

SOME ASPECTS OF THE PROLIFERATION AND DISTRIBUTION OF FINE ROOTS IN RUBBER (*HEVEA*)

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INTRODUCTION

The root system of the rubber tree comprising of a large tap root, lateral roots and a large mass of fine roots is very extensive and is adapted to exploit a large volume of soil (Snoog, 1976). These feeder roots of the system being the active absorbing zone are meant for increasing the surface area and is an important parameter for the acquisition of water and nutrients, when transport to the root and not the uptake into the root is the limiting step in resource acquisition (Schroth, 1999). Their abundance which is measured as root length density (RLD), is not the only parameter that decides the efficiency of the root system. The abundance of the fine roots, is also a factor that makes plants more competitive in their natural environments (Schroth, 1999).

The formation of fine roots is a continuous process and their growth pattern is inherently determined but can be greatly modified by environmental factors such as the clone of the rubber tree, type and physical properties of the soil. Their production for instance in sandy soils was greater than in silty soils (Snoog, 1976). Agronomic practices such as the application of organic fertilizer and plant residues and crop associations also influence their proliferation. There were more fine roots under a Pueraria cover or intercrops as cinnamon than under highly competitive forage grasses (Pathiratna and Perera 2003). The growth of fine roots is also seasonal, and according to Snoog (1976), the maximum root development seem to occur in February/March corresponding to the time of re foliation when the active uptake of nutrients and water at it's peak. Their extension into the surrounding area with the expansion of lateral roots also depends on the age of the trees. Under favourable conditions fine roots become more abundant in the top soil and gradually reduce with depth (Snoog, 1976).

Proliferation with age

The growth of fine roots into the area around the tree is gradual and the measurements taken in a young clearing with bud grafted trees in a land in the Kalutara district (annual rainfall 2300mm), show that during the first 2-3 years there were more fine roots in the first 2m from the base of the tree in a 20cm. depth. The RLD in between two trees, spaced 2.4m in a row was high even in the 3rd and 4th years, reaching a level of 207.8 and 312.3 cm/1000 cm³ respectively. But with the expansion of the root system the RLD in these positions were reduced to levels as low

as 127 cm/1000 cm³ in the 7th year. This is an indication that root activity of an individual tree moves away from the base of the tree with the lateral distribution of the roots. The low RLD (40.0 cm/1000 cm³) in the middle of the inter row (8.1m inter row spacing system) in the 3rd and 4th years is also an indication of their low abundance in the middle of the inter row at this stage. They seem to explore the whole inter row space in about seven years (Pathiratna and Perera, 2003), and there is the possibility that roots from both rows intermingle in the inter row at this stage. In very wide inter-row spacings (18.0m) their abundance in the middle of the inter row was as low as 3.5 cm/1000 cm³, showing that very few roots have reached that distance in 5 years.

When the rubber trees grow older as seen in a 18 years old clearing, RLD in the 20cm depth was 217.5 cm/1000³. The distribution of fine roots at this stage was uniform over the whole inter row space and seem to dominate the whole area irrespective of the presence of intercrops (Pathiratna and Perera, 2006).

Effect fertilizer

Fine roots also proliferate fast and dense in the presence of applied organic manure or plant remains. When cow dung was added at the rate of 15,000 kg/ha as fertilizer to herbaceous medicinal plants grown in the inter row of a 4.5 years old rubber, their RLD increased to very high levels (1373.0 cm/1000 cm³) in positions close to rubber trees (2.1m from the rubber tree) within three months. This was a very large increase compared to plots where no organic fertilizer was added (Pathiratna and Perera, 2005). A similar situation has been reported for cacao, where large concentrations of rubber fine roots were found under cacao plants where there had been plenty of leaf litter (Schroth, 1999). This is an indication of possible enhanced root competition from rubber on intercrops fertilized with organic fertilizer.

Effect of intercrops or other vegetation

The presence of a vegetation or inter crops also affects the proliferation of fine roots of rubber in the inter row. Under a cover consisting of a mixture of *Pueraria phasioloides* and naturals, the RLD of fine roots was low and was 64.0 cm/1000³ in the 3rd year and it increased up to 140.8 cm/1000³ in the 7th year possibly due to the effect of the leaf litter collected and also due to the retardation of the growth of the cover crops due to shade. In the presence of cinnamon or coffee, RLD was low (26.6 and 16.8 cm 1000³) in the 3rd year but have recorded a 5.7 and 5.1 fold increase respectively in the 7th year possibly due to the same reasons (Pathiratna and Perera, 2003).

Competition from associated crops also influences the RLD of rubber. In the presence of a highly competitive forage grasses (eg. *Brachiaria brizantha*) as the inter crop the RLD in the 3rd year was low (44.7 cm/1000³), but with the smothering of grass due to shade RLD has increased 2.7 fold in the 7th year. Under such situations displacement of rubber roots due to competition from grass roots is also possible (Schroth, 1999).

Proliferation of fine roots above the soil surface

The situation of fine root proliferation on a rainy month after litter fall (wintering) in an old rubber clearing (18 years) with a diverse vegetations as under cover was different from the above. These observations were made at the RRISL sub station in Kuruwita, where the annual rain fall was between 3000mm- 4000mm. Under these environmental conditions in the clearing, the proliferation of fine roots was extensive and active on the surface and in the cover vegetation.

The moist conditions at the base of a tree protected with weeds also have favoured fine root proliferation in high densities over almost all decaying debris including the decaying bark of the base of the tree up to a height of about 20cm. It is expected that the micro climate here to be very favourable to their growth and prevent the dessication of the fine roots (Plate 1a). The special feature here is that on contact with decaying plant debris the fine roots have branched profusely to increase their length density increasing the surface area for absorption (St. John, 1983).

In the same area where the under-cover was mainly of a lush growth of ferns (*Nephrolepis* spp.) the proliferation of fine roots was extensive, proliferating on almost all dead plant material (Plate 1b). This is probably because of the favourable micro climate within the lush growth of ferns mixed with other weeds. The leaves, twigs and petioles falling from rubber trees were seen held loosely in between ferns and have been infested with fine roots and their density was very high ($2361.1 \text{ cm}/1000^2$). These fine roots seem to have made direct contacts with the debris forming a mat. The photograph (Plate 1b) shows a leaf petiole being completely covered with fine roots. The plant debris present in this area at the time of the assay was estimated to be around 3880-4000 kg/ha.

Fine root proliferation was high under a cover consisting of *Pueraria* and naturals in the same area. The RLD of fine roots above soil was $1014.0 \text{ cm}/1000^2$ and their growth was profuse beneath the cover exploring a thick layer of plant debris. Here too the fine roots seem to have made direct contact with decaying plant material (Plate 1c).

The RLD of fine roots was also high under rubber leaf litter collected after wintering and was $1723.5 \text{ cm}/1000^2$. In this area there was no ground cover except the fallen litter. The profuse growth of fine roots in the mass of decaying leaf debris was seen when the top layer of leaves were removed. Direct contact of fine roots with a decaying litter is clearly seen in the Plate 1d.

In the same experimental area with similar conditions, proliferation of fine roots were seen even under inter cropped cinnamon. The surface soil under cinnamon also had a profuse mass of fine roots in places covered with leaf litter. The root mass along with the plant debris here was about 3.0cm thick in most places and in such places the RLD on the surface was $806.5 \text{ cm}/1000^2$. Here too the only reason for the fine roots to grow there was the presence of the leaf litter (Plate 1e).

A similar situation was also seen in a 10 year old rubber clearing after the leaf fall on wintering. The collected leaf litter was mostly present on the bare floor and a mat of fine roots was seen under the leaves and their RLD on the surface was

284.3cm/1000². Unlike in other places some of the fine roots here were seen to be dry even at this stage due to their exposure with the removal of litter by the rains (plate 1f).

CONCLUSION

The proliferation of fine roots in soil of rubber plantations is affected by environmental conditions and agronomic practices and their length density is the main factor in absorption of water and nutrients. Fine roots can explore a large area of soil and their expansion depends on the extension of lateral roots. They also have to face competition from associated crops. The important aspect that needs attention here is the observation of their heavy proliferation in contact with decaying debris above the soil surface. Close observations also showed that there is direct contact between fine roots and decaying plant debris. These observations were made in a heavy rainfall area immediately after the rainy season and seasonal behavior of their proliferation needs attention.

The peculiar feature of the fine root proliferation seen in rubber is most probably an inherited character. Rubber (*Hevea brasiliensis*) is a tree that has been adapted to survive in the tropical rain forest environments of the Amazon. They belong to the distinctive characteristics of a peculiar system where almost all cations are stored in the living biomass and humus above soil and the functional peculiarity of recycling in the Amazon system is remarkable with a very high recycling index (Jordan, 1982). In other types of soil the mineral soil is an important component of the nutrient cycle (Jordan, 1982). The vital mechanism of nutrient conservation is located in the mat of roots and humus that occurs on or near soil surface (Jordan and Harera, 1981). This root mat is thick between 15-40 cm and it grows rapidly covering the freshly fallen leaves and prevents nutrient leaching. P³² tracer studies also have shown that the mycorrhiza fungi are one of the ways in which the nutrients are transferred from decomposing leaf litter to root (Stark, 1971). The important observation here is the heavy proliferation of fine roots on the decaying plant debris probably making direct contact with them. The association of endogone type of mycorrhiza on rubber roots (Wastie, 1965) is common and the vital role of these fine roots in making use of decaying litter seems obvious. They are most probably absorbing nutrients from these plant debris directly with the intervention of mycorrhiza, just as they do in the native Amazons. These features of fine root proliferation also represent the highly competitive nature of the rubber tree.

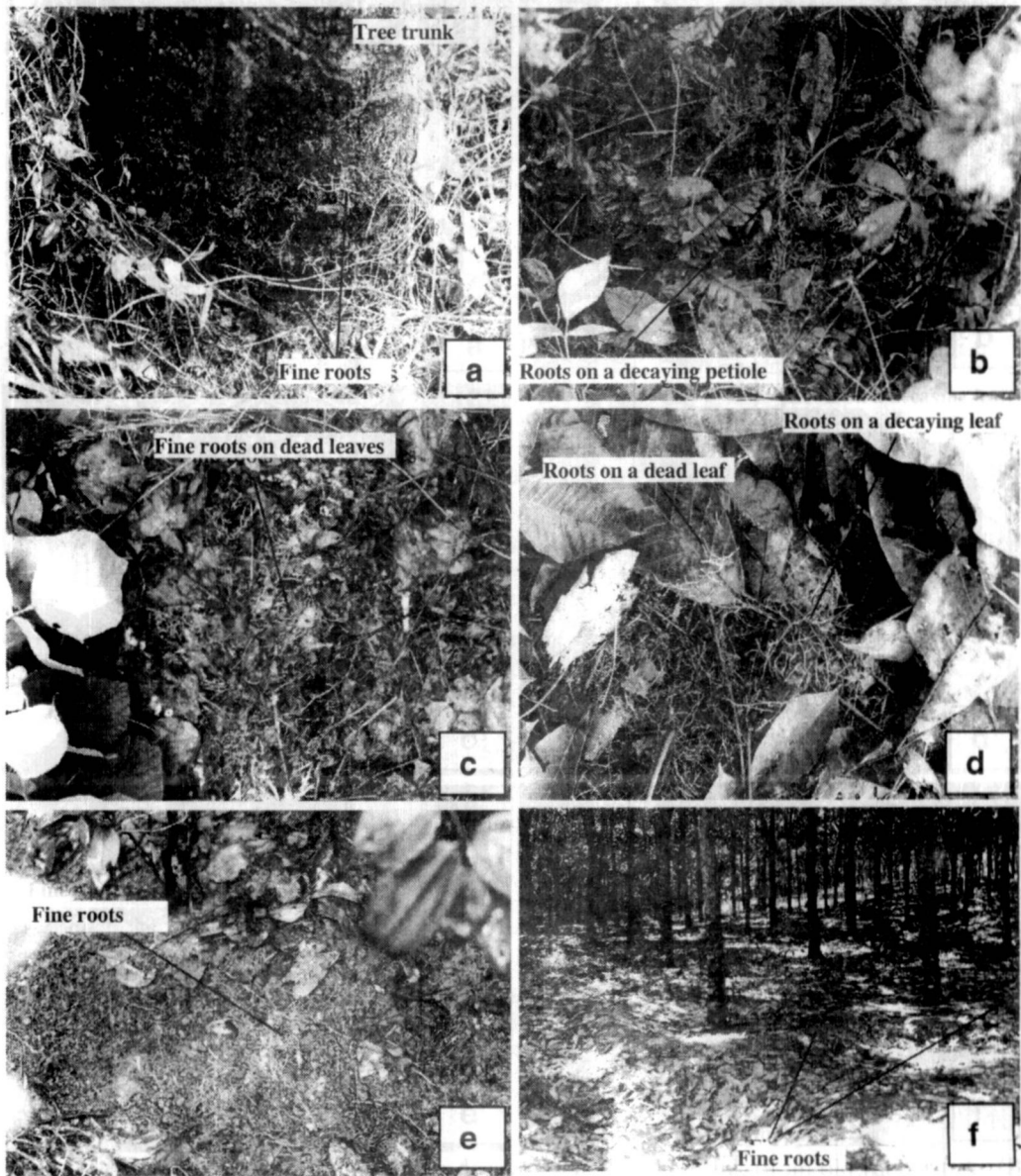


Plate 1. (A) Fine roots of rubber on the decaying bark of the trunk of an old rubber tree; (B) Fine roots on plant debris in a ground cover consisting of ferns (*Nephrolepis*) and other weeds, making direct contact with decaying plant material, note fine roots covering a decaying petiole; (C); Fine roots on plant debris under a mixed cover growing in a mature rubber clearing; (D) Roots on decaying rubber leaves, note the proliferation of fine roots on a leaf making direct contact; (E) Mass of fine roots on the floor of a plot intercropped with cinnamon; (F) Mass of fine roots on the floor under ten years old rubber. Photograph was taken after wintering and with the onset of rains. Fine roots were exposed because most of the leaf litter has been washed away by rain.

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