Reprinted from

Proceedings of the International Symposium on
Soil Fertility Evaluation, New Delhi

Volume 1, 1971

Determination of Active Root Distribution of *Hevea brasiliensis* using Radioactive Phosphorus

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(Proc. int. Symp. Soil Fert. Evaln., New Delhi, 1, 1971)

Determination of Active Root Distribution of *Hevea brasiliensis* using Radioactive Phosphorus

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ABSTRACT

Phosphorus uptake by Hevea *seedlings from nutrient solution and by mature* Hevea *trees from the soil was studied using P^{32} tracer. The usefulness of leaves and latex for detecting P^{32} uptake by* Hevea *was compared. Latex assay was found to be more convenient and reliable than leaf assay and was used to determine the relative distribution of active roots of Hevea in three different soil zones under study. Maximum root activity was found to be in the first 12 feet from the trees, reflecting past cultural practices.*

Injection of P^{32} into the trunk of a mature rubber tree showed translocation into the leaves and latex but no radioactivity could be detected in the roots or in the surrounding soil indicating that trunk injection was unsuitable for estimating the distribution of active roots in soil.

The quantity, size and zonal distribution of roots of *Hevea* in different Malayan soils have been measured by manual excavation methods (Rubber Research Institute of Malaya 1967, 1958; Soong, 1970). Radiotracer techniques, on the other hand, allow *in situ* estimation of the activity of roots in taking up nutrients from the soil (Lott *et al.* 1950; Hall *et al.* 1953; Boggie *et al.* 1958; Oksbjerg 1958) with minimal soil disturbance. No *in situ* measurements of the uptake of nutrients from different soil zones by rubber have been made hitherto. This work describes studies in the use of radiophosphorus to measure the relative uptake of nutrients by *Hevea* from different soil zones.

EXPERIMENTAL

Three studies were conducted:

(i) Uptake of P^{32} from a nutrient solution in pots by young *Hevea* seedlings and its distribution in the leaves,

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* Rothamsted Experimental Station, Harpenden, Herts., England.

(ii) Injection of P^{32} into the trunk of a mature *Hevea* tree and its distribution in leaves, latex, roots and surrounding soil, and

(iii) Uptake of P^{32} applied to soil and its distribution in leaves and latex of mature *Hevea* trees.

(i) *Uptake from nutrient solution in pots*

The pots contained 25 litres of nutrient culture solution which was continuously aerated and whose volume was topped up daily with ion-free water (Bolle-Jones 1956). The tracer was 1 mC of P^{32} and uptake was followed in the leaves of the young seedlings by punching leaf discs (1.5 cm in diameter) regularly every 3-4 days. The leaf discs were dried between two filter papers in an oven at 80°C. The dried leaf discs were secured by quick-drying glue to planchettes and P^{32} activity counted on a Panax P 7702 A Autoscalar using an end-window GM tube.

(ii) *Trunk injection*

The method of injection described by Roach and Roberts (1945) had been shown to be unsatisfactory with *Hevea* (Shorrocks, private communication). A modification based on Postlethwait and Rogers (1958) was therefore introduced. A hole 2 inches deep at a height of 50 inches from the ground was drilled into a 12 year old budded tree (clone RRIM 513) using an Irwin auger bit. The drilling was done in water to prevent air locks and sealing was with a polypropylene plug through which a lead was connected with a water reservoir. The tracer (3 mC of P^{32} in 0.1 mg P in 10 ml water) was placed in the hole before connecting the water reservoir.

Leaf samples were collected at weekly intervals from different positions on the tree ; from the top where leaves received maximum sunlight, from the base where leaves were in the shade and from intermediate positions of the canopy. The leaves were dried and ground (< 0.5 mm), packed into a liquid detector GM tube and the activity measured. The sufficiency of leaf material available permitted the use of this liquid detection procedure, with which higher counts were obtained than with the leaf discs described earlier.

Latex samples were representative of normal collection and were preserved by addition of a formaldehyde-sodium carbonate anti-coagulant solution (Cook 1960). Radioactivity in latex was measured in the liquid detector already described, using 10 ml of samples. Soil samples were taken from different points around the tree, dried and ground (< 0.2 mm). Radioactivity was measured as with powdered

leaf material. Roots were separated mechanically from the soil and ground (< 0.2 mm) and radioactivity was also measured as with powdered leaf material.

(iii) *Uptake from soil application*

Uptake was measured separately for the 0-6″ and 6-12″ soil layers and for different distances from the tree. Labelling with tracer was done in the inter-row areas. The tracer for each site was 2 mC P^{32} in 5 mg P in 300 ml water and was distributed over 10 holes about 6″ apart, each hole receiving 3 doses of 10 ml of tracer solution from a hypodermic syringe. 2″ layers of soil were returned to the holes between doses and the holes were re-filled to ground level after completing the operation. For the 6-12″ application, a polythene tube was attached to the syringe so as to avoid P^{32} contamination of surface soil.

In one experiment on a granite-derived sandy clay loam soil (Rengam series), P^{32} uptake was measured weekly by examining radioactivity in leaves (top-light, low shade and middle leaves being collected separately) and in latex. The results were used to compare the suitability of leaf and latex assay for detecting P^{32} uptake. In subsequent studies to compare P^{32} uptake from three different soils only latex sampling collected at fortnightly intervals was used, for reasons given later in the discussion. The three soils were a Rengam series, a Sungei Buloh series (alluvial coarse sandy soil) and a Munchong series (shale-derived sandy clay soil) and supported mature trees of similar age (12 years) and of similar planting material (RRIM 513, RRIM 519 and RRIM 623 clones respectively), receiving a uniform cultural treatment. The planting distances were 11, 20 and 12 feet apart on the rows which were 22, 20 and 24 feet apart, for the three soils respectively.

In all the above studies, the usual corrections for lost counts decay and background activity were made to standardise the radioactive counts.

RESULTS AND DISCUSSION

P^{32} uptake by Hevea *from nutrient solution in pots*

The variability in P^{32} content between leaf discs from a single leaflet was small (generally < 10%) when the count rate was about 5000 counts/100 secs. This count rate was reached about 1 week after labelling. A random two-fold variation was observed between P^{32} content of different leaves in any one whorl. The mean value

in any one whorl (6-10 leaves) was therefore used to study differences in P^{32} content in leaves of different whorls, one leaf disc being taken per leaf at each sampling. The P^{32} content of the leaves increased rapidly in a linear fashion in the first 10-12 days, after which the rate of P^{32} uptake was much reduced (Figure 1); the P concentration in the nutrient solution dropped from 32 ppm to 8 ppm during this 10 day period. Of the four plants examined, the top-most whorl of three plants had the lowest P^{32} content while differences in P^{32} content of whorls of the remaining plant were negligible, thus showing no definite pattern in P^{32} content of the different whorls.

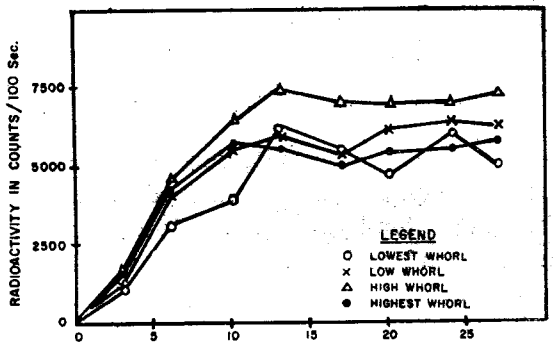

Fig. 1. P^{32} content of leaves of a *Hevea* seedling showing potential variation in P^{32} uptake

Translocation of P^{32} after injection into the trunk of Hevea *tree*

The trunk injection of P^{32} induced high activity in leaves and latex but no P^{32} was detected in the roots, in the surrounding soil or in adjacent trees. Hence this method of P^{32} application could not be used to measure distribution of active roots of *Hevea* in soil unlike those for wheat reported elsewhere (Racz *et al.* 1964).

The P^{32} was detected in both leaves and latex at the first sampling done 3 days after the P^{32} injection of the tree. Radioactivity in latex was very much higher than that in leaves (Table 1) for the same volume of material. The maximum content of P^{32} was reached in about 2 weeks in the leaves while radioactivity in latex was at a maximum around the 4th week. These results are in agreement with the movement of nutrients upwards in the xylem flow and subsequently downwards through the phloem. At maximum P^{32} activity (2 weeks after tree injection), low shade leaves had 3 times more radioactivity than middle leaves which had 4 times more activity than top light leaves.

TABLE 1

Radioactiivty in latex and leaves of Hevea *following trunk injection of* P^{32}

Time after injection (days)	3	7	14	28	35
Material	radioactivity in counts/100 sec.				
Latex	15,800	26,000	33,300	47,300	42,900
Leaves					
top light	310	400	250	200	120
middle	420	910	970	910	370
low shade	1200	720	3000	1700	1500

Uptake of P^{32} *by* Hevea *from soil application*

The Rengam series study showed the positional variation of P^{32} activity in leaves observed in the pot investigation to be even greater in the field ; the P^{32} content of leaves of any particular tree showed large fluctuations between different samplings, giving a haphazard uptake pattern. With latex, the time delay between sampling and assay that is unavoidable with leaf assay was avoided, hence reducing the extent of P^{32} decay after sampling and allowing more sensitive assay of the radioactive content of the sample. Also, the P^{32} uptake proved satisfactorily regular showing a continuous increase in P^{32} content with time. In consequence latex sampling was selected for subsequent studies. Latex assays achieved maximum sensitivity 4-6 weeks after the tracer application to soil.

Fig. 2 represents the uptake of P^{32} from various soil zones by mature *Hevea* trees in three different soils at 6 weeks after application. Each value is a mean of a triplicate treatment. Large variations were found between the replications and even 10 fold differences were encountered between the replicates. Nevertheless the levels of activity were sufficiently different for the various distances and soils to allow a general comparison of the use of the techniques.

All the three soils showed maximum uptake within the first 12 feet from the tree. Uptake was small from 20 feet onwards. The results indicate that maximum root activity is concentrated up to 12 feet although some root activity is found at least up to 20 feet. It appears that the normal practice of fertiliser application which is to broadcast fertiliser in a band of about 3 to 9 feet from the tree, has encouraged rooting activity in this region.

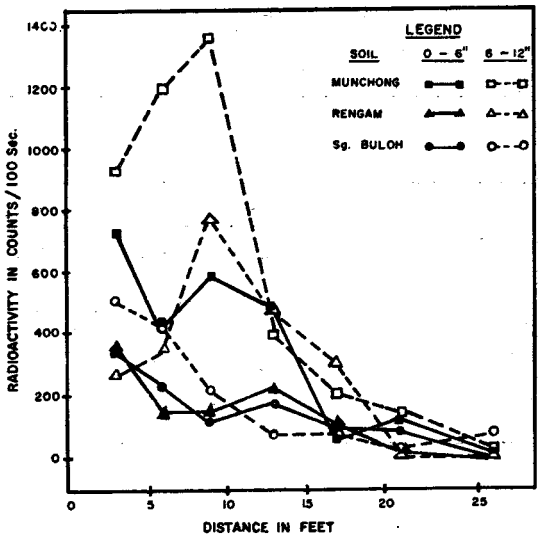

Fig. 2. Uptake of P^{32} by *Hevea* from surface soils and sub-soils at various distances from tree

It appeared that P^{32} uptake was at least as high from sub-soil than top-soil. This result is in disagreement with physical root measurements which showed higher rooting in the top soil, as seen from Table 2. It was also observed that though the relative uptake of P^{32} from different soils was in the order Munchong > Rengam > Sungei Buloh series soil, Sungei Buloh series which showed least P^{32} uptake had the maximum amount of feeder roots (Table 2). Possible explanations for these observed discrepancies are microbial activity and competition by ground covers. Rapid immobilisation of inorganic P in solutions by microbial populations has been observed elsewhere (Rubber Research Institute of Malaya, 1967).

TABLE 2

Mean densities of fine feeder roots at various depths in different soils*

Depth	0-3"	3-6"	6-12"	12-18"
Soil				
Sungei Buloh	27.8	12.6	6.0	3.5
Rengam	10.6	4.5	1.8	1.1
Munchong	8.3	6.7	4.5	2.9

*expressed as gm of dry root/cu. ft. of soil.