

PENETRATION AND ACTIVITY OF SOYBEAN ROOTS IN REDDISH BROWN EARTHS

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ABSTRACT

Knowledge on root development characteristics is a prerequisite to understanding problems in irrigation and fertilizer management. This information is lacking for most of the upland crops grown in the Dry Zone of Sri Lanka. Penetration and activity of soybean roots on previously puddled Reddish Brown Earths were studied by soil injection method of radioisotope phosphorus ($P-32$). Results indicate that the soybean roots penetrate to 60 cm in 18 days. Maximum rooting depth was found to be around 90 cm by the end of one month.

INTRODUCTION

Knowledge on root development characteristics of a crop is a prerequisite to understanding problems in irrigation and fertilizer management, as the root system has the prime function of absorbing water and nutrients. Very little information is available on root development and growth of most of the upland crops grown in Sri Lanka.

Somapala (unpublished) observed that roots of irrigated soybean penetrate up to 90–100 cm at maturity on well drained Reddish Brown Earth (RBE/WD) soils. He reported that there was no seasonal variation of root penetration during *Yala* and *Maha* seasons. These observations however were based on physical root counts. Physical root counts do not depict 'root activity' accurately.

Depth of penetration and "root activity", or the absorbing capacity of roots at each layer, are the basic root information that could be well correlated with plant growth. Conventional techniques used in the field for "root studies" are tedious and not accurate. Radioisotope tracer technique, however, provides a very fast and direct means of measuring *in situ* root activity of crops (IAEA 1975). Recently this technique has been widely

used to study root activity and root distribution patterns of a large number of upland crops and tree crops. The present paper discusses the results of some experiments conducted to study the root penetration and root activity of soybean on RBE/WD soils, at different growth stages, using soil injection method of radioisotope phosphorous (P—32).

MATERIALS AND METHODS

The experiments were carried out on RBE/WD soils at the Agricultural Research Station, Maha Illuppallama, during the *Yala* seasons of 1982 and 1983. Experimental site was a paddy field where puddled lowland paddy had been grown for 3 consecutive seasons.

Soybean (cultivar PB 1) was planted in 3×1 m plots, ploughed to 10—15 cm depth, in a complete randomised design with a spacing of 15×30 cm and two plants/hill, replicated four times. Basal fertilizer was applied at rate of 40 kg K₂O and 20 kg N/ha. Phosphorus fertilizer was not applied so as not to dilute the applied P—32 and thereby reduce its absorption. It is unlikely that this would affect crop growth as soil P levels are fairly high. Other management practices were in accordance with the recommendations of the Department of Agriculture. During the first two weeks the crop was irrigated twice a week and followed by one irrigation a week with sufficient water to wet the soil profile to about 1 metre.

After germination two hills were selected from each replicate and two holes were made by Veihmeyer soil sampling tube. This was done 10 cm away from the plants (between rows) up to required depth. 2.25 (=5%) micro curies of carrier free P—32 (as orthophosphate in dilute HCl) were placed in each hole using a repeating micro dispensing bottle. Ten (10) ml of water were poured into each hole and closed with soil leaving no hollows inside. P—32 placements were done on the 14th, 28th and 56th after germination of soybean. On the 14th day the depths of placements were 15, 30, 45 and 60 cm. On the 18th day 15, 30, 45, 60, 75 and 90 cm. On the 56th day 15, 20, 45, 60, 70, 90 and 105 cm. Second and third fully opened leaves from the P—32 placed plants were sampled 4 days after placing the P—32. Leaves were dried in an oven at 80°C (ground) and a sample of 0.5g was counted in the Geiger Muller Counter for radioisotope activity. Counts were corrected to the date of sampling.

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The same experiment was repeated with 8 replicates in the *Yala* season 1983. P—32 placement was done only on the 26th day after germination. Each hill (two plants) received 7.5 (+5%) micro-curies of P—32. Other procedures were as the same as described above.

RESULTS AND DISCUSSION

Crop growth was normal and the plants were healthy. Table 1 shows P—32 contents (in counts / minute / gram of leaf powder) found in soybean leaves. Presence of P—32 in leaves showed that there had been active roots in the soil layers where P—32 was placed. Roots had penetrated to 60 cm at the age of 18 days. At the age of one month roots were found in layers up to 90 cm. At two months further penetration was not seen, showing that the maximum root penetration of soybean at the experimental site was between 90—100 cm. At the age of one month soybean had obtained its full rooting profile.

Table 1. Mean root activity of soybean in different soil layers during Yala 1982 and 1983.

Age Depth cm.	Yala 1982				Yala 1983			
	18th day		32nd day		60th day		30th day	
	C/M/G**	SD*	C/M/G**	SD*	C/M/G**	SD*	C/M/G**	SD*
15	196	52	488	108	94	41	602	594
30	226	42	430	36	133	38	677	620
45	290	13	315	87	104	74	474	417
60	275	16	312	84	66	38	582	459
75	—	—	155	137	115	83	659	484
90	—	—	161	85	81	58	388	387
105	—	—	—	—	0	0	—	—

*SD—Standard Deviation of counts

**C/M/G—Count / Minute / Gram dry matter

When using this technique to obtain information on root activities in a soil profile, it is assumed that the roots have an equal chance of encountering the tracer at each spot injected, that the tracer is immobile in the soil but available for root absorption, and that the specific activity of the tracer is nearly uniformly injected (Bohm 1979). The amount of radio activity taken up by the plants is reported to give a measure of the intensity of root activity (IAEA 1975), Table 1 shows that the root activity of soybean at different depths is different. Table II shows the root activity at each depth

as a percentage of the total root activity. It is seen that certain zones have high root activity in relation to another zone. High activity at a point may be due to presence of higher number of active roots or presence of a favourable soil environment at that particular point. Soil water content, soil air and nutrient status of the soil are considered to be some of the soil environmental factors which influence root growth (Bohm 1979).

Table II. Mean percent root activity of soybean in different soil layers during Yala 1982 and 1983

Age	Yala 1982				Yala 1983			
	18th day		32nd day		60th day		30th day	
Depth (cm)	%	SD*	%	SD*	%	SD*	%	SD*
15	18.8	3.3	26.2	7.4	16.5	6.3	17.6	6.5
30	25.8	1.8	22.8	1.7	20.0	3.1	17.0	5.0
45	28.2	1.2	17.8	3.2	19.5	15.6	10.2	7.0
60	26.9	3.9	16.6	4.2	9.8	4.7	18.5	8.2
75	—	—	8.1	7.1	20.0	3.1	12.4	11.0
90	—	—	8.2	4.2	14.0	6.3	10.6	5.3
105	—	—	—	—	0	0	—	—

SD* — Standard Deviation

It is seen that the variability of counts is very high in certain soil layers. This may be due to soil heterogeneity or due to the tracer not encountering the same number of roots in all replicates owing to the limitation of the number of the injection points.

It was seen that the maximum depth and root penetration in soybean was restricted to 90—105 cm. This is in agreement with the results of Somapala (unpublished) who reported the physical root counts in soybean in RBE soils. However, other workers (Willatt *et al* 1978, Allmaras *et al* 1975) have reported the maximum rooting depth of soybean to be more than what is reported here for some other soil types. Table III shows the gravel content (particle size > 2 mm), bulk density and mechanical analysis of different soil layers at the experimental site. Soil profile was not homogeneous. Bulk density showed an increasing trend with profile depth except in 30—45 and 45—60 cm layers. Gravel content increased up to 60—75 cm. Sand content also increased with the depth. Somapala (unpublished) observed the 30% volumetric gravel content in RBE soils significantly reduced the root length of soybean. Nayakakorala (unpublished) observed that root activity

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of soybean was greatly reduced by a layer of 38% volumetric gravel content with bulk density of 1.69 g/cm³, placed in different soil depths. Such observations suggest that the mechanical impedance caused by high gravel content found in sub-surface soil layers of Reddish Brown Earth is a factor that contributes to restrictions on the depth and penetrations of soybean roots in RBE soils.

Table III. Mechanical composition, soil bulk density and gravel content of soils in different layers at the experimental site, Yala seasons 1982 and 1983.

Soil layer	Bulk density g / cm ³	% Volumetric gravel content	% Gravimetric		
			Sand content	Clay con.	Slit con.
0—15 cm	1.65	1	56.6	34.4	9
15—30 cm	1.67	1	49.0	38.6	12.4
30—45 cm	1.60	1.6	51.0	44.4	4.6
45—60 cm	1.56	18.6	53.6	39.5	6.9
60—75 cm	1.68	30.9	88.2	11.4	0.6
75—90 cm	1.69	18.6	90.2	9.0	0.0

It is also speculated that puddling of soil followed by drying continued for several years forms a "hard pan" in sub surface layers which hinders root penetration. However, the results of the present study, where soil was always ploughed to a depth of 10—15 cm show that the root penetration in RBE / WD soils is not affected by the hard pan.

CONCLUSIONS

Results show that eighteen days after germination under highland conditions soybean roots penetrate to a minimum depth of 60 cm in RBE / WD soils where puddling had been done in previous years. When soybeans are one month old roots penetrate to 90 cm. Root penetration did not increase at two months. Research has confirmed that gravel content and depth to the gravel layer in the field vary from place to place, and as root penetration is largely influenced by such variations results on the depth of root penetration studies in the field should be cautiously interpreted.

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