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Interaction Effect of Root Characters and Yield in Crop Establishment Methods and Nutrient Management Practices in Low Land Rice

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Field experiment was carried out at wetland of Tamil Nadu Agricultural University, Coimbatore during *Kharif* (August-December) 2008. in factorial randomized block design with three replications. The treatments consisted of two establishment techniques (Direct planting system and drum seeding) and four levels of nutrient management practices (control (no manure), RDF, RDF+FYM and RDF+FYM+Biofertilizers). Direct planting system recorded higher root length, root volume, root mass density (RMD) and root length density (RLD) and higher number of white colour roots compared to drum seeding method of crop establishment. Application of recommended dose of fertilizers (150:50:50 NPK kg ha^{-1}), FYM 12.5 t ha^{-1}and biofertilizers (Azosphosmet @ 2 kg ha^{-1}) + PPFM (pink pigmented facultative methylotroph) @ 5 l ha^{-1} enhanced the root length, root volume, RMD and RLD over other treatments under Direct Planting System when compared with drum seeding method. The white colour roots were also higher under DPS than drum seeding method due to higher aeration created by rotary weeding with wider spacing which ultimately resulted in higher grain yield in direct planting system than over drum seeding method of crop establishment.

Key words: Rice Direct Planting System, Drum seeding, Nutrient management

Rice is the major staple cereal crop in India. It is the only cereal cultivated under different types of ecosystems. International Rice Research Institute classifies four broad ecosystems *viz.,* irrigated, rainfed lowland, upland and flood prone. Depending upon the ecosystem, the crop undergoes different methods of crop establishment within each ecosystem (Carriger and Vallee, 2007). The irrigated ecosystem, the predominant ecosystem, cultivated in about 49 M ha is patronized with many methods of stand establishments. Transplanting and direct seeding are the two well-known techniques. Transplanting has many methods like manual line planting, manual random planting, mechanical transplanting, system of rice intensification etc. Direct seeding can be categorized into wet seeding and dry seeding. Both these seedings are being performed by manual and mechanical means. Manual seeding further undergoes broadcasting and drilling (very limited extent only). Some of the direct seeding methods are, manual broadcasting, spot seeding or dibbling and row seeding by drum seeder under aerobic or surface wet seeding and anaerobic broadcasting and anaerobic drum seeding under anaerobic wet seeding (Rajendra Prasad, 2004).

Rice is grown mainly as a wetland crop by transplanting seedlings on to puddled fields. Transplanting is the most popular crop establishment method in Asia's irrigated rice-growing areas. Since labour has become a decisive cost factor, transplanting is increasingly being replaced by direct seeding into puddled soil (De Datta, 1986).

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Root health assessment is a measure of the quality and function of the roots as indicated by size, color, texture and the absence of symptoms and damage by root pathogens including the fungi *Fusarium, Pythium, Rhizoctonia, Thieviopsis* and plant-parasitic nematodes such as northern root-knot (Surendra Babu *et al.,* 2006).

Healthy roots are essential for vigorous plant growth and high yield by being efficient in mining the soil for nutrients and water, especially during stress-full conditions such as drought. Good soil tilth, and low populations and activities of root pathogens and other pests are critical for the development of healthy roots. Healthy roots also contribute to the active fraction of soil organic matter, promote rhizosphere microbial communities, contribute to increased aggregation, and reduced bulk density and soil compaction (Thakur *et al.,* 2006). It is necessary that any new crop establishment techniques need to be evaluated with interaction effect of root characters, nutrient uptake and yield for achieving higher productivity.

Materials and methods

Methodology

Field experiment was conducted in the wetland of TNAU, Coimbatore during *Kharif* (August to December), 2008. The experiment was laid out in a Factorial Randomized Block Design with three replications. The soil fertility status was low in available nitrogen (196.3 kg ha^{-1}), medium in available

phosphorus (20.4 kg ha^{-1}) and high in available potassium (450.2 kg ha^{-1}), respectively. Medium duration rice variety CO (R) 48 was used as a test variety in the present study. The treatment consists of drum seeding and direct planting system (DPS) along with no manure, RDF Recommended done of fertilizer (150:50:50 NPK kg ha^{-1}), FYM Farmyard manure (12.5 t ha^{-1}) and biofertilizers (Azosphosmet @ 2 kg ha^{-1}) + PPFM @ 5 l ha^{-1}. The PPFM spray was given on 45, 75 and 100 DAS. The field was puddled and perfectly levelled and adequate drainage facility was provided. A seed rate of 30 kg ha^{-1} was adopted. The sprouted seeds were uniformly broadcasted in criss cross direction. Careful water management practices were adopted in the first one week. Rotary weeder was used along the rows at 8 DAS to thin the plants in the rows of operation and across the rows at distance of 25 cm apart. Rotary weeding was repeated on 21 DAS. After second rotary weeding, the plants in the intersects were thinned out to one and the weeds removed manually.

Manually operated rice drum seeder developed by TNAU, Coimbatore was used. The seeder has two wheel at both the ends. It drops the seeds at 20 cm apart in continuous row. At a time, eight rows of rice seeds were sown.

Recommended dose of fertilizer at 150:50:50 kg N, P_2O_5, K_2O ha^{-1} was applied as per treatment schedule. The entire quantity of P was applied as basal as direct planting system DAP Diammanium phosphate. Nitrogen in the form of urea and potassium as muriate of potash were applied in four equal splits at basal, active tillering, panicle initiation and at flowering stages. The farm yard manure was applied @ 12.5 t ha^{-1} at last ploughing, incorporated and then leveled as per treatment. Azosphosmet @ 2 kg ha^{-1} was applied as basal dose (soil application) as per the treatment. Pink Pigmented Facultative Methylotroph (PPFM) was sprayed @ 1 ml/lit of water at active tillering, panicle initiation and at 50 per cent ear head emergence stages.

The roots were removed carefully from the soil without damage for measuring the total root length of each plant. The roots scooped along with soil and whole plant were washed in running water carefully and detached from the nodal bases. Any excess moisture adhering on the surface of the roots was removed wiping with blotting paper. Then, the volume of the roots was measured by volume displacement method and expressed as cc $hill^{-1}$. The root length density (RLD) and root mass density (RMD) were determined at different growth stages. For this, the method and the technique as developed by Pantuwan *et al*. (1997) was employed in the present study. Two adjacent hills were randomly selected before taking measurements. A root auger of 5 cm inner diameter and 50 cm length fabricated with galvanized iron tube was placed immediately next to a hill with less than 1 cm between the tiller and the tube. The soil sample to a depth of 45 cm was collected and placed on a 1 mm mesh screen. Then, the roots were washed free of soil using tap water. Roots present in the core sample auger were measured for their total length and its dry weight. Then, the RLD and RMD were calculated by dividing the length/ weight of roots present in per unit volume of soil up to a depth of 45 cm and the values expressed as cm cm^{-3} and mg cm^{-3} of the soil for RLD and RMD respectively.

Results and Discussion

Root length and root mass

Root growth is a good indicator of soil health. Root volume, root length density and root mass density varied significantly among methods of stand establishment. Similar results were reported by Zamir Ahmed *et al.* (2006) and Raghveer Rao *et al.* (2006). Direct planting system was recorded with higher values of the above parameters than drum seeded rice on hill basis. Wider spacing and soil aeration ensured by rotary weeding on either direction might have favoured better volume of root mass, whereas in drum seeding, the row spacing was closer and between plants also the spacing was too close than direct planting system, as a result the root volume per hill, root mass density were less in drum seeding method.

The SRI method of rice establishment is reported with higher root volume, root mass density similar to direct planting system, since direct planting system also provided the identical soil environment like that to SRI. Similar result was reported by Vijiyakumar (2003). Barison (2002) opined that appearance of more nodal roots for every newly formed tillers, and lead more developed root system. In this experiment, better root health is a joint effect of better soil aeration produced by rotary weeding and proper water management practices in accordance with young seedlings (Table 1 and 2).

Two way rotary weeding done under DPS with 25 cm wider spacing might have provided better soil aeration than drum seeding. Cono weeding resulted in increased soil aeration by increasing pore spaces and higher CEC of roots leading to increased root growth (Randriamiharison, 2002). In drum seeding, rotary weeding was used along the rows only. Moreover the space between rows was only 20 cm. Though the root mass and volume $hill^{-1}$ were less than DPS on hill basis, the total root mass occupied by this system on unit soil basis was higher than DPS.

Root colours

Colour of the roots at a given time of crop growth is another indicator of soil health (soil aeration). Water and nutrient management practices play vital role in deciding the soil health. Poor internal field drainage and continuous flooding drastically affects the root activity. The presence of white colour roots decreased proportionately towards maturity while black and brown colour roots increased. Root oxidizing power decreases as per study reported by Ramasamy *et al.* (1997). In this study also, root colours varied due to methods of stand establishment and

Table 1. The Root volume (cc hill^{-1}) and total root length (m hill^{-1}) as influenced by stands establishment and nutrient management practices in wet seeded lowland rice

Treatment	Root volume		Total root length	
	AT	PI	AT	PI
D_1N_1: DS- No manure	12.4	29.1	13.7	19.3
D_1N_2: DS- RDF	15.1	33.1	14.6	21.6
D_1N_3: DS- RDF + FYM @12.5 t ha^{-1}	19.2	32.3	15.4	22.2
D_1N_4: DS- RDF + FYM @12.5 t ha^{-1} + Biofertilizers	22.5	34.6	16.2	26.7
D_2N_1: DPS - No manure	22.6	30.8	15.2	25.5
D_2N_2: DPS - RDF	23.7	34.2	16.5	29.3
D_2N_3 : DPS - RDF +FYM @12.5 t ha^{-1}	25.4	34.9	17.3	31.5
D_2N_4: DPS - RDF +FYM @12.5 t ha^{-1}+ Biofertilizers	26.3	40.6	19.4	34.6
SEd	0.5	0.7	0.3	0.2
CD	1.1	1.4	0.5	0.5
Methods of stand establishment				
D_1 :Drum seeding with modified drum seeder	17.3	32.3	14.8	22.5
D_2 :Direct Planting System	75.5	35.1	17.1	30.2
SEd	0.2	0.3	0.1	0.1
CD	0.5	0.7	0.3	0.2
Nutrient management				
N_1: No manure	17.5	30.0	14.3	22.4
N_2: RDF	19.4	33.7	15.6	25.5
N_3: RDF + FYM @12.5 t ha^{-1}	22.3	33.6	16.4	26.9
N_4: RDF + FYM @12.5 t ha^{-1} + Biofertilizers	24.4	37.6	17.6	30.7
SEd	0.4	0.5	0.2	0.2
CD	1.3	1.0	0.4	0.4
D x N SEd	0.5	0.7	0.3	0.2
D x N CD	1.1	1.4	0.5	0.5

DS-Drum seeding, DPS-Direct Planting system RDF-Recommended dose of fertilizers (150:50:50 NPK kg ha^{-1})

AT- Active tillering, PI -Panicle initiation

nutrient management practices.

The method DPS maintained higher proportion of white roots with the combination of farm yard manure and biofertilizers. Chemical manuring deceased the white roots and enhanced brown roots compared to no manure under drum seeding technique. Brown colour roots were dominant than white and black. In general, white coloured roots decreased towards maturity and black ones increased. Relatively higher proportions of white roots were recorded in DPS with farm yard manure and biofertilizers which indicated the presence of better soil aeration than drum seeding (Table 3).

Higher root mass, less soil aeration might be the reasons for lesser white roots. Higher proportions of black roots are indication of highly reduced soil aeration. Ramasamy *et al.* (1997) opined that poor internal field drainage, higher decaying root biomass due to anaerobic soil condition are the reasons for the poor root activity as measured by alpha napthylamine oxidizing power.

DPS had advantage to maintain root activity till maturity compared to drum seeded rice. Presence of higher microbial population through biofertilizers application might have enhanced the enzymatic activity and converted some amount of decayed root in the vicinity of rhizosphere to maintain root colour either brown or white depending upon the intensity of the microbial consortia established in the soil. Higher proportions of white roots are indication of highly

Table 2. The Root length density (cm cm^{-3}) and root mass density (mg cm^{-3}) as influenced by stand establishment and nutrient management practices in wet seeded lowland rice

Treatment	Root length density		Root mass density	
	AT	PI	AT	PI
D_1N_1: DS- No manure	2.83	5.13	3.10	4.33
D_1N_2: DS- RDF	3.73	5.63	3.67	4.33
D_1N_3: DS- RDF + FYM @12.5 t ha^{-1}	4.30	7.07	4.67	5.33
D_1N_4: DS- RDF + FYM @12.5 t ha^{-1} + Biofertilizers	5.20	8.47	5.17	5.80
D_2N_1: DPS - No manure	4.77	9.13	6.33	6.77
D_2N_2: DPS - RDF	5.97	11.23	8.17	9.33
D_2N_3: DPS - RDF +FYM @12.5 t ha^{-1}	7.73	11.73	8.70	9.80
D_2N_4: DPS - RDF +FYM @12.5 t ha^{-1}+ Biofertilizers	8.40	12.18	9.60	12.33
SEd	0.24	0.42	0.20	0.72
CD	0.51	0.89	0.42	1.54
Methods of stand establishment				
D_1 :Drum seeding with modified drum seeder	4.02	6.58	4.15	4.95
D_2 :Direct Planting System	2.25	11.07	8.20	9.56
SEd	0.12	0.21	0.10	0.36
CD	0.25	0.45	0.21	0.77
Nutrient management				
N_1: No manure	3.80	7.13	4.72	5.55
N_2: RDF	4.85	8.43	5.92	6.83
N_3: RDF + FYM @12.5 t ha^{-1}	6.02	9.40	6.68	7.57
N_4: RDF + FYM @12.5 t ha^{-1} + Biofertilizers	6.80	10.32	7.38	9.07
SEd	0.17	0.29	0.14	0.59
CD	0.36	0.63	0.30	1.09
D x N SEd	0.24	0.42	0.20	0.72
D x N **CD**	0.51	0.89	0.42	1.54

DS-Drum seeding, DPS-Direct Planting system

RDF- Recommended dose of fertilizers (150:50:50 NPK kg ha^{-1})

AT- Active tillering, PI - Panicle initiation

oxidised soil aeration. Ramasamy *et al.* (1997) opined that good field drainage, lower decaying root biomass due to aerobic soil condition are the reasons for the good root activity as measured by alpha napthylamine oxidizing power.

Hence, it may be concluded that the DPS had advantage to maintain root activity till maturity compared to drum seeded rice. Presence of higher microbial population through biofertilizers application might have enhanced the enzymatic activity and converted some amount of decayed root in the vicinity of rhizosphere to maintain root colour either brown or white depending upon the intensity of the microbial consortia established in the soil.

Grain yield

Direct Planting System of crop establishment technique produced significantly higher yield (6914 kg ha^{-1}) compared to drum seeding method (5817 kg ha^{-1}).

Application of manure had positive impact on grain yield. Scheduled fertilizer application improved the grain yield significantly (6002 kg ha^{-1}). It further enhanced the grain yield when FYM 12.5 t ha^{-1} was combined (6529 kg ha^{-1}). A combined of application

Table 3. Stand establishment and nutrient management practices influence on root colours in wet seeded lowland rice

Treatment	Active tillering (%)			Grain yield (t/ ha)
	Black	White	Brown	
D_1N_1: DS- No manure	37.00	30.67	32.33	4896
D_1N_2: DS- RDF	25.00	25.67	49.33	5546
D_1N_3: DS- RDF + FYM @12.5 t ha^{-1}	21.33	25.33	53.33	6033
D_1N_4: DS- RDF + FYM @12.5 t ha^{-1} + Biofertilizers	20.00	28.33	51.67	6791
D_2N_1: DPS - No manure	28.67	20.00	53.33	6191
D_2N_2: DPS - RDF	25.00	24.67	50.33	6458
D_2N_3: DPS - RDF +FYM @12.5 t ha^{-1}	23.33	25.00	51.67	7025
D_2N_4: DPS - RDF +FYM @12.5 t ha^{-1}+ Biofertilizers	13.67	35.00	51.33	7983
SEd	1.96	0.61	1.84	81
CD	4.18	1.30	3.94	174
Methods of stand establishment				
D_1 :Drum seeding with modified drum seeder	25.83	27.50	46.67	5817
D_2 :Direct Planting System	22.67	26.17	51.67	6914
SEd	0.97	0.30	0.92	40
CD	2.09	0.65	1.97	87
Nutrient management				
N_1: No manure	32.83	25.33	42.83	5544
N_2: RDF	25.00	25.17	49.83	6002
N_3: RDF + FYM @12.5 t ha^{-1}	22.33	25.17	52.50	6529
N_4: RDF + FYM @12.5 t ha^{-1} + Biofertilizers	16.83	31.67	51.50	7387
SEd	1.38	0.43	1.30	57
CD	2.95	0.92	2.78	123
D x N SEd	1.96	0.61	1.84	81
D x N CD	4.18	1.30	3.94	174

DS-Drum seeding, DPS-Direct Planting system RDF-Recommended dose of fertilizers (150:50:50 NPK kg ha^{-1})

scheduled fertilizer + FYM + biofertilizers further enhanced the grain yield (7387 kg ha^{-1}) over crop establishment methods. The yield increase under combined nutrient management practice was much higher under DPS (38.7 per cent) than direct seeding technique (28.9 per cent) compared to the yield under no manured crop.

Application of farm yard manure and biofertilizers enhanced the microbial consortia, improved the root biomass and root colour from black to brown and brown to white in DPS and hence the improvement in per cent of grain yield from the no manure to nutrient management practices compared to drum seeded rice.

From the study, it is inferred that in low land rice, higher white colour roots (soil aeration) contributed to higher yield in DPS over drum seeding of crop establishment with application of RDF (150:50:50 NPK kg ha^{-1}) + FYM (12.5 t ha^{-1}) + biofertilizers (Azosphosmet @ 2 kg ha^{-1}) with three spray of PPFM @ 5 l ha^{-1}on 45, 75 and 100 DAS.

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