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SPATIAL DISTRIBUTION OF ROOTS AND NUTRIENTS IN SOIL UNDER RUBBER PLANTATIONS IN TRIPURA

Varghese Philip, D.V.K.N. Rao, Mary Varghese, K.K. Vinod, Jacob Pothen and A.K. Krishnakumar

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Spatial distribution of roots and nutrients in the horizontal and vertical planes was assessed in a five year old rubber plantation in Tripura, India. Root concentration was seen in the top 18 cm layer. Horizontally the roots were found upto 200 cm away from the plant base. Nutrient concentrations were also higher in the top layer than in the lower layers. There was a positive correlation between available phosphorus and fine root concentration suggesting influence of phosphorus in root development.

Key words : Available nutrients, *Hevea brasiliensis*, Root length density, Spatial distribution, Tripura.

Varghese Philip (for correspondence), Rubber Research Institute of India, Kottayam - 686 009, Kerala, India; D.V.K.N. Rao, Mary Varghese, K.K. Vinod and Jacob Pothen, Rubber Research Institute of India, Regional Research Station, Agartala - 799 006, Tripura, India and A.K. Krishnakumar, Rubber Board, Kottayam - 686 002, Kerala, India.

INTRODUCTION

Hevea is a surface feeder with the feeder roots (rootlets) acting as absorbing sites of the root system (Soong, 1976). Root development in any plant is governed by factors such as nutrient availability, soil physical properties and genetic characters (Hamblin, 1985). Changes in the nutrient profile and root density has been reported within the rhizosphere in forest trees depending upon the throughfall, stem flow, litter accumulation, *etc.* (Parker, 1983). The rooting pattern of crops is also influenced by the depth of placement of fertilizers (Marshner, 1986). Drastic variation in the feeder root distribution of rubber ranging from 28 per cent in a clayey soil to 50 per cent in a sandy soil have been reported by Soong (1976) under Malaysian conditions.

The present study aims at evaluating the influence of the method of placement of fertilizers on the horizontal and vertical distribution of roots and nutrients in an Aquic Dystrochrept soil in Tripura with a view to facilitating formulation of appropriate agromanagement practices.

MATERIALS AND METHODS

The study was carried out in an already existing field experiment laid out in 1988 at Mohanpur, Agartala (23° 53' N; 91° 15'E; 30m MSL) with clone RRII 105. The soil was fine, mixed, hyperthermic Aquic Dystrochrept with bulk density of 1.53 g per cc. The spacing was 5 x 5 m and the experiment was laid out in a split plot design. The whole plot treatment was combination of the nutrients N, P_2O_5 and K_2O with Mg at the rate of 40:40:20:6 kg per ha (T) and 40:40:20 kg per ha (t) without Mg. The sub plot treatments were mthods of fertiliser application, *i.e.*, band application (d_0) around the tree in a band 30 cm from base, placement at 15 cm (d_1) and at 30 cm (d_2) depth at four points around the tree. The spatial aspects of the present study were taken as the sub sub plot treatments. The plantation was in the fifth year after planting at the time of sampling. The fertilizer treatments were imposed for four years from planting.

Root length density

Determination of root length density (RLD) was carried out using soil core break method (Escamilla *et al.*, 1991). Soil core samples were taken in November 1992, horizontally at 30, 75, 115, 160 and 200 cm away from plant base at right angles in two directions and vertically at 18, 36 and 54 cm sequentially at a horizontal distance of 30 cm in each direction using an 18 cm long core of radius 4.25 cm. Soil was then retrieved, washed and live rubber roots separated from dead roots. RLD was then calculated per unit volume of soil (cm per 1000 cm^3). Roots upto 0.85 mm in diameter were classified empirically as fine and those above as big roots.

Available nutrients

Soil samples were also collected simultaneously from all the treatment plots at 30, 110 and 220 cm horizontally at 18 cm depth and vertically at 18, 36 and 54 cm at a distance of 30 cm from plant base. Organic carbon was determined by Walkley and Black's method as described by Jackson (1973), available P using Bray II (Bray and Kurtz, 1945) and available K using Morgan's reagent (Morgan, 1941). Ca and Mg from the Morgan's extract was estimated using a Hitachi Z-600 Polarized Zeeman Atomic Absorption Spectrophotometer. The data were analysed statistically using a programme developed for the purpose.

RESULTS AND DISCUSSION

Data on the horizontal distribution of fine roots in the surface layer (0-18 cm depth) is furnished in Table 1. Though the root length density in the surface layer manifested different trends treatmentwise, no definite pattern related either to placement or manurial combination could be noticed. Nevertheless, the method of application was found to influence the concentration of roots as evidenced by the mean values of RLD. In general, there was an increase of RLD at horizontal distance of 200 cm from the plant base. In all the treatments the concentration of roots at 160 cm from plant base was less than that at 200 cm. Preceding the sampling, manurial application was done in the square patch, 200-250 cm away from the plant base as per recommendation. This along with the apparent proliferation of roots near the base in band application (d_0) points to root concentration near to loci of fertilizer application irrespective of horizontal distances.

Table 1. **Mean horizontal distribution of RLD of fine roots (cm/1000 cm^3)**

Treatment	Horizontal distance (cm) from plant base				
	30	75	115	160	200
Td_0	368.84	940.98	310.65	476.01	432.10
Td_1	299/09	487.27	375.36	646.69	988.39
Td_2	105.00	176.81	184.01	183.32	386.87
td_0	433.08	369.95	159.83	99.54	103.14
td_1	581.38	261.29	309.10	207.61	454.59
td_2	140.51	141.59	488.96	133.61	355.04

All values are non significant

Pooling the RLD values for the horizontal distances, the sub plot treatments, placement at 15 cm depth (Td_1 and td_1) showed the maximum value of RLD suggesting a better influence than band application (Td_0) and placement at 30 cm (Td_2).

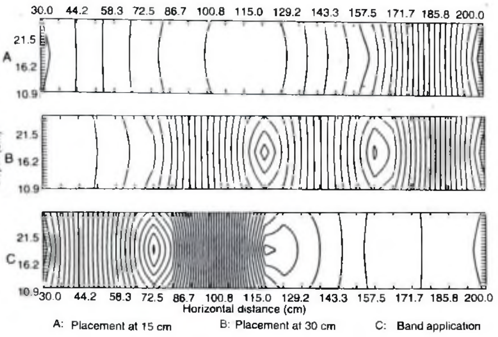

Fig. 1. Distribution pattern of RLD of fine roots in horizontal plane

Pattern of root distribution is shown in Figs. 1 and 2. The fine root distribution showed varied concentrations horizontally with the method of fertilizer application. Band application showed higher root concentration in the 75 to 115 cm distance from plant base compared to placement at 15 cm which showed higher root concentration between 160 to 200 cm. A lower concentration of big roots was seen at horizontal distances away from plant base. Congregation of feeder roots particularly at the fertilizer enriched area is reported by Bowen

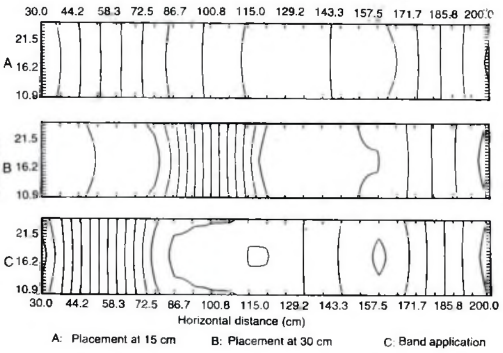

Fig. 2. Distribution pattern of RLD of big roots in horizontal plane

(1984). This is due to the stimulation of root growth by increased nutrient levels from fertilizer application.

The concentration of fine roots at 0-18 cm in the vertical direction was highest in placement at 15 cm depth (Table 2). There was a sharp decrease from surface (0-18 cm) to the sub-surface (18-36 cm) layer and the concentration in the surface layer varied from 33 to 76 per cent. The lowest value observed was in placement at 30 cm depth (Td_2). The results show that the subsoil was less explored by rubber roots. Soong (1976) also noticed a feeder root concentration of 28-50 per cent in the top 7.5 cm in Malaysian soil, which varied with the soil type. Analysis of variance of the data reveals that RLD of fine roots at 0-18 cm depth is significantly higher than those in 18-36 and 36-54 cm depths. RLD of the latter two were on par.

Table 2. **Mean vertical distribution of RLD of fine roots (cm/1000 cm^3)**

Treatment	Vertical distance (cm) at 30 cm from plant base		
	0 - 18	18 - 36	36 - 54
Td_0	364.84 b	130.07 d	303.99 bc
Td_1	299.09 bc	153.07 cd	103.87 d
Td_2	105.00 d	60.86 d	50.71 d
td_0	433.08 b	158.66 cd	74.10 d
td_1	581.38 a	74.25 d	103.26 d
td_2	140.51 d	175.99 cd	101.11 d

Means followed by a common alphabet are not significantly different at P = 0.05

LSD (P = 0.05)

1. Vertical distribution (VD) - 56.56
2. Placement x VD - 30.97
3. Fertiliser x VD - 79.99
4. Fertiliser x placement x VD - 138.55

The RLD of big roots compared to that of fine roots was extremely low. The distribution of big roots also showed that RLD was highest at 200 cm away from plant base (Table 3). The general trend of hori-

Table 3. **Mean horizontal distribution of RLD of big roots (cm/1000 cm³)**

Treatment	Horizontal distance (cm) from plant base				
	30	75	115	160	200
Td_0	17.08	35.44	27.07	42.07	24.47
Td_1	24.91	50.79	65.74	33.87	55.07
Td_2	3.82	12.00	26.10	35.61	41.98
td_0	17.86	27.01	34.83	26.67	32.31
td_1	15.47	36.81	43.47	65.64	82.72
td_2	14.05	10.52	49.78	42.14	51.98

LSD (P = 0.05) - Horizontal distribution - 16.41

zontal distribution indicated that RLD was lowest at the base. Significant increase in RLD was seen away from the plant base. The vertical distribution also indicated a decrease in the lower layers in general (Table 4) eventhough the treatments did not significantly influence the RLD.

The distribution of available nutrients is summarised in Tables 5 and 6. Analysis of variance revealed no significant treatment variation in horizontal distribution of organic carbon, available P, K, Ca and Mg. However, the variation in pH was significant horizontally with base of the trees recording lowest values and a gradual increase with horizontal distance. The lowering of pH at the base of the plant can be attributed to increased leaching at the base of the plant due to stem flow. Similar observation has been reported in pine (Parker, 1983).

Table 4. **Mean vertical distribution of RLD of big roots (cm/1000 cm³)**

Treatment	Vertical distance (cm) at 30 cm from plant base		
	0 - 18	18 - 36	36 - 54
Td_0	17.08	4.16	21.05
Td_1	24.91	19.67	15.81
Td_2	3.82	0.97	8.81
td_0	17.86	3.42	5.14
td_1	15.47	8.51	10.00
td_2	14.05	30.07	27.78

All values are non-significant

Table 5. **Horizontal distribution of soil available nutrients (mg/100 g/soil) and pH**

Treatment	Distance from base(cm)	OC (%)	P	K	Ca	Mg	pH
Td_0	30	0.97	0.53	2.55	7.37	7.75	4.42
	110	1.01	0.66	2.65	12.25	10.12	4.68
	220	1.18	0.31	2.55	8.50	8.87	4.80
Td_1	30	1.49	0.04	3.35	8.62	13.25	4.60
	110	1.81	0.02	3.15	9.12	23.50	4.84
	220	1.93	0.06	3.45	10.37	14.00	4.87
Td_2	30	1.74	0.15	3.90	6.37	10.25	4.73
	110	2.43	0.31	2.85	9.12	23.50	4.84
	220	1.06	0.23	2.90	6.62	10.25	4.87
td_0	30	0.98	0.24	3.85	9.75	12.65	4.48
	110	0.91	0.25	4.40	12.87	16.37	4.69
	220	0.93	0.09	4.05	12.50	18.00	4.84
td_1	30	2.11	3.41	2.50	27.37	17.11	4.80
	110	1.02	0.20	2.60	8.37	8.62	4.78
	220	1.13	0.25	2.65	11.75	11.87	4.90
td_2	30	1.03	0.28	3.40	8.25	9.12	4.69
	110	0.96	0.34	4.00	13.75	14.50	4.83
	220	0.86	0.13	4.10	13.87	20.87	4.86
LSD(P=0.05)	ns	ns	ns	ns	ns	ns	0.058

There is a positive correlation between organic carbon and RLD (r=0.591*). Vertically, the organic carbon showed a decline while moving towards deeper layers. This may be attributed to higher organic matter accumulation through litter decomposition in the surface layer (Kumar *et al.*, 1991). An increase in organic carbon content with the increasing root concentration has been reported through discharge of sloughage and organic acids (Mengel and Kirkby, 1987).

The observed P level in the soil under study was low. The extreme deficiency of P in soils of North East India has already been reported (Kumar and Potty, 1989).

Table 6. **Vertical distribution of soil available nutrients**

Treat-ment	Depth (cm)	OC (%)	Nutrients (mg/100 g soil) P	K	Ca	Mg	pH
Td_0	0-18	0.97	0.53	2.55	7.37	7.75	4.42
	18-36	0.78	0.18	2.75	2.50	4.50	4.22
	36-54	0.65	0.25	2.90	3.62	7.25	4.31
Td_1	0-18	1.49	0.04	3.35	8.62	13.25	4.60
	18-36	1.29	0.01	3.00	7.62	12.12	4.67
	36-54	1.39	0.01	2.80	5.25	10.50	4.72
Td_2	0-18	1.74	0.15	3.90	6.37	10.25	4.73
	18-36	1.25	0.33	3.75	21.25	14.25	4.61
	36-54	1.25	0.11	3.05	4.62	9.00	4.48
td_0	0-18	0.98	0.24	3.85	9.75	12.62	4.48
	18-36	0.97	0.31	3.05	4.62	8.87	4.62
	36-54	1.07	0.20	2.65	3.87	7.62	4.63
td_1	0-18	2.11	3.41	2.50	27.37	17.11	4.80
	18-36	0.97	0.31	3.05	4.62	8.87	4.62
	36-54	0.81	0.14	2.25	3.25	6.37	4.49
td_2	0-18	1.03	0.28	3.40	8.25	9.12	4.69
	18-36	0.95	0.19	2.75	4.57	7.50	4.58
	36-54	0.81	0.14	2.25	3.87	6.50	4.56
LSD (P=0.05)							
1. VD		0.30	0.29	5.47	2.91	ns	ns
2. F x P		0.68	ns	ns	ns	ns	ns
3. F x VD		0.44	ns	7.74	ns	ns	ns
4. P x VD		0.53	ns	ns	ns	ns	ns
5. F x P x VD		1.51	ns	ns	ns	ns	ns

VD = Vertical distance; F = Fertilizer; P = Placement
ns = non-significant

The vertical distribution of P was significantly higher at 0-18 cm than at 18-36 and 36-54 cm. There was no significant difference between concentration of P at 18-36 and 36-54 cm depths. Similarly the concentration of K and Ca was also significantly higher in the 0-18 cm depth than their concentration at lower layers. The distribution of Mg as well as pH showed no significant variation vertically.

Correlation studies of RLD *versus* available nutrients showed a positive correlation between RLD of fine roots and horizontal distribution of P ($r=0.49^{**}$), showing an active role of phosphorus in the development of fine roots. RLD also showed positive significant correlation with P in the vertical plane ($r=0.63^{**}$). Positive correlation ($r=0.59^{**}$) between RLD in the horizontal plane and organic carbon was also recorded. Similarly, significant correlation existed between RLD of fine root and vertical distribution of Ca ($r=0.34^{*}$). A positive role of calcium ions in feeder root development was described by Pilet (1996).

CONCLUSION

Fine roots and nutrient concentration are more in the surface layer than in the deeper layers in rubber soils. Horizontal root concentration can be seen upto 200 cm and vertically the concentration was more upto 18 cm depth. Efficient utilisation of nutrient inputs can be achieved by applying nutrients in this region. Since there was no appreciable difference between band application and placement of fertilisers at 15 cm depth, the former can be adopted as a convenient management practice.

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