and 8 years old rubber trees was found to be about 1.5 meters and 2.5 meters respectively (RRIM, 1958).

Lateral roots

The primary lateral roots which arise directly from the tap root in a whorl within 30 cm of the soil surface may grow horizontally, or only slightly downwards. The remaining laterals may be commonly produced at a depth of 40-80 cm. Yet, they do not extend horizontally as far as those nearer to the surface. The laterals normally extend well beyond the spread of the branches (canopy). Hence, in rubber plantations at the normal spacings (3.6m x 5.4m), lateral roots commonly grow through the adjacent planting rows. It was found that the 3 years old trees had laterals extending up to 6-9 meters and the trees of 7-8 years had laterals over 9 meters long.

In areas of mature rubber, more than 15 years old, the root density across the inter rows was found to be fairly even and not significantly related to distance from the trees. In general, it would appear that, once the roots from trees in adjacent rows have met, a ramification of the roots takes place. The final result being that there is only a slight variation in the concentration of surface roots along with distance from the tree in mature rubber plantations.

Another significant feature of the rooting habit of rubber was the observation of lateral roots well below the soil surface. The fine feeder roots which arose from these laterals are therefore capable of absorbing nutrients and moisture from deep soil layers.

Feeder roots

All the laterals ultimately give rise to unsuberized yellow-brown roots with a diameter of about 1 mm, known as feeder roots. These feeder roots, which possess root hairs extend over at least the last six inches of the lateral roots and are mainly responsible for absorption of nutrients and water (Soong, 1976). Although thick roots may partially contribute in the absorption of nutrients and water, the most efficient zone of absorption is near the root tip. Therefore the important factors in this regard are the number of tips and the number of fine or feeder roots presence in the soil (RRIM, 1958).

The rate of growth (elongation) of these feeder roots is in the region of 3-5 cm per week. Once the lateral roots of neighboring trees are met, ramification occurs with the result that in the mature plantation there was little variation in the concentration of feeder roots across the inter rows, except where the roots branched prolifically on entering a patch of particularly well-aerated, moist or nutrient-rich soil (RRIM, 1958).

The density of feeder roots at different depths showed that there was a significant difference in their vertical distribution with the highest percentage of roots being in the surface soil layers; 0-10cm and 10-20cm (Soong, 1976 and Samarappuli *et al*, 1996). The amount of feeder roots in the surface soil was about 35-50 percent of the total feeder roots. Moreover, only about 14% and 5% of the total root weight were found in the lower soil layers of 30-45cm and 50-90cm, respectively (Soong, 1976 and Samarappuli *et al*, 1996).

Clonal effects

There were significant differences in feeder root development between various clones of *Hevea brasiliensis*. Vigorous clones like RRIC 102, RRIC 121, RRIC 100 and RRIC 110 had more feeder roots than a less vigorous clone like PB 86 (Samarappuli *et al* 1996). Data from RRIM also showed that vigorous clones like RRIM 605 and RRIM 623 had more feeder roots than a less vigorous clone like RRIM 513 (Soong, 1976). It therefore appears, that the better growth of clones, over others, on a wider range of soils may be due to a larger amount of feeder roots available for absorption of moisture and nutrients.

This particular concept, to some extent has been confirmed in various commercial areas where a less vigorous clone like PB 86 has grown poorly and has shown symptoms of nutrient deficiency in areas where more vigorous clone like Tjir 1 has been healthy and strong (RRIM, 1985). Furthermore, RRIC 102 clone has shown that it can withstand moisture stress conditions when compared to PB 86 under Sri Lankan conditions (Samarappuli *et al*, 1992). Thus, it is likely that if a clone has the ability to produce a vigorous root system it would be suited for planting over a wide range of soil and climatic conditions.

Soil series

In soils, where the subsoil is compact with coarse soil structure, like *Durian* and *Malacca* series in Malaysia (Owen, 1951) and *Ratnapura* and *Boralu* series in Sri Lanka (Silva, 1970), root penetration to lower depths was poor. These soils have more than 50% of the total root weights in the top 7.5 cm of soil and it decreases rapidly with depth until it reaches about 10% in the lowest soil layer. Therefore, the bulk of nutrient and moisture uptake is likely to occur in the top 15 cm in these types of soil. Similar trends in the vertical distribution of roots was also found in excessively drained and sandy soils. However, in those soils which had little profile differentiation and did not possess a compact layer or laterite band like *Munchong* series in Malaysia (Owen, 1951) and *Parambe* series in Sri Lanka (Silva, 1970), root distribution at different depths were rather uniform. The strong development of both the tap root and the lateral roots was also observed with tap roots of 1.5 meters and lateral roots of over 9 meters in these type of soils. The surface soil layer contained only about 28% of the total root weight and the decline with depth was more gradual, with more than 20% of root by weight being at the lowest soil layer. Such uniform vertical distribution indicates that subsoils have been more uniformly exploited for nutrients and moisture.

Soil properties

Physical factors like soil texture, soil structure etc. have important influence on root growth and development. Clone RRIM 623 produced two and half times more feeder roots when grown on sandy soils than on clayey soils. Significant positive correlations were found between fine sand content ($<200\mu$ diameter) and root density at various soil depths (Samarappuli *et al*, 1995). Correlations were better at the lower soil depth where possibly the interference by organic matter, soil microbial activity and other factors were less pronounced. In general, soils with higher fine sand content had higher root density and this could be due to the formation of more favourable soil structure, resulting in better aeration for root growth: or it could be the trees' reaction to a soil with low moisture retention. Clay content was negatively correlated to root density, the correlation being significant at the lower soil depths. As in the case of fine sand, interference by organic matter, microbial activity and other factors in the surface soil layer probably did not cause the relationship between clay and root density to be significant (Samarappuli *et al*, 1996).

Since soil texture is an inherent property of soil, and cannot be altered easily by management practices, the above relationships could indicate the potential of soils for rubber cultivation. Soils with high clay contents will inhibit root development. Unless the soils contain sufficient amounts of sesquioxides and organic matter to offset this inhibition by generating good soil structure, the growth of rubber trees will be affected.

Bulk density had the general tendency to increase with depth in each soil, but the increase was considered too small to explain the sharp drop in root density at the lower soil depth.

Seasonal variation

The rubber tree being deciduous in nature, has an annual leaf fall period of about 3 months (generally commencing in mid-December to February the following year) after which a period of active refoliation follows. During refoliation considerable amounts of water and nutrients were required for forming new leaves as well as for the increased metabolic activity in the tree. This heavy demand exerted by the tree, especially by the foliage, will therefore generate a greater development of feed roots. In the surface soil layer, maximum root development occurred during the period when the tree was producing new canopy and this development persisted till March after which there was a decline to a minimum in August/September. There were indications that the tree began to develop new roots some time after December when the old leaves began to fall or had fallen. In the subsoil, maximum root development was reached only some time in May/June and declined to a minimum in the period August to December. During the period of February to June the rubber trees exhibit maximum uptake of water and nutrients and this being reflected in the development of larger amount of feeder roots. A higher uptake of water and nutrient are required for leaf formation and expansion and also for increased metabolic activity of the plant.

Effect of cover management

The tropical climate in rubber growing countries necessitates a system of management that ensures minimum erosion and constant protection of the soil surface from the sun. In young rubber, the policy of growing cover plants has been practiced rigidly since very early stages. The value of different cover plants (Yogaratnam *et al.* 1984) and soil management practices in enhancing rubber growth (Samarappuli, 1992b) and improving the chemical and physical properties of soil (Samarappuli, 1992a) have been investigated. The best effect was obtained with mulching and data obtained show that there was more vigorous feeder root development under mulching than under legume cover or natural cover (Samarappuli *et al*, 1996). Such differences in feeder root development of *Hevea* under different soil management practices could be attributed to the higher organic matter content of the soil under mulching, competition for moisture and nutrients by roots of legumes and the release of toxic substances from the natural cover.

Mycorrhizae and root development

The presence of mycorrhizae on the roots of rubber trees has been recorded and the occurrence of endotropic, vesicular arbuscular mycorrhizae on the roots was found to be general on rubber trees of all ages and on a variety of soils. Spores of several species of endomycorrhizal fungi have been identified in soil samples from rubber plantations examined by Jayaratne (1982) in Sri Lanka and by Ikram and Mahmud (1984) in Malaysia. It is not known whether the mycorrhizae are of significance in the nutrition of the rubber tree, but mycorrhizae may be of value on soils high in organic matter or of low phosphate content.

Root development and fertilizer application

It was evident that the root development and distribution of a rubber plant varies in relation to environmental changes and management practices. Such information is of vital importance to understand the correct time and method of fertilizer application for rubber at different growth stages of the rubber plant.

For young trees where the feeder roots are concentrated close to the tree, the normal method of applying fertilizer in the weeds free circle is satisfactory. With trees, older than 4 years, it was found that the root density was significantly greater in the center of the inter row area than close to the tree. It is to be noted that the high concentration of roots observed in the center of the inter row area was the result of root growth from two rows of trees and not one. Assuming that each row makes an equal contribution to this root concentration, the root concentration in the center of the inter row resulting from one row was roughly the same as the concentration close to the tree; in many cases the concentration was greater close to the tree (RRIM, 1958).

The feeder root concentration in the 60-90 cm depth in the soil, close to the tree, is considerably greater than in the center of the inter row area. The lower feeder roots close to the tree is important in absorbing nutrients that have been leached out of the top soil. Very few such lower feeder roots are present in the center of the inter row area. For trees more than 4 years of age, the fertilizer should, therefore, be applied at 2 to 4 points, in areas cleared of cover crops and weeds, around the tree within the circle of 105-120 cm radius.

Moreover, to secure the most efficient use of fertilizers, they should be applied at the time when the trees' demand is greatest. This suggests that the best time for applying fertilizers in mature rubber is within one month after refoliation, since maximum surface root development occurs during this period. This has been confirmed in fertilizer trials by timing its application.

REFERENCES

Ikram, A and Mahmud, A W (1984). Endomycorrhizal fungi in soils under rubber. *Journal of Natural Rubber Research* **32,** 198-206.

Jayaratna, A H R (1982). Endomycorrhizas of rubber growing soils in Sri Lanka. *Journal of the Rubber Research Institute of Sri Lanka* **60**, 47-47.

Owen, G (1951). A provisional classification of Malayan soils. *Journal of the Rubber Research Institute of Malaysia* **13**, 20-42.

Rubber Research Institute of Malaysia (1958). Rooting habit. *Planters' Bulletin* **39**, 120-128.

Samarappuli, L (1992a). Effects of some soil management practices and moisture regimes on the performance of *Hevea*. *PhD Thesis*, University of Peradeniya.

Samarappuli, L (1992b). Some agronomic aspects in overcoming moisture stress in *Hevea brasiliensis*. *Indian Journal of Natural Rubber Research* **5**, 127-132.

Samarappuli, L, Yogaratnam, N and Hettiarachchi, R (1992). Performance of some RRIC 100 series clones under different soil moisture regimes. *Journal of the Rubber Research Institute of Sri Lanka* **72**, 49-61.

Samarappuli, L, Yogaratnam, N, Karunadasa, P and Mitrasena, U (1996). Root development in *Hevea brasiliensis* in relation to management practices. *Journal of the Rubber Research Institute of Sri Lanka* **77**, 93-111.

Silva, C G (1964). Provisional classification of rubber soils of Ceylon and their relationship to Malayan soils. *Journal of the Rubber Research Institute of Malaya* **24**, 217-224.

Soong, N K (1976). Feeder root development of *Hevea brasiliensis* in relation to clones and environment. *Journal of the Rubber Research Institute of Malaysia* **24**, 283-298.

Webster, C C and Paardekooper, E C (1989). The botany of the rubber tree. In: *Rubber*. pp. 69-70 (Eds. C C Webster and W J Baulkwill), Longman, Harlow, UK.

Yogaratnam, N, Perera, A M A and De Mel, J G (1984). Management of ground covers for optimum production. *Proceedings of the International Rubber Conference, Sri Lanka* 521-527.