

## Root Traits of Rice (*Oryza sativa* L.) Varieties under Two Hydrological Situations as Influenced by Different Methods of Establishments

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**Abstract:** Study on root traits of different rice varieties under two hydrological situations of aerobic and anaerobic revealed that aerobic rice Pyari measured longest roots (43.34cm) under aerobic and highest root dry weight (2.73g hill<sup>-1</sup>) under anaerobic condition while Naveen –a low land rice recorded maximum horizontal spread (19.3cm) under anaerobic and root volume (28.0cc) under aerobic conditions. Root length- spread ratio (6.28) and root length-root dry weight ratio (25.60) was highest with Naveen under aerobic situation. All the root traits recorded higher values with aerobic transplanting (20cmx20cm) and modified SRI (20cmx20cm) under aerobic and anaerobic conditions, respectively. Aerobic (25cmx25cm) and conventional transplanting recorded higher root-length ratio of 3.82 and 2.55 under aerobic and anaerobic situations respectively. The ratio of root length to root dry weight was however, higher with direct seeding (29.83) and conventional planting (22.2) under similar situations.

**Key words:** Aerobic transplanting • Hydrological situation • Modified SRI • Root traits • Spot seeding

### INTRODUCTION

Adaptability of rice to a wide range of agro-climatic and geo-hydrological situations makes it a plant of unique character. Rice does differ genetically in its rooting pattern but it also varies with the change of soil environment. In recent years few water saving techniques are being advocated to raise a rice crop (Tuong *et al.*, 2005) [1] where in differential soil moisture regime like aerobic, partial anaerobic and anaerobic are maintained. Kato and Okami (2010) [2] viewed that a change in root proliferation is necessary for rice to adopt itself under a given environment and is a character to be looked after by the rice breeders. However, Knowledge of rooting habit of promising genotypes under such environments is of interest due to timeliness of breeding outcome. Such study is prerequisite for development of proper agronomic technique. Keeping this in view a field trial was undertaken during wet season to study the complexities of interrelationship between root morphological characters of different rice genotypes under different establishment methods in a soil environment having different hydrological situation.

### MATERIALS AND METHODS

Field study was carried out at the Agronomy Main Research Farm, Orissa University of Agriculture and Technology, Bhubaneswar (20° 15'N latitude & 85° 52'E longitude 25.9 m above MSL) during wet season of 2012. The soil of the two hydrological situations of aerobic (un flooded) and anaerobic(flooded) was inceptisol with corresponding values of bulk density, field capacity, PWP, available soil moisture and maximum water holding capacity of 1.65 & 1.57 Mg m<sup>-3</sup>, 6.65 and 10.19% w/w, 3.32 & 6.10 % w/w, 7.14 & 8.60% and 14.80 and 15.97%. The pH and EC of soil of corresponding hydrological situations was 5.90 & 6.10 and 0.13 & 0.138 dSm<sup>-1</sup>. Treatments consisted of three varieties (V<sub>1</sub>-Jyotirmayee-short duration upland, V<sub>2</sub>-Naveen-medium duration low land, V<sub>3</sub>-Pyari- medium duration aerobic rice) in main plot with five methods of establishments (M<sub>1</sub>-direct seeding in solid rows 20 cm apart; M<sub>2</sub>-spot seeding with 2-3 seeds at 20 cm x 20 cm spacing, M<sub>3</sub>-spot seeding with 2-3 seeds at 25 cm x 25 cm spacing, M<sub>4</sub>- Aerobic transplanting at 20 cm x 20 cm spacing, M<sub>5</sub>- Aerobic transplanting at 25 cm x 25 cm spacing) in sub plot under aerobic hydrological

situation. Seeds were sown in solid rows in main field for M<sub>1</sub>, M<sub>2</sub> & M<sub>3</sub> treatments and for aerobic transplanting (M<sub>4</sub> & M<sub>5</sub>) seedlings were raised on dry seed bed on the same date. One seedling at two leaf stage was transplanted at a spacing of 20 cm x 20 cm (M<sub>4</sub>) and 25 cm x 25 cm (M<sub>5</sub>) under un-puddled un-flooded aerobic condition on well pulverised soil soaked with water one day before transplanting. Another set of experiment as observation strip with three planting methods was laid out under puddled flooded anaerobic condition consisting of three treatments like S<sub>1</sub>- conventional Transplanting with 2-3 seedlings at 4 leaf stage with 20 cm x 10 cm spacing, S<sub>2</sub>- Modified SRI (transplanting of 1 seedling at 2 leaf stage with 20 cm x 20 cm spacing) and S<sub>3</sub>- SRI (transplanting of 1 seedling at 2 leaf stage with 25 cm x 25 cm spacing), respectively. Both sets of experiments were fertilized with a uniform dose of 80-40-40 kg N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O ha<sup>-1</sup>. All P & K and 25% of N was applied as basal while remaining 75% N was applied in 2 splits of 50% at tillering stage and 25% at panicle initiation stage. Crop received a total of 967.9 mm rain in 77 rainy days and supplemental irrigation was provided to meet the crop need. Data on various root traits such as root length, root spread, root volume and root dry weight were taken periodically. Ratio of root length to root weight was worked out as per Kato and Okami (2010) [2] and root length to root spread was worked out as per Kamath (1971) [3].

## RESULT AND DISCUSSION

**Effect on Variety:** Among the varieties Pyari (aerobic rice) recorded higher root length at all the periods of observation and measured the longest root (43.3cm) at 75 days after sowing (DAS) under aerobic condition showing its greater water acquisition ability. Roots were the longest (22.7cm) with Naveen- low land rice at 60 DAS. Longer roots under aerobic situation can be attributed to changes in assimilate partitioning under water limitation as reported by Kato *et al.* [4]. Length of root increased up to 75 and 60 DAS under un puddled un flooded- aerobic and puddled-anaerobic conditions, respectively and decreased thereafter at harvest in all the three varieties. The rate of increase was the maximum between 45- 60 DAS in both the hydrological situations (Table 1).

Root spread was, however, found to be more under anaerobic condition particularly during early stage of the crop. The Highest horizontal expansion of 19.3 cm was

Table 1: Root length (cm) as influenced by different treatments

Aerobic condition						
Variety	Days after sowing					
	15	30	45	60	75	At harvest
Jyotirmayee	2.45	10.21	18.31	33.40	36.41	31.48
Naveen	2.54	11.51	17.93	32.97	38.86	30.87
Pyari	2.85	12.84	19.75	39.83	43.33	33.09
Method of establishment						
DS (20 cm R to R)	2.96	11.9	24.67	39.08	39.65	32.17
SS (20cmx20cm)	3.72	13.00	25.29	42.77	41.34	30.62
SS (25cmx25cm)	3.49	12.50	22.13	37.28	36.74	29.28
ATP (20cmx20cm)	2.36	9.27	24.64	42.25	44.41	35.00
ATP (25cmx25cm)	2.36	9.03	21.59	39.57	40.51	31.99

DS: Direct seeding, SS: spot seeding, ATP: Aerobic Transplanting

Anaerobic condition						
Variety	Days after sowing					
	15	30	45	60	75	At harvest
Jyotirmayee	1.31	6.44	15.86	22.37	19.27	16.13
Naveen	1.61	7.19	16.04	22.67	21.57	17.20
Pyari	1.50	6.69	15.84	21.43	20.33	21.99
Method of establishment						
CP (20cm x 10cm)	1.53	6.66	15.74	21.49	20.5	16.70
Mod.SRI (20cmX20cm)	1.72	6.88	16.08	22.77	24.70	17.73
SRI (25cmX25cm)	1.66	6.78	15.92	22.20	23.07	16.40

CP: Conventional planting, Mod.: Modified, SRI: System of Rice Intensification

with variety Jyotirmayee- a short duration rice, at 60 DAS under aerobic and with Naveen (19.6cm) at 75 DAS under anaerobic condition (Table 2). Depth of root penetration and lateral spread are variety and environment dependent (Uphoof and Randri Amiharisoa, 2007 [5] and Kato and Okami, 2011 [6]). Higher values of other root traits under aerobic condition can be attributed to better aeration and less degeneration of roots. Larger values of length and spread resulted in more root volume and maximum volume of 28.0 and 22.3 cc was noticed with Naveen and Pyari at 75 DAS under aerobic and anaerobic conditions, respectively, an increase of 25.3 % over anaerobic condition (Table 3). Similar findings have also been reported by Sridhar *et al.* [7]. Root dry weight peaked up at 75 DAS and then decreased at harvest due to senescence and root mortality. Variety Pyari recorded highest root dry weight (2.73g hill<sup>-1</sup>) under anaerobic condition, an increase of 17.9% over aerobic with a weight of 2.09 g hill<sup>-1</sup> (Table 4). Shoot to root ratio was marginally higher under flooded condition irrespective of the varieties and the ratio was the highest (16.36) with Jyotirmayee under flooded and with Naveen (16.03) under unflooded condition at harvest (Table 5).

Table 2: Root spread as influenced by different treatments

Aerobic condition						
Variety	Days after sowing					At harvest
	15	30	45	60	75	
Jyotirmayee	1.62	4.10	7.96	13.60	15.96	13.97
Naveen	1.66	4.26	6.34	13.59	16.25	14.01
Pyari	1.65	4.44	6.82	14.30	16.30	14.60
Method of establishment						
DS (20 cm r to r)	1.66	4.36	7.35	13.86	14.11	13.22
SS (20cmx20cm)	1.78	4.65	7.80	13.62	14.62	13.68
SS (25cmx25cm)	1.72	4.28	7.15	13.00	14.00	12.95
ATP (20cmx20cm)	1.53	3.69	7.23	14.64	15.79	14.75
ATP (25cmx25cm)	1.53	3.37	5.66	13.70	15.23	12.70

DS: Direct seeding, SS: spot seeding, ATP: Aerobic Transplanting

Anaerobic condition

Variety	Days after sowing					At harvest
	15	30	45	60	75	
Jyotirmayee	3.14	4.43	4.87	11.82	17.17	12.77
Naveen	3.44	4.38	5.70	12.0	19.58	14.13
Pyari	3.15	4.36	4.51	11.97	16.53	15.57
Method of establishment						
CP (20cmx10cm)	2.77	3.98	6.16	10.47	20.27	12.93
Mod.SRI (20cmx20cm)	3.65	4.77	7.11	12.82	24.40	15.73
SRI (25cmx25cm)	3.31	4.43	6.87	12.49	20.20	13.83

CP: Conventional planting, Mod.: Modified, SRI: System of Rice Intensification

Table 3: Root volume as influenced by different treatments

Aerobic condition						
Variety	Days after sowing					At harvest
	15	30	45	60	75	
Jyotirmayee	4.88	7.40	14.88	17.06	18.14	10.74
Naveen	4.78	7.45	11.86	17.20	20.54	10.92
Pyari	4.54	6.48	12.74	18.22	22.34	12.94
Method of establishment						
DS (20 cm R to R)	4.00	6.30	9.10	14.20	14.47	11.33
SS (20cmx20cm)	8.40	7.47	13.83	18.73	19.17	11.17
SS (25cmx25cm)	6.50	7.83	15.30	18.77	18.9	11.57
ATP (20cmx20cm)	1.67	7.27	15.77	19.83	20.43	13.83
ATP (25cmx25cm)	1.43	6.67	15.50	18.93	20.73	11.77

DS: Direct seeding, SS: spot seeding, ATP: Aerobic Transplanting

Anaerobic condition

Variety	Days after sowing					At harvest
	15	30	45	60	75	
Jyotirmayee	2.00	2.30	9.67	23.67	23.00	15.67
Naveen	2.10	2.67	11.07	25.67	28.0	16.0
Pyari	2.13	2.23	10.43	22.67	26.0	16.0
Method of establishment						
CP (20cm x 10cm)	2.00	1.82	8.17	20.67	22.65	17.55
Mod.SRI (20cmx20cm)	2.20	2.80	12.5	30.00	31.67	19.33
SRI (25cmx25cm)	2.20	2.57	10.5	24.33	25.67	16.67

CP: Conventional planting, Mod.: Modified, SRI: System of Rice Intensification

Table 4: Root dry weight (g hill-1) influenced by different treatments

Aerobic condition						
Variety	Days after sowing					At harvest
	15	30	45	60	75	
Jyotirmayee	0.230	0.592	1.238	1.488	1.940	1.750
Naveen	0.230	0.686	1.298	1.556	2.020	1.742
Pyari	0.224	0.702	1.302	1.580	2.096	1.748
Method of establishment						
DS (20 cm R to R)	0.250	0.703	1.080	1.310	1.827	1.547
SS (20cmx20cm)	0.350	0.740	1.307	1.577	2.083	1.737
SS (25cmx25cm)	0.280	0.753	1.257	1.433	1.947	1.590
ATP (20cmx20cm)	0.185	0.550	1.300	1.790	2.233	1.903
ATP (25cmx25cm)	0.190	0.523	1.320	1.597	2.007	1.790

DS: Direct seeding, SS: spot seeding, ATP: Aerobic Transplanting

Anaerobic condition

Variety	Days after sowing					At harvest
	15	30	45	60	75	
Jyotirmayee	0.25	0.37	1.01	1.65	2.54	2.20
Naveen	0.30	0.37	1.05	1.77	2.64	2.75
Pyari	0.27	0.33	1.01	1.68	2.73	2.50
Method of establishment						
CP (20cm x 10cm)	0.27	0.30	1.01	1.40	2.43	2.29
Mod.SRI (20cmx20cm)	0.35	0.40	1.14	1.95	2.70	2.54
SRI (25cmx25cm)	0.30	0.36	1.05	1.75	2.55	2.35

CP: Conventional Planting, Mod.: Modified, SRI: System of Rice Intensification

Table 5: Shoot-root ratio as influenced by different treatments

Aerobic condition						
Variety	Days after sowing					At harvest
	15	30	45	60	75	
Jyotirmayee	6.64	7.16	7.26	7.20	9.72	14.67
Naveen	6.94	7.03	7.54	8.75	10.62	16.03
Pyari	7.40	7.30	7.23	8.34	10.78	15.15
Method of establishment						
DS (20 cm R to R)	5.57	5.70	7.13	8.50	8.53	13.98
SS (20cmx20cm)	7.72	7.88	7.93	8.12	10.49	15.34
SS (25cmx25cm)	6.95	7.07	8.16	8.56	9.71	14.87
ATP (20cmx20cm)	6.85	7.10	7.21	8.27	11.59	16.17
ATP (25cmx25cm)	6.67	7.03	7.00	7.79	10.13	15.82

DS: Direct seeding, SS: spot seeding, ATP: Aerobic Transplanting

Anaerobic condition

Variety	Days after sowing					At harvest
	15	30	45	60	75	
Jyotirmayee	8.08	9.10	10.98	11.24	11.33	16.36
Naveen	7.53	9078	11.19	11.01	11.10	15.92
Pyari	8.04	10.58	11.00	11.40	11.50	13.10
Method of establishment						
CP (20cm x 10cm)	8.00	10.27	13.16	13.69	13.86	16.66
Mod.SRI (20cmx20cm)	6.17	9.78	10.16	11.68	11.88	15.36
SRI (25cmx25cm)	7.10	9.72	11.26	11.58	12.43	14.64

CP: Conventional planting, Mod.: Modified, SRI: System of Rice Intensification

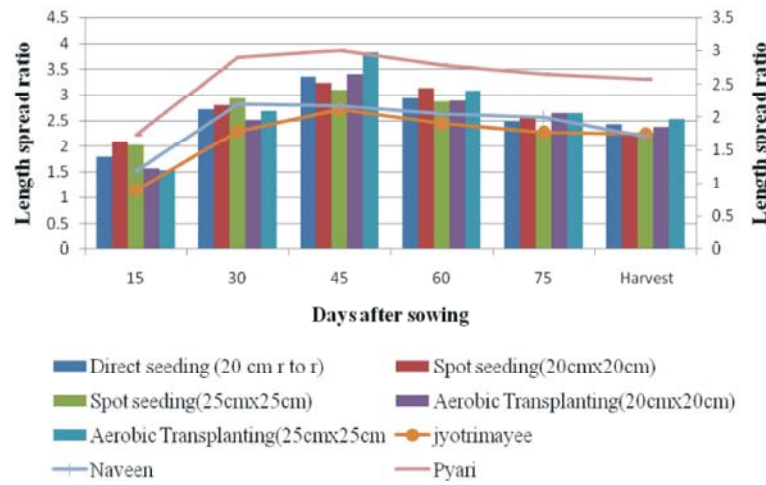


Fig. 1: Length – spread ratio of rice varieties as influenced by establishment methods under aerobic condition

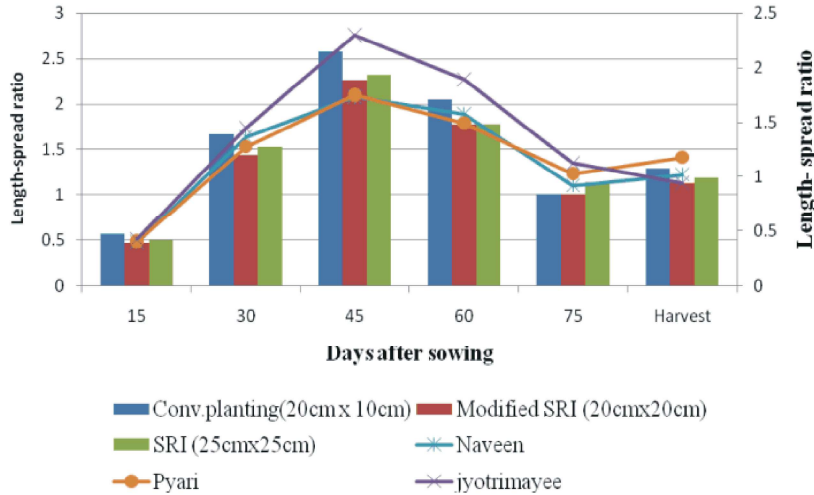


Fig. 2: Length – spread ratio of rice varieties as influenced by establishment methods under anaerobic condition

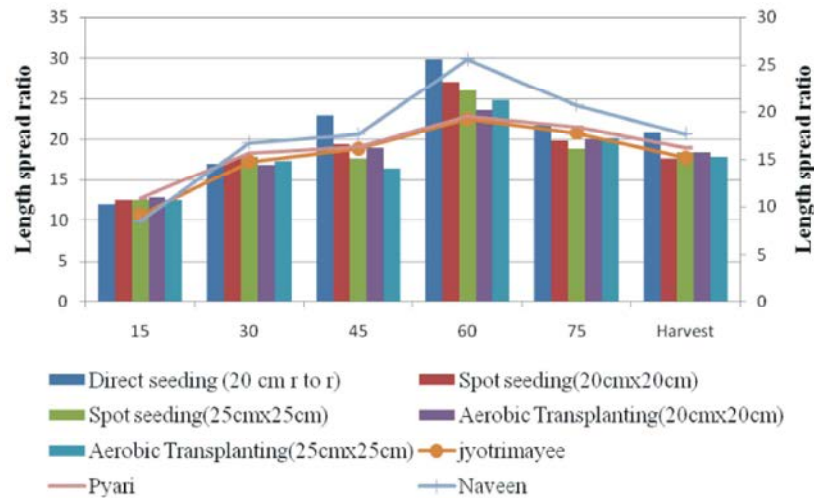


Fig. 3: Ratio of root length to root dry weight in rice varieties as influenced by establishment methods under aerobic condition

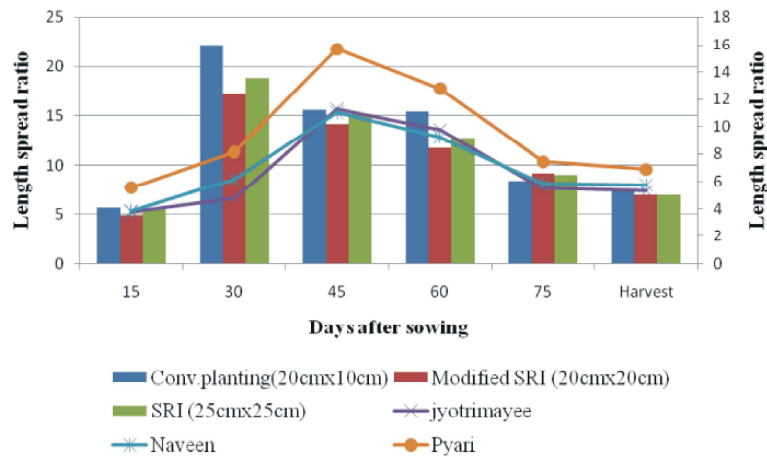


Fig. 4: Ratio of root length to root dry weight in rice varieties as influenced by establishment Methods under anaerobic condition

Length-spread ratio is a good measure of compactness of root system. Higher ratio was observed under aerobic condition at any stage of growth and was the maximum, 6.28 and 1.89 with variety Naveen both under aerobic and anaerobic condition, respectively (Fig. 1 and 2). Ratio of root length to root dry weight was more under aerobic condition during all the observations irrespective of varieties. It increased with age up to 60 and up to 45 DAS under un-flooded and flooded condition, respectively and decreased thereafter towards harvest. Variety Naveen (25.60) and Pyari (15.68) showed higher ratios under aerobic and anaerobic hydrological situations, respectively (Fig. 3 & 4).

**Method of Establishment:** Longest roots were measured at 75 DAS under both the situations due to establishment methods. Aerobic transplanting (ATP) with a spacing of 20cmx20cm and modified SRI at 20cmx20cm measured longest roots of 44.41 and 24.70 cm under aerobic and anaerobic situations, respectively. Root length was the maximum under direct seeding treatments of M<sub>1</sub>, M<sub>2</sub> and M<sub>3</sub>, decreased marginally under ATP (M<sub>4</sub>, M<sub>5</sub>) and appreciably under anaerobic transplanting. (S<sub>1</sub>, S<sub>2</sub>, S<sub>3</sub>). Similarly, aerobic transplanting (20cmx20cm) and modified SRI (20cmx20cm) also recorded more spread (16.8 and 24.4 cm), root volume (20.73 and 31.70 cc) and root dry weight (2.23 and 2.70 g hill<sup>-1</sup>). Results are in conformity with Sridhar *et al.*, (2011).

Aerobic transplanting (25cmx25cm) under un flooded and conventional transplanting under flooded condition recorded higher values of root length-spread ratio (3.82 and 2.55), respectively at 45 DAS

(Fig. 1 & 2). But the ratio of root length to root dry weight was maximum with M<sub>1</sub> (29.83) at 60 DAS under un flooded and with S<sub>1</sub> (22.2) at 30 DAS under flooded condition. In both the situations, it decreased at harvest, the decrease was more conspicuous under anaerobic situation (Fig. 3 & 4).

## CONCLUSION

Root length- spread ratio (6.28) and root length-root dry weight ratio (25.60) was highest with Naveen under aerobic situation. All the root traits recorded higher values with aerobic transplanting (20cmx20cm) and modified SRI (20cmx20cm) under aerobic and anaerobic conditions, respectively. Aerobic (25cmx25cm) and conventional transplanting recorded higher root-length ratio of 3.82 and 2.55 under aerobic and anaerobic situations respectively. The ratio of root length to root dry weight was however, higher with direct seeding (29.83) and conventional planting (22.2) under similar situations.

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