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MOVEMENT OF APPLIED PHOSPHORUS IN RUBBER (*HEVEA BRASILIENSIS*) GROWING SOIL

Phosphorus, unlike nitrogen and potassium is generally considered to be immobile in soil. Crop removal of P is low, and the utilization of surface-applied P by the crop depends on the extent of its translocation to the root zone (Malhi *et al.*, 1992). In the acid soils of the traditional rubber(*Hevea brasiliensis*) growing areas of India, P fixation is reported to be high due to the presence of large proportion of Fe and Al oxides and hydroxides (Karthikakuttyamma *et al.*, 1991). Hence rock phosphates are recommended as the major phosphorus fertilizer for *Hevea*. Phosphorus in rock phosphate is water insoluble, and is reported to be slowly available under the acid pH of rubber growing soils (Khasawneh and Doll, 1978; Syamala *et al.*, 1999).

Surface broadcasting in between two rows of trees is the general method of fertilizer application in mature rubber plantations. There are conflicting reports about the movement of surface-applied P into the subsoil. Guertal *et al.* (1991) studied the P retention characteristics of Ohio soils cultivated with corn and reported that P accumulates in the surface layer of non-tilled soils. Fertilizer P applied to an acidic, medium textured soil cropped with Timothy grass for 26 years could penetrate into the subsoil even when applied at low rates, and the rate of translocation was related to the rate of P application (Richards and Belanger, 1989). On black chernozem soils of Alberta, most of the surface-applied P could be recovered from soil as extractable P remained in the top 5 cm layer, and the depth of movement increased with P application rate, but no P was recovered below 15cm (Malhi *et al.*, 1992). In oxysol under arecanut, annual application of superphosphate enriched subsoil P level up to 1 m depth (Mohapatra, 1991). White (1996) studied the effect of surface-banding on the movement of P into a Vienna loam soil and observed rapid downward movement of P in the field. However in compacted laboratory columns, most of the applied P was retained in the upper 4cm segment. The present study was undertaken to quantify the availability of P at different depths of the soil, in a mature rubber plantation, at fixed time intervals after P fertilizer application.

An experiment was conducted using PVC columns, 60cm long and 8 cm diameter. Sixteen columns were filled with a sandy clay loam soil from a mature rubber plantation in Koney Estate, Kerala State. The soil was sampled depth-wise and filled in the proper depth order into the columns. Considering 20 per cent of the area as the effective area of fertilizer application, rock phosphate at the rate of 30kg P_2O_5 per ha (420mg/kg soil) was applied on the top of the soil column. Deionised water was added from the top to maintain the soil moisture at field capacity. Four columns each were withdrawn on 5, 10, 15 and 30 days after fertilizer application. The columns were segmented at every 10cm, soil samples collected, processed and analyzed for available P by Bray II method (Bray and Kurtz, 1945).

Soil samples were collected from two field experiments, on rate of P application in mature rubber, conducted in sandy clay loam soils belonging to the ultisol order. Experiment 1 located at Koney Estate, Koney, in Pathanamthitta district in Central Kerala was initiated in 1986 and the treatments were applied continuously for 14 years. The treatments included four levels of broadcast application of P_2O_5, *viz.*, 0, 15, 30 and 45 kg per ha with five replications in a randomized block design. Experiment 2 located at Boyce Estate, Mundakayam, in Kottayam district in Central Kerala was initiated during 1997 and the P treatments were supplied for 4 years. Treatments included five levels of broadcast application of P_2O_5 *viz.*, 0, 10, 20, 30 and 40 kg per ha, replicated four times in a randomised block design.

Soil samples were collected during

2000, at four depths *viz.*, 0-10, 10-30, 30-45 and 45-60cm, once before and three times after (15, 30 and 60 days) fertilizer application from the two field experiments and analysed for available P using Bray II extractant (Bray and Kurtz, 1945). The extracted P was estimated on a spectrophotometer using molybdophosphoric blue color method.

Table 1 shows the quantity of available P in mg per 100g, recovered from soil samples at different depths of the column at definite intervals of time. The results show that most of the applied P was concentrated in the 0-10cm depth of the column, even after 30 days. Compared to initial samples (before fertilizer application), significant increase in available P was observed at all depths of the column as a result of fertilizer application. The quantity of available P recovered decreased significantly down the column up to a depth of 40cm. In the surface layers, highest availability was observed 5 days after application, whereas in deeper layers, *i.e*, below 20cm, availability increased up to 15 days and decreased thereafter probably due to the precipitation of P by iron and aluminium oxides and hydrous oxides.

Table 1. **Available P(mg/100g) at different depths of the column, at different time intervals after fertilizer application**

Depth(cm)	Days					
	0	5	10	15	30	Mean
0-10	2.27	10.03	6.06	7.03	6.35	5.08
10-20	1.02	3.97	2.22	2.53	3.18	2.60
20-30	0.79	2.10	1.26	1.24	1.03	1.28
30-40	0.38	0.63	0.69	0.80	0.53	0.61
40-50	0.29	0.57	0.60	0.70	0.48	0.53
50-60	0.15	0.57	0.55	0.79	0.40	0.49
Mean	0.82	2.88	1.90	2.17	2.00	

CD ($P \leq 0.05$) for days = 0.27; depth = 0.29; days x depth = 0.66

Fertility status of the two experimental fields is shown in Table 2. In both the areas, soil was acidic in reaction and showed sandy clay loam texture. Organic carbon, available P and K were in the medium range.

Table 2. **Fertility status of the experimental fields**

Location	OC (%)	pH	Av.P	Av.K	Texture
			(mg/100g soil)		
Koney estate	1.25	4.94	1.51	12.35	scl
Boyce estate	1.43	4.60	1.07	6.95	scl

scl: sandy clay loam

Available P recovered from different depths of the soil at varying intervals of time and levels of application in Experiment 1 is shown in Table 3. Compared to initial values, significant increase in available P was observed at all the three levels of applied fertilizer in the 0-10cm depth, but among the levels no significant difference was observed. Though marginal increase in available P was noted after 30 and 60 days of fertilizer application, the increase was not significant. Only P application at 45 kg P_2O_5 per ha showed significant change in available P at 30 days, which was maintained upto 60 days also, while the lower levels had no such effect.

A sharp decrease in available P content was observed at 10-30cm depth compared to the 0-10cm layer. In the control plot, the available P decreased from 2.22 mg to 0.80 mg per 100 g. The same trend was observed in the fertilizer applied plots also. However, all the three levels of applied fertilizer showed significant increase in available P compared to control, but were statistically on par. At this depth, significant increase was noted only at 60 days from application. Among levels, 30 kg P_2O_5 per ha showed significant increase in available P at 60 days and 45 kg P_2O_5 per ha at 30 days after fertilizer application. This is in agreement with the earlier reports by Richards and Belanger (1989) and Malhi *et al.*,(1992) that translocation of P is higher at higher rates of fertilizer application.

Further decrease in available P was observed at 30-45cm depth. In the control plot, the value diminished to 0.34 mg per 100g and the same trend was observed in the fertilized plots also. At this depth, levels of fertilizer application and period of sampling had no effect on available P content. No signifi-

Table 3. **Available P (mg/100g) at different depths of the soil**

Soil depth	0-10 cm					10-30 cm					30-45 cm					45-60 cm				
Levels (kgP_2O_5/ha)	0	15	30	45	Mean	0	15	30	45	Mean	0	15	30	45	Mean	0	15	30	45	Mean
Experiment 1																				
Initial	2.22	3.20	3.06	3.18	2.92	0.80	0.98	0.88	0.93	0.90	0.34	0.36	0.38	0.3	0.35	0.16	0.19	0.18	0.2	0.18
15 days	2.03	3.20	3.45	3.58	3.07	0.77	1.04	1.03	1.12	0.99	0.38	0.40	0.41	0.43	0.40	0.18	0.21	0.22	0.23	0.21
30 days	2.27	3.25	3.48	3.74	3.19	0.81	0.88	0.93	1.13	0.94	0.36	0.36	0.38	0.39	0.37	0.20	0.20	0.22	0.22	0.21
60 days	2.31	3.26	3.49	3.97	3.26	0.65	0.98	1.20	1.31	1.04	0.36	0.38	0.40	0.40	0.38	0.15	0.21	0.21	0.22	0.20
Mean	2.21	3.23	3.37	3.62		0.76	0.97	1.01	1.12		0.36	0.38	0.38	0.39		0.17	0.2	0.21	0.22	
CD(P=0.05)levels	0.41					0.19					NS					NS				
CD(P=0.05)days	0.23					0.09					0.06					0.04				
CD(P=0.05)LxD	0.44					0.19					0.12					0.09				
Experiment 2																				
Initial	1.53	1.57	1.41 1.75	1.55	1.56	0.60 0.35	0.70	0.85	0.79	0.66	0.38	0.23 0.25	0.43	0.20	0.30	0.20	0.18	0.20	0.20	0.18 0.19
15 days	1.68	1.66	1.90 2.18	2.34	1.95	0.77 0.41	0.73	0.90	0.90	0.74	0.36	0.28 0.40	0.45	0.48	0.39	0.21	0.18	0.22	0.23	0.30 0.23
30 days	1.70	1.90	2.17 2.68	2.26	2.14	0.66 0.44	0.80	1.18	1.41	0.90	0.38	0.29 0.41	0.50	0.57	0.43	0.21	0.21	0.23	0.23	0.24 0.22
60 days	1.46	1.70	2.17 2.39	2.30	2.00	0.42 0.39	0.70	0.95	1.07	0.71	0.33	0.25 0.37	0.31	0.44	0.34	0.13	0.15	0.15	0.16	0.27 0.17
Mean	1.59	1.71	1.91 2.25	2.11	-	0.61 0.40	0.73	0.97	1.04	-	0.36	0.26 0.36	0.42	0.42	-	0.19	0.18	0.20	0.21	0.21 -
CD(P=0.05) levels	0.30					0.12					0.11					0.07				
CD(P=0.05) days	0.17					0.09					0.06					0.04				
CD(P=0.05)LXD	0.37					0.20					0.13					0.08				

cant change in P content was observed as a result of fertilizer application at the 45-60 cm depth.

The quantity of available P recovered from different layers of the soil at varying intervals of time in Experiment 2 is also shown in Table 3. Significant increase in available P content in 0-10cm layer was observed in plots, which received 20, 30 and 40 kg P_2O_5/ha whereas 10 kg/ha was on par with control. Significant increase in P availability was observed from 15 days itself for all levels of P application, unlike in the case of Experiment 1 where such effect was observed only at 30 days.

Reduction in P availability was observed in the 10-30cm layer compared to 0-10cm layer of the soil as with the case in Experiment 1. Compared with the control, application of 30 and 40 kg P_2O_5/ha significantly increased the available P content at this depth from 15 days onwards while 10 and 20 kg/ha were comparable to control.

The recovery of available P was further reduced at 30-45 cm depth and no significant change was observed among different levels of applied P. Although significant increase in available P was observed after 15 and 30 days of fertilizer application, this was not maintained at 60 days. At 45-60cm depth, available P status was still lower and treatment differences were not significant.

Both column study and field experiments indicated similar trends of P movement. In the columns, though increase in available P up to 60cm depth was noticed, most of the available P was concentrated in the 0-10cm layer, indicating low mobility of P. In the field experiments also, applied P moved down only up to 30cm and major portion of the available P remained in the 0-10cm layer. In the case of mature rubber the feeder roots are concentrated in the surface layer. Philip *et al.*(1996) reported that the vertical distribution of feeder roots is higher at the 0-18 cm layer of the soil. Hence the roots are supplied with adequate quantities of P from applied sources and this may be one of the reasons for the adequate P nutritional status of the rubber leaf even in low P soils.

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