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Studies on the Root Distribution of Rice (*Oryza sativa* L.) Varieties Using P^{32} Plant Injection Technique

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The root distribution patterns of high yielding rice varieties (IR 8, IR 20, IR 22, Co 29, TKM 6, ADT 27, Co 33, Co 34, Co 35, Co 36 and Bhavani) in their natural habitat in fields using P^{32} plant injection technique were studied. The results revealed that 55 to 75 per cent of roots were concentrated in the soil zone covered by 10 cm lateral distance and 16 cm depth from the base of the plant and 80 to 85 per cent in the soil zone covered by 15 cm lateral distance and 24 cm depth. Heading stage was found to be the best stage for taking soil-root core samples for evaluating the root distribution pattern. Slight variations were observed among varieties in the percentage root distribution in the soil zone covered by 10 cm lateral distance and 16 cm depth but the root distribution in the soil zone covered by 15 cm lateral distance and 24 cm depth was almost same for all the varieties. Neither nitrogen levels nor different spacings of planting influenced the root distribution. The method of phosphorus application either broadcasting after last ploughing or broadcasting before last ploughing also had no influence on the rooting pattern of the rice crop.

The traditional methods of studying the distribution of plant roots were based on physical observations after excavating roots, washing them free of soil and recording length, volume, weight etc. In such studies, the total volume or weight of the roots may well be assessed but the *in situ* distribution of the roots in the soil which is very important to decide the forage area, cannot be known. Hall *et el.* (1953) at North Carolina evaluated root distribution of crops based upon P^{32} uptake from different soil zones. This method has been reported to suffer from many defects (Rennie and Halstead, 1965). Racz *et al.* (1964) proposed P^{32} plant injection technique for studying root distribution pattern of wheat. Katyal and Subbiah (1970) employed the P^{32} plant injection technique to evaluate the root distribution of rice crop. The advantage of this technique is that it is very rapid in evaluating the *in situ* distribution of roots under natural habitat of the crop. The present investigation deals with the application of this technique to rice varieties under field conditions.

MATERIALS AND METHODS

Four field experiments were conducted at Tamil Nadu Agricultural University Farms at Coimbatore and Bhavanisagar during 1972–75. In the first experiment at Coimbatore, rice varieties of IR 8, IR 20 and IR 22 were grown as test crops in R. B. design during January and June, 1972 follow-

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ing a spacing of 20cm between rows and 10 cm between plants. Nitrogen, phosphorus and potassium were applied to all the plots as urea, super phosphate and muriate of potash to supply 75kg N, 15kg P and 29 kg K/ha. Five hundred microcuries of P^{32} ($H_3P^{32}O_4$ in dilute HCl) in 0.2ml were injected into the second internode of a suitable tiller of the hill using microlitre syringe. Three plants of each variety were injected with P^{32} at (i) tillering and (ii) primordial stages. Two basic phenomena which are expected to influence the direction of movement of injected P^{32} within the plant are metabolic use and transpiration process. In the present investigation the shoot of the selected hill of the crop was cut off above the second internode to prevent upward movement of injected P^{32}. This is a modification over the method proposed by Katyal and Subbiah (1970).

Soil–root core samples were collected using sampling tubes on the 8th day after P^{32} injection, from 0-8cm, 8-16cm, 16-24cm and 24-32cm depths at 5cm, 10cm, 15cm and 25cm lateral distances from the base of the plant on all sides of the hill. The soil-root core samples were dried, ground and kept in the muffle at 500°C for 6 hours to ash the roots present in them. Then representative ground soil samples were taken in cup-planchets and subjected to radioassay in the Geiger Muller Counter. From the percentage distribution of P^{32} in the different soil-root cores, the relative percentage distributions of rice roots in the respective zones were estimated.

In the second experiment at Coimbatore, three tall rice varieties of ADT 27, Co 29 and TKM 6 and three dwarf rice varieties of Co 33, Co 34 and Co 35 were grown during August–December, 1977 as test crops with manurial schedules and spacings as under the first experiment. Five hundred microcuries of carrier–free P^{32} were injected to 3 plants in each variety at (i) tillering (ii) primordial and (iii) heading stages.

The third experiment was also conducted at the Central Farm of Tamil Nadu Agricultural University at Coimbatore during January-June. 1974. The experiment was laid in a strip plot design to accommodate three levels of nitrogen viz., 50, 75 and 100kg N/ha and three spacings of 10cm x 7.5cm, 20cm x 10cm and 25cm x 20cm in plots of 6M x 2M size using rice variety of Bhavani as the test crop. Phosphorus and potassium were applied at the rate of 15kg P/ha and 29kg K/ha. Each treatment was replicated thrice. Five hundred microcuries of P^{32} were injected to the plants as in the previous experiments at (i) tillering (ii) primordial and (iii) heading stages. Soil-root core samples were collected and the radioassay was carried out as explained under Experiment I.

In the fourth experiment at Agricultural Research Station, Bhavanisagar three rice varieties of Bhavani, Co 36 and IR 20 were grown as test crops during September, 74 to January, 75 with a fertilizer schedule of 75kg N, 15kg P and 29kg K/ha following a

spacing of 20cm between rows and 10cm between plants. Nitrogen and potassium were applied as in the first experiment while phosphorus was applied in two ways (i) basal dressing of superphosphate after last ploughing i.e. just before transplanting and (ii) basal dressing before last ploughing. Each treatment was replicated four times. Five hundred microcuries of P^{32} was injected to selected tiller of a hill in each replication at the heading stage. Soil - root core samples were collected and the radioassay was carried out as under Experiment I.

RESULTS AND DISCUSSION

The results of the first and second experiment conducted on 9 high yielding rice varieties revealed that 55 to 75 per cent of the roots were concentrated in the soil zone covered by 10cm lateral distance and 16cm depth from the base of the plant and 80 to 90 per cent of roots in the soil zone covered by 15cm lateral distance and 24cm depth at tillering and heading stages (Table I). Of course, slight variations in the percentage distribution of roots in the zone covered by 10 cm lateral distance and 16 cm depth were observed among the varieties but the differences in the percentage root distribution in the zone covered by 15cm lateral distance and 24cm depth were not marked among varieties. Comparing the rooting among the tillering, primordial and heading stages, the percentage distribution of roots of all the varieties in the zone covered by 10cm

TABLE I. Percentage distribution of roots in the different soil zones for different varieties of rice as revealed by P^{32} distribution

Rice Variety	Tillering stage		Primordial stage		Heading stage	
	10 cm lateral 16 cm vertical	15 cm lateral 24 cm vertical	10 cm lateral 16 cm vertical	15 cm lateral 24 cm vertical	10 cm lateral 16 cm vertical	15 cm lateral 24 cm vertical
Experiment I						
IR 8	63.2	84.7	55.1	80.4	—	—
IR 20	68.9	88.0	60.9	82.5	—	—
IR 22	74.6	90.8	52.3	74.6	—	—
Mean	68.9	87.8	56.1	75.8	—	—
Experiment II						
Co 29	61.8	81.9	68.3	85.6	59.5	82.5
TKM 6	61.6	85.6	50.2	78.1	52.8	77.0
ADT 27	58.0	83.3	62.9	86.4	48.8	76.1
Co 33	54.4	81.6	54.0	81.3	53.5	78.6
Co 34	61.2	82.0	53.8	78.8	48.2	79.9
Co 35	58.7	83.8	62.6	84.2	49.2	75.8
Mean	59.3	83.0	58.6	82.4	52.3	78.3

TABLE II. Percentage distribution of roots in different soil zones as influenced by N levels and different spacings Rice Variety : BHAVANI

Treatment kg N/ha	Tillering stage		Primordial stage		Heading stage	
	15 cm lateral 16 cm vertical	25 cm lateral 24 cm vertical	15 cm lateral 16 cm vertical	25 cm lateral 24 cm vertical	15 cm lateral 16 cm vertical	25 cm lateral 24 cm vertical
Spacing : 10 x 7.5 cm²						
50	52.0	79.4	67.2	80.5	43.4	72.2
75	55.5	81.6	69.1	85.8	48.5	73.3
100	63.4	83.7	54.1	79.4	47.4	70.8
Spacing : 20 x 10 cm²						
50	54.9	80.8	50.7	80.0	47.5	77.1
75	64.1	86.4	61.2	80.3	52.0	74.C
100	59.5	82.6	51.8	79.8	47.9	77.4
Spacing : 25 x 20 cm²						
50	60.7	82.5	53.0	79.2	49.6	71.8
75	55.4	81.7	51.0	75.9	49.4	74.5
100	62.3	82.6	52.6	77.7	47.9	74.7
Mean	58.6	82.4	56.7	79.7	48.2	74.0

lateral distance and 16cm depth from the base of the plant decreased slightly from the tillering to heading stage which is due to spreading of roots both laterally and vertically with the advance of crop growth. However, the percentage distribution of roots of all the varieties in the zone covered by 15cm lateral distance and 24cm depth remained almost same revealing that spreading of rice roots beyond this zone is very limited. The results also revealed that soil-root core samples for root distribution studies of this crop should be taken at the heading stage rather than at earlier stages since the root system would have developed almost fully at this stage. The results of the third experiment also showed that root distribution of Bhavani rice variety in the different soil zones at the three growth stages was almost of the same pattern as under the first two experiments (Table II). The results further revealed that neither the increase in nitrogen level nor the increase in spacing influenced the root distribution behaviour of the crop. The root system of rice crop is of adventitious nature and the root growth of a rice plant did not seem to be impeded seriously by the root growth of the adjacent plants when a minimum spacing of 10cm x 7.5cm was provided.

In the fourth experiment, besides the three rice varieties of Bhavani, IR 20 and Co 36, two methods of place-

ment of phosphate were tried as variables to evaluate the influence of method of application of phosphate on the root distribution. The results of this experiment also revealed that the rice varieties followed the same pattern of root distribution as established in the earlier experiments irrespective of the method of application of the phosphate (Table III).

TABLE III. Percentage distribution of roots in different soil zones as revealed by P^{32} distribution

Treatment	Heading stage	
	10 cm lateral 16 cm vertical	15 cm lateral 24 cm vertical
V_1P_1	51.9	76.3
V_2P_1	59.9	77.5
V_3P_1	57.5	80.5
V_1P_2	54.7	74.9
V_2P_2	64.4	80.2
V_3P_2	59.4	77.5
Mean	57.9	77.8

V_1 : Bhavani
V_2 : Co 36
V_3 : IR 20

P_1 : Phosphorus applied after last ploughing
P_2 : Phosphorus applied before last ploughing

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