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IMPORTANCE OF LARGE ROOT SYSTEM ON INCREASING YIELD IN DRIP IRRIGATED AEROBIC RICE

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ABSTRACT

Study on the influence of drip irrigation system on certain root characters and grain yield in aerobic rice study was conducted during Dry Season (2011) in Coimbatore, India. The two lateral spacings with two discharge rate dripper treatments were experimented by using ADT(R) 45 variety. Chosen root characters were observed and correlated with the yield of aerobic rice. The increased root length, root density (length and weight), root oxidizing power, specific root length which are much favoured the yield of aerobic rice under 0.8 m lateral distance with 1.0 lph drippers. The physiological parameter of root oxidizing power improved the root activity, which was 38.2 per cent higher in 0.8 m LD with 1.0 lph dripper over the conventional aerobic rice treatment. Optimum yield (5793 Kg ha^{-1}) was obtained in 0.8 m lateral distance, with 20x10 plant spacing along with 1.0 lph dripper treatment. Higher correlation coefficient root parameters such as Root Mass Density (0.865**), total root length (0.864**) were proved that the root system parameters were favoured the yield increment in rice under drip irrigation system. This 0.8 m lateral distance, with 20x10 plant spacing along with 1.0 lph dripper treatment might be recommended for the water scarce environment to achieve better root growth and yield in aerobic rice.

INTRODUCTION

Rice responses to the anaerobic-to-aerobic transition would obviously differ from drought responses (Suralta and Yamauchi, 2007). Frequent water applications are especially important when using drip systems, which tend to restrict soil wetting and thus produce a smaller root system. Suralta and Yamauchi (2007) studied the root response to dry spells in rainfed low lands and separately examined the effects of drought in the aerobic conditions. Aerobic rice cultivars need to have a deeper rooting and a higher Root Length Density than lowland rice cultivars because of the limited water availability under aerobic as compared to flooded conditions (Matsuo *et al.*, 2010). Phene (1991) studied the distribution of roots under sweet corn as a function of drip placement and fertilization treatment.

Control of root development in crops could be achieved with the use of new varieties with efficient root traits and application of directional rhizosphere management such as localized nutrient/water supply (Zhang *et al.*, 2010). Root biomass production is ascribed to adventitious root development at the phytomer level, or more simply, to dynamic changes in the number of adventitious roots and in individual root growth (Kato *et al.*, 2007). Deeper rooting can alleviate rice plant dehydration under intermittently dry soil conditions (Bernier *et al.*, 2008). Rooting vigor at the early growth stage resulting from the greater individual root growth and a higher root-to-shoot ratio are important for the improvement of rice for aerobic culture (Kato and Okami, 2010). The drip irrigation with humic acid plants showed favourable root growth characters with improved yield attributes leads higher grain yield (Vanitha and Mohandass, 2014). The present study focuses on the varied lateral distance and low discharge rates drip irrigation system on root response and yield performance of aerobic rice. With this strong review, the root traits were correlated with the grain yield under aerobic drip environment in the present study besides analysing.

MATERIALS AND METHODS

The experiment was conducted during Dry Season 2011 (DS 2011) in the wetlands of Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India situated at 11ºN latitude, 77ºE longitude and at an altitude of 426.72 m above Mean Sea Level. Field experiment was conducted in the RBD (Randomized Block Design) was adopted with three replications using ADT (R) 45 as the test variety. The irrigation was given through PVC pipe (50 mm OD) after filtering through the screen filter by 7.5 HP motor from the bore well. The pressure maintained in the system was 1.2 Kg cm^{-2}. From the sub-main, in-line laterals were laid at a spacing of 0.6 m, 0.8 m and 1.0 m with 0.6 or 1.0 lph discharge rate emitters positioned at a distance of 30 cm. Irrigation was given based on the Open Pan Evaporation (PE) values (125% PE).

There were eleven treatments employing three lateral spacings and two discharge rates of emitters. The treatments were: distance between laterals 0.6 m with the spacing of 20 cm between rows of plants and spacing of 10 cm between plants

(T_1), distance between laterals 0.6m, spacing between rows of plants from lateral (20x10x10x20) (instead of three rows of 20 cm each) (T_2), lateral distance of 0.8 m, spacing of 20 cm between rows of plants and spacing of 10 cm between plants (T_3), lateral distance of 0.8 m, spacing between rows of plants from lateral (5x20x30x20x5) (instead of four rows of 20 cm each) (T_4), lateral distance of 1.0 m, spacing of 20 cm between rows of plants and spacing of 10 cm between plants (T_5), laterals distance of 1.0 m, spacing between rows of plants from lateral (7.5x15x15xempty bed (25cm) x15x15x7.5) (instead of five rows of 20 cm each) (T_6), laterals distance of 0.8 m, spacing of 20 cm between rows and spacing of 10 cm between plants + 30 percent more water (T_7), lateral distance of 1.0 m, spacing of 20 cm between rows of plants and spacing of 10 cm between plants + 30 percent more water (T_8), lateral distance of 0.8 m, spacing between rows of plants from lateral (5x20x30x20x5) (instead of four rows of 20 cm each) with 0.6 lph drippers (T_9), lateral distance of 1.0 m, spacing between rows of plants from lateral (7.5x15x15xempty bed (25cm) x15x15x7.5) (instead of five rows of 20 cm each) with 0.6 lph drippers (T_{10}) and conventional irrigation at IW/CPE ratio of 1.25 at 30 mm depth of irrigation (conventional irrigation) (T_{11}).

The weather parameters prevailed during cropping season was observed in Agromet Observatory in Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu and India. The average values for maximum, minimum temperature were 30.7°C, 22.7°C and sunshine hours of 5.7 h d^{-1}. The total evaporation recorded was 628.3 mm with the total precipitation of 533.0 mm. The effective rainfall was taken into account while scheduling irrigation under drip and surface methods.

Sampling and data collection

Root traits

To measure the root growth, the roots were removed carefully from the soil without damaging the roots measuring the total root length of each plant. Randomly selected ten roots were weighed and their length was measured and totaled. The total root length was calculated by using the weight of the total roots at the same moisture level. Then the total root length (m hill^{-1}) = (Length of sample roots (cm) x Weight of total roots (g)) / Weight of sample roots (g). The Root Length Density (RLD) and Root Mass Density (RMD) were measured by the procedure of Pantuwan*et al.* (1997) and expressed as cm cm^{-3} and mg cm^{-3} respectively. Specific Root Length, the ratio of root length to root weight - was also calculated. Root-Shoot ratio was calculated by using the dry weights of shoot (leaf + culm + panicle) and root. Root biomass values were expressed as g hill^{-1}. Harvesting of crop (grain) from each treatment and replication was made from the net plot.

Yield performance

After thrashing the grains, weight of the grain was taken. Grain yield per hectare was calculated from the mean plot yield and expressed in kg ha^{-1} at 14 % moisture content.

Statistical Analysis

The recorded data were subjected to statistical analysis in the Randomized Block Design (RBD) using ANOVA Package (AGRES version 7.01) following the method of Gomez and Gomez (1984).

RESULTS

The drip irrigation system in aerobic rice showed significant variation among the treatments. The total root length is an important root trait, that symbolize total root system size: the size of contact with soil (major determinant for water and nutrient uptake as an entire root system). The root length of aerobic rice in drip irrigation recorded a higher significance level (0.864**) with yield. Higher total root length was observed in treatment T_3 (50.74) and lower in T_{10} (41.38) (Table 1.). The RLD registered a higher value in T_3 (1.58) followed by T_1 (1.51). Similarly RMD recorded an increased value in T_3 (1.17) and lower in T_{10} (0.95). The root parameters of RMD (0.865**), root dry weight (0.858**) attained positive significance with yield (Table 2.). The RLD of the aerobic rice showed positive significance (0.772**) with the grain yield under drip irrigated environment (Table 1.).

Table 1: Effect of root parameters of aerobic rice under drip irrigation (LD: Lateral Distance)

Treatments	RL	RDW	RV	RP	RLD	RMD	SRL	ROP	R/S ratio
LD 0.6m, row spacing 20 x 10 cm	50.25	3.98	34.5	37.78	1.54	1.14	0.13	81.36	0.12
LD 0.6m, row spacing from lateral (20x10x10x20)	48.28	3.57	30.2	37.04	1.49	1.10	0.14	78.61	0.12
LD 0.8m, row spacing 20 x 10 cm	50.74	4.18	35.8	38.28	1.58	1.17	0.12	87.68	0.13
LD 0.8m, row spacing from lateral (5x20x30x20x5)	46.60	3.47	27.8	36.92	1.46	1.08	0.13	72.12	0.12
LD 1.0m, row spacing 20 x 10 cm	44.62	3.16	28.1	36.51	1.41	1.05	0.14	71.64	0.11
LD 1.0m, row spacing from lateral (7.5x15x15xEmptybed(25cm)x15x15x7.5)	44.23	3.09	33.7	36.37	1.37	1.03	0.14	68.31	0.11
LD 0.8m, row spacing 20 x 10 cm + 30% more water	45.89	3.69	37.1	36.65	1.45	1.08	0.12	83.01	0.12
LD 1.0m, row spacing 20 x 10 cm + 30% more water	46.20	3.50	47.9	36.84	1.47	1.08	0.13	70.39	0.12
LD 0.8m, row spacing from lateral (5x20x30x20x5) with 0.6 lph drippers	44.43	3.07	20.0	35.27	1.40	1.00	0.14	67.20	0.11
LD 1.0m, row spacing from lateral (7.5x15x15xEmptybed (25cm) x15x15x7.5) with 0.6 lph drippers	41.48	2.49	29.6	32.32	1.25	0.95	0.17	60.67	0.10
IW/CPE ratio of 1.25 at 30 mm depth of irrigation	43.14	3.48	19.4	34.46	1.31	0.98	0.13	63.40	0.13
Mean	45.99	3.43	31.3	36.22	1.43	1.06	0.14	73.13	0.12
S.Ed.	0.706	0.144	5.24	0.356	0.049	0.017	0.007	1.136	0.006
CD<0.05	1.473	0.299	10.92	0.742	0.103	0.036	0.015	2.371	0.122

RL - Root Length (m hill^{-1}); RDW - Root Dry Weight (g hill^{-1}); RV - Root Volume (cc hill^{-1}); RP - Root Porosity (%); RLD - Root Length Density (cm^3 hill^{-1}); RMD - Root Mass Density (g cm^{-3}); SRL - Specific Root Length; ROP - Root Oxidizing Power

Table 2: Effect of yield and Harvest Index of aerobic rice under drip irrigation (LD: Lateral Distance)

Treatments	Total Dry Matter Accumulation (g hill^{-1})	Harvest Index (%)	Grain Yield (kg ha^{-1})
LD 0.6m, row spacing 20 x 10 cm	37.0	41.39	5554
LD 0.6m, row spacing from lateral (20x10x10x20)	34.5	41.80	5327
LD 0.8m, row spacing 20 x 10 cm	37.1	42.78	5793
LD 0.8m, row spacing from lateral (5x20x30x20x5)	33.4	42.55	5408
LD 1.0m, row spacing 20 x 10 cm	32.7	40.48	4475
LD 1.0m, row spacing from lateral (7.5x15x15xEmptybed(25cm)x15x15x7.5)	31.6	39.96	4256
LD 0.8m, row spacing 20 x 10 cm + 30% more water	35.1	42.75	4896
LD 1.0m, row spacing 20 x 10 cm + 30% more water	33.8	42.00	4969
LD 0.8m, row spacing from lateral (5x20x30x20x5) with 0.6 lph drippers	30.0	38.78	4070
LD 1.0m, row spacing from lateral (7.5x15x15xEmptybed (25cm) x15x15x7.5) with 0.6 lph drippers	27.8	39.04	3819
IW/CPE ratio of 1.25 at 30 mm depth of irrigation	29.5	41.65	4612
Mean	33.0	41.20	4835
S.Ed.	0.164	1.049	82.5
CD<0.05	0.341	2.188	172.2

Table 3: Effect of root system on aerobic rice yield under drip treatments (N = 30)

	RL	RDW	RV	RP	RLD	RMD	SRL	ROP	R/S ratio	GY
RL	1	0.769**	0.374*	0.807**	0.859**	0.913**	-0.469**	0.854**	0.336	0.864**
RDW		1	0.307	0.771**	0.749**	0.784**	-0.895**	0.805**	0.812**	0.858**
RV			1	0.376*	0.452**	0.445**	-0.170	0.359*	0.048	0.318
RP				1	0.808**	0.864**	-0.678**	0.814**	0.419*	0.806**
RLD					1	0.870**	-0.524**	0.770**	0.386*	0.772**
RMD						1	-0.547**	0.872**	0.352*	0.865**
SRL							1	-0.587**	-0.864**	-0.691**
ROP								1	0.421*	0.800**
R/S ratio									1	0.505**
Yield										1

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed):; RL - Root Length; RDW - Root Dry Weight; RV - Root Volume; RP - Root Porosity; RLD - Root Length Density; RMD - Root Mass Density; SRL - Specific Root Length; ROP - Root Oxidizing Power; GY - Grain Yield

The root porosity was observed higher in treatment T_3 (38.28 %) followed by T_1 (37.78 %) over the other treatments. The root porosity recorded a higher level of significance (0.806**) with yield of drip irrigated aerobic rice. Higher root volume was observed in treatment T_3 (35.8 cc hill^{-1}) and lower volume in T_{11} (19.4 cc hill^{-1}). Nevertheless, lesser correlation was observed in root volume with grain yield (0.376) in the present study. The specific root length was observed from a range of 0.12 to 0.17. The root - shoot ratio is the function of assimilates allocation of rice crop.

The Total Dry Matter Accumulation of drip irrigated aerobic rice data showed that there was an increase in TDMA in T_3 (37.1 g hill^{-1}) followed by T_1 (37.0 g hill^{-1}) and lower accumulation in T_{10} (27.8 g hill^{-1}). The grain yield data of drip irrigated rice revealed that the higher yield was obtained in T_3 (5793.4 kg ha^{-1}) followed by T_1 (5554.1 kg ha^{-1}) and lesser yield recorded in T_{10} (3819.0 kg ha^{-1}) followed by T_9 (4070.0 kg ha^{-1}) (Table 2.). The root - shoot ratio was observed with the range of 0.10 to 0.13. In the present study the root shoot ratio recoded positive significance (0.505**) with yield (Table 3.).

DISCUSSION

The correlation analysis of root parameters with yield showed a greater impact on the importance of root in enhancing the grain yield in aerobic rice. Positive correlation existed between root surface areas or root length with yield was noted by Gao *et al.* (2005). The RLD and RMD are functional characteristics of rate of water and nutrient uptake in rice crop. Critical RLD depended on soil conditions, especially moisture (Siopongco *et al.*, 2005). Genotypic variation in the response of deep rooting to dry-down stress would exist even in lowlands where a hardpan layer exists; deep rooting is closely associated with plant water status under intermittent drought (Henry *et al.*, 2011).Al-Omran *et al.* (2004) with higher RLD observed similarly in subsurface drip irrigation than in the surface drip. The root volume is the functional characteristics of plant ability to permeate a large volume of soil. In the present study, an increase in root volume was observed in Rajesh and Thanunathan (2003). Negative correlation was observed in specific root length with the grain yield under aerobic rice. Enhanced root activity as evident from the presence of longer roots and higher root volume, which in turn increased total dry matter production and nutrient uptake (Rajesh and Thanunathan, 2003). The drip irrigated aerobic rice increased the root - shoot ratio. Similar increase was observed in upland rice condition (Singh *et al.*, 2000). Kanbar *et al.* (2009), based on canonical correlation studies conducted under contrasting moisture regimes, suggested that increased values for root depth, root-shoot ratio, and root dry weight conferred an advantage to grain yield under stress.

The increase in grain yield under drip irrigation of present experiment was in accordance with the previous work of Viraktamath (2006) in micro irrigated aerobic rice.In between the root characters with Specific Root Length (SRL) the negative and lesser positive correlation co efficient was observed under drip irrigated rice. Champoux *et al.* (1995) also reported low but significant negative correlations between root parameters viz., root thickness, root:shoot ratio, root dry weight per tiller, maximum root length and drought avoidance/tolerance in rice RIL population.

The drip irrigated aerobic rice study concluded that there is an increase in grain yield along with increased root parameters. Based on the data of altered row spacing and lateral spacing, discharge variations, the root characters of rice under drip showed significant and characteristic flexibility in roots of rice plant. The root length, RMD, root dry weight and root oxidizing power exhibited higher significant correlation with grain yield over the other root parameters. Higher yield was registered in 0.8 m lateral distance with 1.0 lph dripper treatments. It could be recommended that 0.8 m lateral distance, with 20x10 plant spacing along with 1.0 lph dripper treatment might be recommended for the water scarce environment to achieve better root growth and yield in aerobic rice.

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