The Pharma Innovation Journal 2020; 9(7): 305-308

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(7): 305-308

www.thepharmajournal.com
Received: 16-05-2020
Accepted: 18-06-2020

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Effects of planting time and nitrogen management on expression of root growth, yield and quality of high protein rice during wet season

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Abstract
Studies on effect of different planting time (July, July-August and August) and nitrogen management of 100% RDN and 150% RDN with 2 different splits (1/2+1/4+1/4 and or 1/3+1/3+1/3) on the growth, yield and quality of high protein rice, was conducted during wet season of 2017 and 2018 at the research farm, National Rice Research Institute, Cuttack, Odisha.
The crop transplanted on August (late planting) was recorded significantly higher root length and root volume at 60 DAT, 90 DAT and at harvest during 2017, 2018 and in pooled data. Significantly higher grain yield was recorded with late planting (August) during 2017, 2018 and in pooled data followed by normal planting (July-August) during 2017 and in pooled data, and early planting (July) during 2018. Crop fertilized with 150% RDN in 3 splits (1/2+1/4+1/4) was recorded higher root length, root volume at 30, 60, 90 DAT and at harvest during both years and in pooled data, however, it was at par with 150% RDN in 3 splits (1/3+1/3+1/3). Minimum root length, root volume was recorded under control (No nitrogen) at 30, 60, 90 DAT and at harvest during 2017, 2018 and in pooled data. Significantly higher grain yield and ASV was recorded with application of 150% RDN in 3 splits (1/2+1/4+1/4) and lower was recorded with control (No nitrogen) during 2017, 2018 and in pooled data.

Keywords: Root length, root volume, alkali spreading value (ASV) and grain yield

Introduction
Rice is the staple food in Asia but also the single biggest user of freshwater. It is mostly grown under submerged soil conditions and requires more water compared with other crops. The demand for rice in India is increasing due to changes in eating habits and increasing urban population. Rice production is affected by various meteorological variables like rainfall, temperature and solar radiation etc (Ji *et al.*, 2007) [5]. This phase was longer under lower temperatures, and varied from 14 to 42 days depending on cultivar and temperature (26-32 °C) in the experiment reported by Collinson *et al*. (1992) [6]. In India, optimum temperatures for plant height (25 °C), tillering (25–31 °C), anthesis (30– 32 °C) and ripening (20–25 °C) of rice are reported by Ray (1968) and Robertson (1976) [9]. Ghose *et al*. (2004) reported that suitable temperature for milking to dough stage (25-29 °C) increased grain yield.
Timing of N, split application, methods, and depths of N applications are the key issues, which have to be considered for maximized N use efficiency. The effects of different N fertilizer practices on growth and grain yield were evaluated to assess the appropriateness of the current N fertilizer practice with the aim to improve rice grain yield. The applied N fertilizer can be either taken up by the crop or lost to the environment. High N levels have been shown to increase fine-root length and surface area in root, which may potentially enhance nutrient and water acquisition from the soil. Furthermore, N is likely to have complementary effects on root morphology development because it stimulates root elongation. Longer fine roots are more efficient in nutrient acquisition than shorter fine roots and allow plants to form larger root systems; whereas thicker roots may provide benefits in infertile or competitive environments. Thus, the objective of this study was to examine different planting time and different split application of nitrogen affects root growth, yield and quality of high protein rice.

Material and Methods
The field experiment was conducted at National Rice Research Institute, Cuttack, Odisha, India (20°25/N, 85°55/E) at an elevation 24 m above mean sea level from 2017 and 2018. Total rainfall during wet season 2017 and 2018 was 1034 mm and 1326 mm, respectively.

It was sufficient and favorably well distributed during 2018, but less rainfall was received during wet season 2017. The maximum temperature during wet season 2017 and 2018 was 20.2 to 35.8 ºC and 24 to 35 ºC and the minimum temperature of the respective years in wet season was 12.1 to 28.1 ^{0}C and 20 to 30 ^{0}C. During wet season 2017 the maximum relative humidity varied 61 to 98% and the minimum was 44 to 98%, and the wet season 2018 was80 to 98and 45 to 90%, respectively. The soil of the experiment field was sandy loam containing 0.512% organic carbon determined by Wakley and Black rapid titration method and 6.29 pH determined by Glass electrode method (pH meter) (Piper, 1967). The field experiment was conducted during wet season 2017 and 2018, laid out in split plot design. Treatment consisted of three planting time *i.e.* T_1- Early planting 15 days before normal planting (July or early planting), T_2 - Normal planting (July-August) and T_3- 15 days after normal planting (August or late planting) and five nitrogen management *i.e.* S_1- 100% RDN (100:50:50 kg ha^{-1}) in 3 splits (1/3+1/3+1/3), S_2- 100% RDN in 3 splits (1/2+1/4+1/4), S_3- 150% RDN in 3 splits (1/3+1/3+1/3), S_4- 150% RDN in 3 splits (1/2+1/4+1/4) and S_5- Control (No nitrogen). The recommended dose of fertilizer (RDF) is 100:50:50:25 kg NPK ha^{-1} was applied in the form of neem coated urea, single super phosphate (SSP), muriate of potash (MOP) and $ZnSO_4$. One third or half dose of the nitrogen, entire dose of phosphorus, potash and zinc were applied at basal dose, remaining nitrogen was applied in during active tillering and panicle initiation stage. Neem coated urea and MOP was broadcasted along the field and SSP was incorporated in the root zone of plants. Test variety 'CR Dhan311' high protein rice cultivar developed by National Rice Research Institute, cuttack, Odisha. It is a semi-dwarf, medium duration variety (120-126 days).

Results and Discussion

Root length

The data presented in table 1 revealed that effect of different planting time and nitrogen management at 30, 60, 90 DAT and at harvest during 2017, 2018 and in pooled data. Root growth, elongation and development hill^{-1} increased up to 90 DAT and thereafter it was declined. Non significant differences among planting time were recorded due to different planting time at 30 DAT during 2017, 2018 and in pooled data. Maximum root length was recorded with late planting (August) (P_3) at 60 DAT (23.40, 22.35 and 22.87 cm), 90 DAT (28.69, 28.97 and 28.83 cm) and at harvest (26.63, 27.27 and 26.95 cm) during 2017, 2018 and in pooled data followed by normal planting (July-August) (P_2) during 2017 and in pooled data and early planting (July) during 2018. Minimum root length was recorded in early planting (July) during 2017 and in pooled data, and in normal planting (July-August) during 2018 at 60 DAT, 90 DAT and at harvest.

In the present study, optimum N fertilizer and N availability had a favourable impact on root growth, root elongation and higher root development after that to increases root biomass production. Significantly higher root length was recorded with application of 150% RDN in 3 splits (1/2+1/4+1/4) (N_4) at 30 DAT (21.26, 20.44 and 20.85 cm), 60 DAT (23.89, 23.67 and 23.78 cm) and at 90 DAT (29.52, 30.92 and 30.22 cm) during 2017, 2018 and in pooled data, respectively. However, it was statistically at par with 150% RDN applied in 3 splits (1/3+1/3+1/3) (N_3) at 30, 60 and 90 DAT during both the years and in pooled data. Whereas, significantly highest root length was observed with 150% RDN applied in 3 splits (1/2+1/4+1/4) at harvest (28.94, 28.33 and 28.63 g) followed by 150% RDN applied in 3 splits (1/3+1/3+1/3) during both the years and in pooled data. Minimum root length was recorded with control (N_5) at the entire interval of observations during 2017, 2018 and in pooled data. Similar findings were also reported by Maheswari *et al.,* (2007) [3].

Root volume

Maximum root volume was recorded in late planting (August) (P_3) at 60 DAT (56.93, 55.13 and 56.03 cm^3 hill^{-1}), 90 DAT (62.93, 63.87 and 63.40 cm^3 hill^{-1}) and at harvest (52.93, 53.27 and 53.10 cm^3 hill^{-1}) during 2017, 2018 and in pooled data, respectively followed by normal planting (July-August) (P_2) during 2017 and in pooled data and by early planting (July) during 2018 (Table 2). Minimum root dry weight was recorded in early planting (July) during 2017 and in pooled data, and in normal planting (July-August) during 2018 at 60 DAT, 90 DAT and at harvest.

Higher root volume was recorded with application of 150% RDN in 3 splits (1/2+1/4+1/4) (N_4) at 30 DAT (16.48, 17.67 and 17.07 cm^3 hill^{-1}), 60 DAT (60.44, 58.89 and 59.67 cm^3 hill^{-1}), 90 DAT (65.22, 63.67 and 64.44 cm^3 hill^{-1}) and at harvest (57.00, 54.00 and 55.50 cm^3 hill^{-1}) during 2017, 2018 and in pooled data, respectively. However, it was at par with application of 150% RDN applied in 3 splits (1/3+1/3+1/3) (N_3) and with 100% RDN applied in 3 splits (1/2+1/4+1/4) at all the interval of observations during both the years and in pooled data except at 30 and 60 DAT during 2018 and in pooled data. Minimum root volume was recorded with control (N_5) at the entire interval of observations during 2017, 2018 and in pooled data. Anil *et al*., (2018) [1] reported that highest root volume and dry weight was recorded with application of 240 kg N ha^{-1} which is on par with 180 kg N ha^{-1} and significantly superior to 120 kg N ha^{-1}.

Alkali spreading value (ASV)

Alkali spreading value of high protein rice did not differ significantly due to different planting time during 2017, 2018 and in pooled data (Fig. 3).

Higher alkali spreading value (3.78 and 3.72) was recorded with application of 150% RDN in 3 splits (1/2+1/4+1/4) (N_4) during 2018 and in pooled data, respectively which was at par with 150% RDN in 3 splits (1/3+1/3+1/3) (N_3). Minimum alkali spreading value of 3.00 and 3.06 was recorded under control (N_5- No nitrogen) during 2018 and in pooled data, respectively which was statistically at par with N_1 (3.00 and 3.11). The alkali value of grain did not differ significantly due to nitrogen management during 2017. Haripriya *et al*. (2017) [8] reported that Alkali spreading values in turn shows a strong inverse relation to gelatinization temperature which is frequently used as a mean for placing varieties into low, intermediate and high cooking temperature classes.

Grain yield

The grain yield of rice is a function of total number of panicles, number of grains panicle^{-1} and the test weight, which was significantly influenced by planting time and nitrogen management (Fig. 1 and 2). Late planting (August) registered maximum grain yield followed by normal planting (July-August) during 2017 and in pooled data, and early planting (July) during 2018. Minimum grain yield was recorded with early planting during 2017 and in pooled data, and normal planting during 2018. Application of 150% RDN in 3 splits

(1/2+1/4+1/4) produced maximum grain yield, which was at par with 150% RDN in 3 splits (1/3+1/3+1/3). Minimum grain yield was recorded under control (No nitrogen) during 2017, 2018 and in pooled data. Ayub (1994) [2] and Maqsood (2000) [4] also reported that grain yield increased significantly with the application of nitrogen fertilizer.

Table 1: Root length (g hill^{-1}) at 30, 60, 90 DAT and at harvest of high protein rice as influenced by planting time and nitrogen management during wet season

Treatments	Root length (g hill^{-1})											
	30 DAT			60 DAT			90 DAT			At harvest		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
Planting time												
P_1	19.75	19.07	19.41	19.60	21.73	20.66	26.82	27.22	27.02	25.12	24.67	24.90
P_2	19.42	19.00	19.21	21.93	21.13	21.53	27.38	27.07	27.23	25.34	24.60	24.97
P_3	18.29	18.67	18.48	23.40	22.35	22.87	28.69	28.97	28.83	26.63	27.27	26.95
SEm±	0.49	0.53	0.40	0.47	0.15	0.23	0.19	0.38	0.22	0.23	0.57	0.36
CD (P=0.05)	NS	NS	NS	1.84	0.59	0.89	0.75	1.48	0.88	0.90	2.25	1.42
Nitrogen management												
N_1	18.57	18.11	18.34	21.00	21.99	21.49	27.57	26.17	26.87	25.15	24.90	25.02
N_2	18.64	19.33	18.99	21.44	21.69	21.57	28.44	26.92	27.68	25.59	25.99	25.79
N3	20.11	20.22	20.17	22.33	22.97	22.65	28.70	30.27	29.48	25.65	26.09	25.87
N_4	21.26	20.44	20.85	23.89	23.67	23.78	29.52	30.92	30.22	28.94	28.33	28.63
N_5	17.18	16.44	16.81	19.56	18.37	18.96	23.95	24.48	24.21	23.16	22.24	22.70
SEm±	0.591	0.648	0.386	0.659	0.507	0.415	0.580	0.488	0.432	0.723	0.581	0.474
CD (P=0.05)	1.73	1.89	1.13	1.92	1.48	1.21	1.69	1.42	1.26	2.11	1.70	1.38

P_1- Early planting 15 days before normal planting (July), P_2 - Normal planting (July-August), P_3- 15 days after normal planting (August)
N_1- 100% RDN (100:50:50 kg ha^{-1}) 3 splits (1/3+1/3+1/3), N_2- 100% RDN in 3 splits (1/2+1/4+1/4), N_3- 150% RDN in 3 splits (1/3+1/3+1/3), N_4- 150% RDN in 3 splits (1/2+1/4+1/4), N_5- Control (No nitrogen)

Table 2: Root volume (cm hill^{-1}) at 30, 60, 90 DAT and at harvest of high protein rice as influenced by planting time and nitrogen management during wet season

Treatments	Root volume (cm hill^{-1})											
	30 DAT			60 DAT			90 DAT			At harvest		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
Planting time												
P_1	13.94	15.47	14.71	51.53	51.80	51.67	58.33	57.53	57.93	48.20	47.93	48.07
P_2	14.87	15.00	14.93	54.73	51.00	52.87	59.73	57.40	58.57	48.93	47.27	48.10
P_3	15.93	16.20	16.07	56.93	55.13	56.03	62.93	63.87	63.40	52.93	53.27	53.10
SEm±	0.54	0.27	0.34	0.54	0.74	0.34	0.59	1.32	0.72	0.75	1.12	0.82
CD (P=0.05)	NS	NS	NS	2.10	2.91	1.35	2.33	5.18	2.83	2.94	4.38	3.24
Nitrogen management												
N_1	14.50	14.33	14.42	51.78	48.11	49.94	57.89	59.56	58.72	48.11	48.67	48.39
N_2	15.06	15.67	15.36	55.22	52.00	53.61	61.33	61.44	61.39	51.00	50.33	50.67
N_3	16.13	16.33	16.23	58.67	57.89	58.28	63.56	62.78	63.17	52.22	51.44	51.83
N_4	16.48	17.67	17.07	60.44	58.89	59.67	65.22	63.67	64.44	57.00	54.00	55.50
N_5	12.41	13.78	13.09	45.89	46.33	46.11	53.67	50.56	52.11	41.78	43.00	42.39
SEm±	0.550	0.534	0.461	2.137	1.439	1.222	1.332	2.364	1.424	2.782	2.030	2.318
CD (P=0.05)	1.73	1.89	1.13	6.24	4.20	3.57	3.89	6.90	4.16	8.12	5.93	6.77

P_1- Early planting 15 days before normal planting (July), P_2 - Normal planting (July-August), P_3- 15 days after normal planting (August)
N_1- 100% RDN (100:50:50 kg ha^{-1}) 3 splits (1/3+1/3+1/3), N_2- 100% RDN in 3 splits (1/2+1/4+1/4), N_3- 150% RDN in 3 splits (1/3+1/3+1/3), N_4- 150% RDN in 3 splits (1/2+1/4+1/4), N_5- Control (No nitrogen)

Table 3: Alkali spreading value and grain yield of high protein rice as influenced by planting time and nitrogen management during wet season

Treatments	Alkali spreading value			Grain yield (q ha^{-1})		
	2017	2018	Pooled	2017	2018	Pooled
Planting time						
P_1	3.33	3.27	3.30	42.83	44.43	43.63
P_2	3.40	3.33	3.37	48.66	41.33	45.00
P_3	3.47	3.40	3.43	51.71	49.23	50.47
SEm±	0.13	0.09	0.05	1.26	0.87	0.93
CD (P=0.05)	NS	NS	NS	4.95	3.43	3.64
Nitrogen management						
N_1	3.22	3.00	3.11	44.93	44.07	44.50
N_2	3.33	3.22	3.28	46.87	44.98	45.92
N_3	3.67	3.67	3.67	53.54	48.58	51.06
N_4	3.67	3.78	3.72	56.09	50.68	53.38
N_5	3.11	3.00	3.06	37.24	36.69	36.97
SEm±	0.165	0.136	0.105	2.03	1.40	1.09
CD (P=0.05)	NS	0.40	0.31	5.93	4.08	3.17

P_1- Early planting 15 days before normal planting (July), P_2 - Normal planting (July-August), P_3- 15 days after normal planting (August)
N_1- 100% RDN (100:50:50 kg ha^{-1}) 3 splits (1/3+1/3+1/3), N_2- 100% RDN in 3 splits (1/2+1/4+1/4), N_3- 150% RDN in 3 splits (1/3+1/3+1/3), N_4- 150% RDN in 3 splits (1/2+1/4+1/4), N_5- Control (No nitrogen)

Conclusion

It may be concluded that, the growth parameters *viz*. root length and root volume were higher in rice crop transplanted during August. Maximum grain yield can be obtained by late planting (August) with application of 150% RDN in 3 splits (1/2+1/4+1/4).

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