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PLANTING IN SMALL PITS: A COST EFFECTIVE TECHNIQUE FOR RUBBER IN DEEP SOILS

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Taking pits for planting rubber (*Hevea brasiliensis)* is one of the most labour intensive and expensive operations in rubber cultivation. A field experiment was conducted at the Central Experiment Station of Rubber Research Institute of India, Chethackal, Pathanamthitta District of Kerala (9°22'N and 76°50'E; 100 m MSL) during the period 2002 to 2008 with the objective to study the effect of pit size on root development and growth of rubber. The soil of the experiment area was sandy clay loam in texture with a depth of around 1m. The treatments were pits of dimensions 45 x 45 x 45 cm, 60 x 60 x 60 cm, 75 x 75 x 75 cm (standard pit size), 90 x 90 x 90 cm, 60 x 60 x 90 cm, 90 x 90 x 60 cm and small pits just sufficient to accommodate polybag plants. Observations over a period of six years indicated that the size of planting pits had no significant effect on development of tap root or lateral roots and growth of rubber. Where the soil was devoid of hard pans, irrespective of the size of the pits, the trees developed a long tap root of length 2.2 to 2.3 m, 6 years after planting. The cost analysis data showed that planting in small pits just sufficient to accommodate the polybag plants could save about 73 per cent of labour cost for pitting compared to the current recommended method of pit size 75 x 75 x 75 cm. The study indicated that planting rubber in small pits, when the soil depth is 1 m or more, did not affect the root development and growth of the plants and by following the method, considerable saving in cost of cultivation could be achieved.

Keywords: Cost of cultivation, *Hevea brasiliensis,* Planting pit, Root distribution

INTRODUCTION

Rubber (*Hevea brasiliensis)* is a forest tree, indigenous to the tropical rain forests of Central and South America. Being a tree crop, rubber possess a well developed tap root and lateral root system, capable of exploiting a large volume of soil to enhance the absorption capacity for both moisture and nutrients (Samarappuli *et al*.,1996). A properly developed root system improves the anchorage of plants in the soil and reduces the chances of wind damage by uprooting. The development and distribution of root systems depend on soil properties to a large extent and influence the growth and yield of plants. Webster and Paardekooper (1989) reported that in deep soils without impediments, the length of tap root and lateral roots of 3 year old rubber plants were 1.5 m and 6 to 9 m, while the respective length of roots of 7 to 8 year old plants were 2.4 m and over 9 m.

Pitting operations prior to rubber planting is carried out to generate favorable conditions for the early establishment and growth of the young plants (Punnoose and

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Lakshmanan, 2000). Size of the pits depends upon the nature of the soil. The standard size of the planting pit recommended for rubber is 75 x 75 x 75 cm in soils having a depth of minimum 1 m. In Kerala, acute labour shortage and high initial land preparation costs are the two major problems faced by rubber growers and around 60 per cent of the expenditure for land preparation is for pitting and filling of planting pits. No information on the influence of size of pits on the establishment and growth of rubber is available till date. Hence, a study was initiated with the objective to find out the effect of various dimensions of planting pits on root development and growth of rubber.

MATERIALS AND METHODS

The experiment was conducted at the Central Experiment Station of the Rubber Research Institute of India, Chethackal, Pathanamthitta district Kerala (9°22′N and 76°50′E and 100m MSL) during the period 2002 to 2008. The experiment was laid out in randomized block design with seven treatments and three replications. The treatments were pits with dimensions 45 x 45 x 45 cm, 60 x 60 x 60 cm, 75 x 75 x 75 cm, 90 x 90 x 90 cm, 60 x 60 x 90 cm, 90 x 90 x 60 cm and small pits just sufficient to accommodate polybag plants. Polybag plants of clone RRII 105 were planted during 2002 at a spacing of 4.6 x 4.6 m with a gross and net plot size of 25 and 9 plants respectively. The general cultural operations and fertilizer applications for rubber were done as per the recommendations of Rubber Board. Girth of rubber plants was recorded annually at a height of 125 cm from the bud union.

The mechanical and chemical properties of the soil in the experiment area were determined before the commencement of the experiment. Soil of the experiment area was sandy clay loam in texture with a depth of 1m and bulk density of 1.19 g/cm^3. The soil was high in organic carbon (1.68 per cent), medium in available P (11 mg/kg soil) and available K (84.1 mg/kg soil) and with a pH 4.87. Organic carbon was determined by Walkley and Black's method as described by Jackson (1973), available forms of P and K were estimated following the standard methodologies as described by Bray and Kurtz (1945) and Morgan (1941) respectively.

Morphological parameters of roots *i.e.* root length density (RLD) and root area (RA) of live roots were investigated using the image evaluation soft ware 'ROOTEDGE' (Kaspar and Ewing, 1997). Collection of root samples was carried out by soil core method. Three plants were selected from each plot and four root samples were collected from each plant. During the second year of planting root samples were collected 45 and 90 cm away from the base of the plant and in the sixth year of planting root samples were collected 2.3 m away from the plant towards the inter row area. Root samples from the core were washed and live and dead rubber roots were separated from roots of other plants. The live roots were scanned at 200 dpi (dots per inch) resolution and the images were analyzed.

For tap root studies twelve trees planted in the largest pits (90 x 90 x 90 cm) and smallest pits (pits just to accommodate polybag plants) were selected randomly. The girth of the selected trees varied from 42 to 48 cm. The length of the tap roots of the selected trees were measured from the tree base to the root tip by partially excavating the soil and not damaging the trees. In some plants restricted growth of tap root was observed due to the presence of hard pans below 1m soil and changes in morphology of such tap roots were studied. Casualty due to wind damage was recorded every year.

RESULTS AND DISCUSSION

Effect of pit size on lateral root distribution

The RA and RLD at 45 and 90 cm distance from the plant basins were not significantly influenced by pits of different dimensions in the second year of planting (Table 1). The highest root area was in the pit size 60 x 60 x 60 cm at both distances (45 and 90 cm) and the values were 3.44 and 4.11 cm^2 per 100 cm^3 of soil, respectively. In the case of root length density, the highest values recorded at both the distances were 18.21 and 22.58 cm per 100 cm^3 of soil in pits of 60 x 60 x 60 cm and 75 x 75 x 75 cm, respectively. In the sixth year of planting, root samples collected from the inter rows of the plants (2.3 m from plants) also showed that, RA and RLD were not significantly different in pits of different dimensions. The data indicated that the root penetration capacity and distribution of lateral roots of plants were not influenced by the size of the pits.

In rubber plantations, during the initial three years, the lateral root system concentrated close to the tree, and by 5^{th} to 7^{th} year, the root abundance was more in the inter row area (RRIM,1958). Srinivasan *et al*. (2004) reported that the lateral root intensity was maximum in the upper 10 cm soil layer. Soil physical factors such as soil structure and texture have significant influence on growth and development of roots. Increased root penetration is also associated with favourable soil structure with better aeration. Soils with a minimum depth of 1m and loamy texture are reported to be best

Table 1. **Effect of pit size on development of lateral roots**

Treatment	2^{nd} year				6^{th} year	
	Root area (cm^2/100 cm^3 of soil)		Root length density (cm/100 cm^3 of soil)		Root area (cm^2/100 cm^3 of soil)	Root length density(cm/100 cm^3 of soil)
	45 cm from plant	90 cm from plant	45 m from plant	90 cm from plant	2.3 m from plant	2.3 m from plant
Small pits to accommodate poly bag plants	2.38	2.33	17.71	8.31	3.36	16.73
45 x 45 x 45 cm	2.46	1.11	15.37	11.81	2.08	16.65
60 x 60 x 60 cm	3.44	4.11	18.21	21.29	2.65	23.74
75 x 75 x 75 cm	1.11	3.03	9.34	22.58	3.38	17.99
90 x 90 x 90 cm	2.12	1.53	12.11	11.97	2.40	20.58
60 x 60 x 90 cm	2.48	0.49	15.84	10.19	3.33	19.55
90 x 90 x 60 cm	1.43	2.12	13.30	14.73	3.46	25.75
SE	0.836	0.914	4.624	4.048	0.449	3.756
CD (=0.05)	NS	NS	NS	NS	NS	NS

suitable for rubber cultivation. Krishnakumar and Potty (1992) reported that *Hevea* could withstand soil physical conditions ranging from stiff clay with impeded drainage to well drained sandy loam and thrives well even in soils with clay content ranging from 14.8 to 71.7 per cent (Soong and Lau, 1977). Moreover, the high organic matter content decreases the penetration resistance of the soil when it is compacted (Ohu *et al*., 1985). Once plant roots penetrate a compact zone, the channels and macro pores formed by these roots generate sufficient path ways in the compact zone for subsequent plant rooting (Unger and Kaspar, 1994). In this experiment, sandy clay loam soil with high organic matter content and ample depth (around 1 m) have provided favorable soil conditions for better development of roots irrespective of the treatments with different size of planting pits.

Effect of pit size on tap root length

The growth of tap root was not influenced by the size of the planting pits. The results indicated that, when the soil was devoid of hard pans, trees planted in largest pits of dimension 90 x 90 x 90 cm and in small pits just to accommodate polybag plants, developed long tap roots of length 2.3 and 2.2 m respectively (Fig. 1). In both treatments, presence of hard pans 1 m below the soil layers restricted the growth of tap roots up to that point (Fig. 2). The roots grow freely in soils which possess a structure loose enough to be penetrated easily (Rolf, 1991) and the root growth is often depressed by the presence of hard pans or hard stones in the soil layers (Thaler and Page, 1999). The present data clearly showed that soil characteristics rather than the size of the planting pits, influenced the growth of tap root.

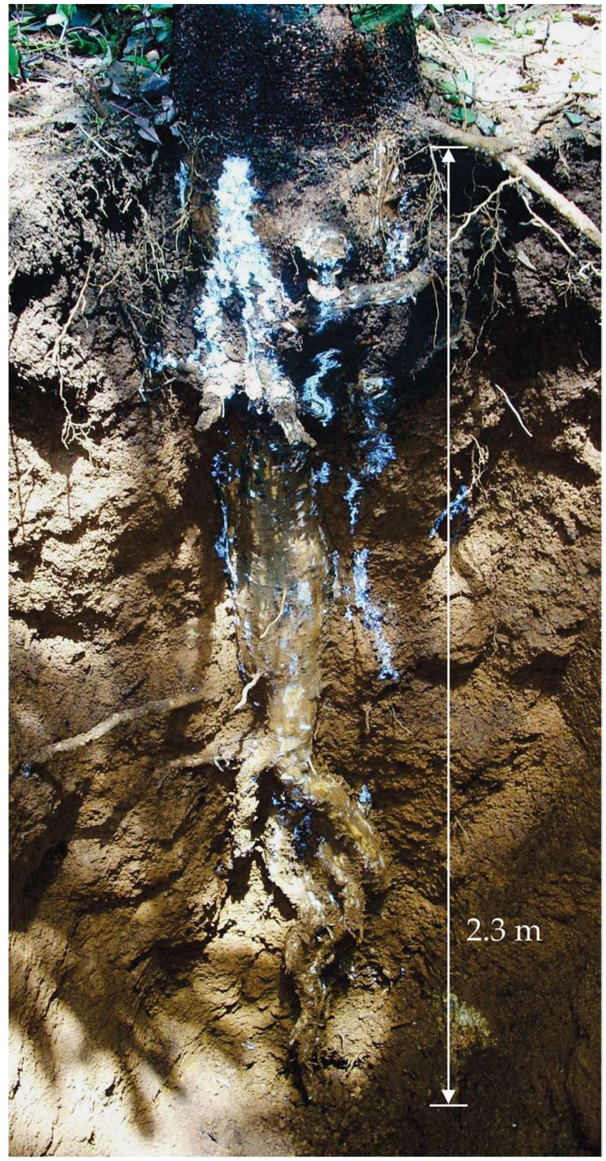

Fig.1. Growth of tap root in soils without obstruction/hard pan

Morphology of tap root

The tap root of plants grown in soils with hard pans or stones 1 m below were examined and morphological changes were observed. In some plants the single tap root was bifurcated at the point of compaction and extended laterally, while in some other plants the tap root was bent and fused just

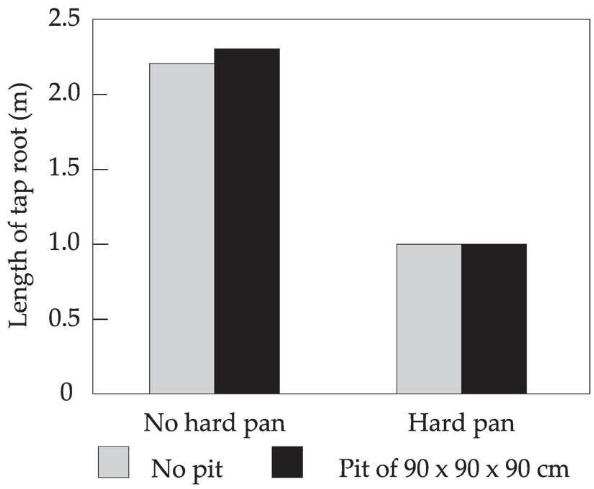

Fig. 2. Effect of hard pan and pit size on length of tap root

above the hard pan and had grown sideways (Fig. 3). Khuder *et al.* (2007) reported that the morphology and topology of the root system continue to change throughout the life of the tree largely depending on the soil conditions.

Effect of pit size on plant growth

The effect of different dimensions of pits on the growth of rubber plants from second to sixth year of planting is shown in Table 2. It was observed that the girth of rubber plants did not differ significantly among the treatments throughout the period of observation.

Bifurcation of tap root

Roots bent and fused above the hard pan

Fig. 3. Modification of tap root when there is an obstruction below 1 m soil depth

Table 2. **Effect of pit size on girth of rubber plants (cm)**

Treatment	Year after planting				
	2	3	4	5	6
Small pits to accommodate poly bag plants	6.98	12.77	19.98	28.01	38.90
45 x 45 x 45 cm	7.37	13.38	20.22	26.36	38.12
60 x 60 x 60 cm	7.31	13.34	20.66	28.16	39.66
75 x 75 x 75 cm	7.84	13.74	20.71	28.35	39.74
90 x 90 x 90 cm	7.74	13.33	20.40	26.22	38.08
60 x 60 x 90 cm	7.28	12.40	20.43	26.19	37.70
90 x 90 x 60 cm	7.12	12.68	19.52	26.58	36.83
SE	0.64	1.31	1.68	2.03	2.51
CD (P=0.05)	NS	NS	NS	NS	NS

The development and distribution of roots in the soil have a great influence on the growth of the plants. The lateral root spread and density were not influenced by different treatments and this might be the reason for the lack of influence of planting pit size on growth of rubber. George *et al*. (2009) reported that *Hevea* is a surface feeder and more than 55 per cent of the total feeder roots of rubber trees were concentrated in the top 10 cm soil layer. Since feeder roots are the major organs of water and nutrient absorption, even the presence of hard pans which restricted the tap root growth did not influence the growth of the plants. Clark *et al*. (2003) observed that the effect of mechanical impedance on growth of trees depends on the extent to which water and nutrients are limiting and how impedance affects the crops ability to gain access to water and nutrients. The peculiarity of the root system of rubber as well as the physico-chemical condition of the soil in the experiment area might have contributed towards the better nutrient uptake and crop growth resulting in the non-significant difference in plant growth among different treatments.

Wind damage

The planting pits of different dimensions did not influence uprooting of plants due to wind. In this study, the plants with shorter tap roots due to the presence of hard pans also survived and casualty of plants due to wind damage was not noticed.

Cost analysis

The cost involved for making standard pit (size 75 x 75 x 75 cm) and small pit just to

Table 3. **Cost of planting in pits of standard size and small size to accommodate the polybag (₹)**

Particular	75 x 75 x 75 cm pit	Small pit just to accommodate poly bag plant
Taking pit	42	-
Refilling	21	-
Planting	10	20
Total cost (₹)	73	20

Wage rate – ₹ 292/day

accommodate poly bagplant is shown in Table 3. The cost of labour was computed on the basis of the wage levels prevailing in the farm of Rubber Board. In rubber, pitting and refilling of planting pits are generally done one month before planting and at the time of planting, small pits are taken at the centre of the refilled pits to insert polybag plants. The cost involved for taking and refilling pit of size 75 x 75 x 75 cm was around ₹ 63/- and planting a polybag plant in this pit was ₹ 10/-. The total cost for pitting and planting was ₹ 73/- per plant and the total cost for one ha was ₹ 32,850/-. In the case of small pit (just to accommodate polybag plants) cost of pitting and planting was only ₹ 20/- per plant and the total cost was ₹ 9000/- per ha. About 73 per cent (₹ 23,850/- per ha.) saving in cost can be achieved by planting rubber in small pits which just accommodate polybag plants.

CONCLUSION

The present study showed that the planting pits of different dimensions did not influence lateral or tap root development and growth of plants in soils having a depth of more than 1 m. However, the presence of hard pans obstructed the tap root development irrespective of the size of the pits. Cost comparison showed that considerable savings can be made by planting in small pits. Planting in small pits (just to accommodate polybag plants) has other advantages such as reduced soil disturbance and erosion, and reduced man power requirement. Moreover, the planting operations can be completed in less time compared to the recommended method of planting, so that, survival rate of plants is more. Therefore, in soils with a depth of 1 m or more, rubber can be planted in pits just sufficient to accommodate the polybag plants.

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