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Performance of Rice Establishment Methods and Nutrient Management Practices on Growth, Yield and Nutrient uptake of Rice (*Oryza sativa* L.)

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Abstract: A field experiment was conducted during *Kharif* seasons of 2018 and 2019 at Rice Research Farm of Birsa Agricultural University, Ranchi, Jharkhand to evaluate the performance of rice establishment methods and nutrient management practices on growth, yield attributes, yield and total nutrient uptake of rice. The wet direct seeding of rice using drum seeder manifested higher number of total tillers/m^2(267), leaf area index (3.58), dry matter accumulation (1292.20 g/m^2), crop growth rate (8.53g/m^2/day), panicles/m^2 (251), panicle weight (3.38g), total grains/panicle (117), grain yield (42.19 q/ha), straw yield (65.22 q/ha) and nutrient uptake of nitrogen (96.13 kg/ha), phosphorus (16.47 kg/ha) and potassium (95.42 kg/ha) which were comparable with normal transplanting but establishes its distinct superiority over aerobic rice. Among the different nutrient management practices, RDF + 25% N through FYM produced maximum growth, yield attributes, yield and nutrient uptake which was comparable with LCC based N application. However, both of the nutrient management practices viz. RDF + 25% N through FYM and LCC based N application led to significantly higher total tillers^2 leaf area index, dry matter accumulation, crop growth rate, panicle/m^2, panicle weight, total grains/panicle, grain yield, straw yield, nitrogen, phosphorus, and potassium uptake than other nutrient management practices viz RDF and 75% RDF + 25% N through FYM and control.

Keywords: Aerobic rice, Crop growth rate, Leaf Colour Chart, Rice establishment method

Rice (*Oryza sativa* L.), a high calorie *kharif* cereal is an essential diet constituent for more than half of the world's production and a basic food crop in the world which directly supply more than 50% of the calories consumed by the entire human population. Human consumption accounts for 85% of total production of rice which provides 21% of global human per capita energy and 15% of per capita protein. Rice also provides minerals, vitamins and fibre, although all constituents except carbohydrates are reduced by milling. Rice production in India is an important part of the national economy. The world's total rice area is 167 million ha and production are about 782 million tons with productivity of 4.67 Mt/ha. The productivity of rice in Southeast Asia is 4.41 tons/ha and China is the largest producer (FAOSTAT 2018). India ranks first in acreage (43.1 m ha) and second in production (96.43 mt) only after China (Directorate of Economics Statistics 2017).Rice is the most important crop to millions of small farmers grown in millions of hectares throughout the region, and to the many landless workers who derive income from working on these farms. Since, the rice production area either remain steady or declining, reflecting a huge gap between the projected demand and present-day production level. The only way to reduce this gap is through enhancing vertical production level by applying scientific approach to farming. The rice establishment methods and appropriate nutrient management practices is one of the practically feasible technologies to enhance rice production. In Jharkhand, more than 80 percent of agricultural area is under rainfed and the late arrival of monsoon usually delays the seedling graising and transplanting operation resulting in lower yield. Under these circumstances, wet direct seeding of rice through drum seeder may be an alternative to transplanting in boosting the rice production. Wet direct seeding of rice through drum seeder is a successful cultivation method which not only boosts the productivity but also conserves water along with reducing the labour requirement thereby proved more economical as compared to normal transplanting. Nutrient management is a major component of soil and crop management system in rice**.** Excessive use of inorganic fertilizers has apparently depleted the fertility status of the soil so appropriate nutrient management practices in rice establishment methods are of utmost importance. Nitrogen is one of the most volatile nutrients presents in the soil subjected to different type of

losses. For need based nitrogen management, plant-based tools such as leaf colour chart (LCC) is gaining popularity for nitrogen management in rice which suggests the dose and time of nitrogen application as per the need of the crop. The intensity of leaf colour is directly proportional to chlorophyll content of leaf which indirectly related to status of leaf nitrogen (Alam et al 2005). However, among the different tools available for measurement of leaf greenness, the non-destructive measurement of green colour intensity of leaf using leaf colour charts (LCC) is most suitable. Thus, adoption of suitable establishment methods and appropriate nutrient management practices can bring tremendous change in agricultural scenario through enhancing the rice productivity and improvement of rural economy.

MATERIAL AND METHODS

A field experiment was undertaken at Rice Research Farm of Birsa Agricultural University, Kanke, Ranchi for two consecutive years during *kharif* season of 2018 and 2019. The soil was clay loam in texture with 37.1, 29.7 and 33.2% sand, silt and clay composition and slightly acidic (6.2) in reaction , medium in organic carbon (4.3 g/kg), available nitrogen (230.00 kg/ha), available phosphorous (36.80 kg/ha), available potassium (161.20 kg/ha) of content. The experiment was laid out in split plot design replicated thrice with rice variety Naveen as test crop. The treatments combination consists of three different rice establishment methods *viz.,* normal transplanting, wet direct seeding of sprouted seeds in puddle field using drum seeder and aerobic rice assigned to main plots and five nutrient management practices *viz.,* Recommended dose of fertilizer (RDF) (80:40:20 Kg NPK/ha), 75% RDF + 25% N through Farm yard manure (FYM), RDF + 25% N through FYM, LCC based nitrogen application and control (no fertilizer) assigned to sub plots. Good quality seeds of cultivar Naveen 50 kg/ha were sown on well-prepared nursery bed for transplanting method of establishment. Twenty-one days old 2-3 seedlings/hill were transplanted manually in the puddled field at a depth of 2-3 cm with a spacing of (20 cm× 15 cm). There were 20 rows in each transplanted plot. Direct sowing of the sprouted seeds through drum seeders under puddled condition is known as drum seeding**.** In the present investigation, the field preparation and puddling matched that of transplanted rice. On pulling the seeder, seeds were placed on the soil surface at a distance of 20 cm between rows. The IRRI 8 row plastic drum seeder was used in the experiment which consisted of four rotating drums with circular holes at the two edges. In aerobic rice treatment, seeds were soaked in water for 10 hours followed by incubation for another 12 hours. After those seeds were treated with carbendazim @ 2 g/kg seed before sowing. Then, line sowing of rice was done with 20 cm row spacing. Irrigate the field immediately after sowing. The field was maintained near saturation without stagnation of water.

Well rotten farm yard manure was applied prior to sowing or transplanting of rice crop, as per the treatment and thoroughly mixed in soil. Full dose (80:40:20 Kg NPK/ha) of phosphorus and potassium and 25% of nitrogen was applied as basal in wet-direct seeded and aerobic rice while 50% of nitrogen with full dose of phosphorus and potassium was applied as basal in transplanted rice plots through urea, diammonium phosphate and murate of potash as per treatment dose. The remaining quantity of nitrogen was top dressed in two equal splits at tillering and at panicle initiation stage in all the establishment methods. In LCC based nitrogen application, full recommended dose of phosphorus, potassium and half of the recommended dose of nitrogen (40 kg/ha) was applied as basal and remaining nitrogen was top dressed at the rate of 13.33 kg N/ha applied thrice on 23rd, 45th and 61st days after sowing or transplanting when color of 6 out of 10 leaves fall below a threshold level of shade 4 on the leaf colour chart. Nominee Gold (bispyribac sodium) was applied @ of 25 g ai/ha (10% SC) at 20 days after sowing/transplanting in the experimental plots as post emergence herbicide to control the weed population. Need based plant protection measure were used for crop protection from insect and pests.

Plant sampling was done at 30, 60, 90 days after sowing or transplanting and at maturity to record the growth parameters such as total tillers/m^2, leaf area index and dry matter accumulation /m^2 while, the yield attributes viz. panicles/m^2, panicle weight, grains/panicle and 1000 grain weight and yield parameters viz. grain and straw yield were recorded at harvest. The crop growth rate was calculated.

$$Crop\ growth\ rate\ (CGR) = \frac{W2 - W1}{t2 - t1} \times \frac{1}{G}$$

Where W_1 and W_2 represent the dry weight of the plant at the beginning and end of the time interval $t_1$and$t_2$respectively. The G represent the ground area.

The plant samples collected at harvest were dried at 70^{0}C, powdered in willey mill and digested to analyze the nutrient compositions. The nitrogen, phosphorus and potassium content in plants were estimated by Kessler's reagent method, HNO_3:$HClO_4$ (9:4) digestion, colour development by Vandomolybdate solution followed by spectrophotometer determination and flame photometric determination after digestion in HNO_3:$HClO_4$(9:4) solution respectively. The nutrient uptake was estimated by multiplying the nutrient concentration with grain and straw yield. Addition of grain and straw nutrient uptake gave the total nutrient uptake by the plants.

RESULTS AND DISCUSSION

Total tillers/m^2: Total tillers per meter square increased with the crop age and reached peak at 60 Days after sowing or transplanting after which declined till maturity (Table 1). The reduction in tillers after 60 DAS/DAT was due to intra species competition for higher space and nutrients which are responsible for degeneration of late formed tillers (Chatterjee 2016). The establishment methods failed to cause significant difference in total tillers/m^2 at the early growth stages i.e., 30 DAS/T of rice. At later growth stages *i.e.* 60and 90 DAS/T and at maturity, wet direct seeding using drum seeder recorded maximum total tillers per meter square (276, 270 and 267) which was statistically at par with normal transplanting (267, 262 and 257). However, both of establishment methods viz. wet direct seeding through drum seeder and normal transplanting produced significantly higher tillers than aerobic rice (237, 231 and 227) at respective stages. Among the nutrient management practices, the maximum tillers per meter square was with RDF + 25% N through FYM (294, 291 and 284) followed by LCC based N application (291, 287 and 283) which was significantly higher than rest of the treatments. However, at 30 DAS/DAT, the application of nutrient under different nutrient management practices establishes significantly higher tillers number than control but, failed to cause significant variation in total tillers/m^2 among themselves.

Dry matter accumulation: Dry-matter accumulation of rice plant increased with the crop age and the maximum value was observed at harvest (Table 2). The rice establishment methods were unable to cause significant differences in dry matter accumulation at the initial period of growth i.e., 30 DAS/T. At subsequent growth stages i.e.60 and 90 DAS/DAT and at maturity, wet direct seeding using drum seeder recorded maximum dry- matter accumulation (512, 1022 and 1292 g/m^2) in plant but, remained at par with normal transplanting method. However, both of establishment methods viz. wet direct seeding using drum seeder normal transplanting method led to significantly higher dry matter accumulation than aerobic rice. The maximum dry matter accumulation with wet direct seeding using drum seeder might be owing to the fact that rice established through drum seeder leads to vigorous initial growth, optimum plant population and better weed control leads to availability of more resources to plants (Gangwar et al 2009).Among nutrient management practices, RDF + 25% N through FYM and LCC based N application due to higher tiller number and leaf area index led to higher dry matter accumulation than other nutrient management practices and control at 60 and 90 DAS/T and maturity. However, the nutrient management practices failed to cause significant variation among themselves except control at 30 DAS/DAT.

Leaf area index: The leaf area index increased successively as the growth progressed up to 90 DAS/DAT (Table 1). Leaf are index was not significantly influenced by establishment methods at 30 DAS/DAT while, at other stages viz. 60 and 90 DAS/DAT, wet direct seeding using drum seeder (2.68 and 3.58) being at par with normal transplanting method. However, both of these methods were superior in leaf area index as compared to aerobic rice establishment method. The higher leaf area index was recorded in transplanted rice

Table 1. Total tillers of rice and leaf area index as influenced by establishment methods and nutrient management practices

Treatments	Tillers count / m^2				Leaf area index		
	30 DAS/T	60 DAS/T	90 DAS/T	Maturity stage	30 DAS/T	60 DAS/T	90 DAS/T
Establishment methods							
Normal transplanting	122	267	262	257	1.31	2.62	3.48
Wet direct seeding using drum seeder	142	276	270	267	1.45	2.68	3.58
Aerobic rice	134	237	231	227	1.38	2.30	3.29
CD (p=0.05)	NS	22.36	13.75	24.40	NS	0.30	0.18
Nutrient management practices							
RDF (80:40:20 kg NPK/ha)	143	271	259	259	1.37	2.48	3.51
75% RDF + 25% N through FYM	139	262	257	254	1.35	2.43	3.52
RDF + 25% N through FYM	153	294	291	284	1.48	2.78	3.77
LCC based Nitrogen application	150	291	287	283	1.46	2.76	3.75
Control (No fertilizer)	78	181	179	172	1.23	2.21	2.71
CD (p=0.05)	16.44	18.76	22.18	23.77	0.15	0.26	0.22
CV%	12.74	7.42	8.96	9.76	11.10	10.40	6.62

which was significantly higher over dry seeded rice at harvest stage (Rajvanshi et al 2021). Among different nutrient management practices, there was no significant difference observed in leaf area index between nutrient management practices at 30 DAS/DAT except control which is significantly lower than rest of the treatments. At 60 and 90 DAS/DAT, nutrient management through application of RDF + 25% N through FYM (2.78 and 3.77) and LCC based N application (2.76 and 3.75) were at par among themselves and recorded significantly more leaf area index than RDF and 75% RDF + 25% N through FYM and control. The higher leaf area index with RDF + 25% N through FYM and LCC based N application might be due to higher number of tillers putting forth more leaves resulting in higher leaf area index.

Crop growth rate (g/m^2/day): Crop growth rate (CGR) of rice increased with the crop age up to 60-90 DAS/DAT and thereafter declined (Table 2). The rice establishment methods through wet direct seeding using drum seeder recorded maximum crop growth rate at all the growth stages which was superior to aerobic rice at 30-60 DAS/DAT (10.65 g/m^2/day) and 90 DAS-at maturity (8.53 g/m^2/day) but, statistically similar to normal transplanting at the respective growth stages. However, at 60-90 DAS/DAT the different rice establishment methods were unable to cause significant statistical differences in crop growth rate and remained at par between themselves. Among nutrient management practices, RDF + 25% N through FYM (12.15 g/m^2/day) and LCC based N application (12.14g/m^2/day)were at par among themselves but, proved their significant superiority over other nutrient management practices and control at 30-60 DAS/DAT while, at 60-90 DAS/DAT all of the nutrient management practices were statistically similar in respect of crop growth rate but, recorded significantly higher crop growth rate than control. However, the significance of nutrient management practices and control were found to be non-significant at 90 DAS/DAT-at maturity. The higher crop growth rate with RDF + 25% N through FYM and LCC based N application might be due better vegetative growth at all the growth stages.

Yield attributes: Significant improvement in yield attributes (Table 3) i.e., number of panicles per meter square (251), panicle weight (3.38 g) and number of grains/panicle (117) was recorded under wet direct seeding using drum seeder as compared with aerobic rice. The wet direct seeding using drum seeder also registered significantly higher number of grains/panicle than normal transplanting (111). However, wet direct seeding using drum seeder and normal transplanting method being *at par* among themselves in respect of number of panicles and panicle weight. The 1000 grain weight of rice was found to be unaffected by different rice establishment method. Among the nutrient management practices, RDF+ 25% N through FYM (277, 3.60 g and 120)was significantly superior to RDF and 75%RDF+ 25% N through FYM and control in respect of number of panicles per meter square, panicle weight and number of grains/panicles but remained at par with LCC based N application. The higher yield attributing characters with application of RDF+ 25% N through FYM might be due to integration of farm yard manure with inorganic sources would have resulted in slow release of nutrient and increased availability which in turn might have

Table 2. Dry-matter accumulation in plant and crop growth rate as influenced by establishment methods and nutrient management practices

Treatments	Dry matter accumulation (g/m2)				Crop growth rate (g/m2 /day)		
	30 DAS/T	60 DAS/T	90 DAS/T	Maturity stage	30 DAS/T	60 DAS/T	90 DAS/T
Establishment methods							
Normal transplanting	184.42	501.80	1008.00	1249.40	10.58	17.34	7.58
Wet direct seeding using drum seeder	192.44	512.00	1022.20	1292.20	10.65	17.47	8.53
Aerobic rice	189.70	458.40	955.40	1149.80	8.96	17.03	6.01
CD (p=0.05)	NS	41.71	50.41	46.34	1.45	NS	2.01
Nutrient management practices							
RDF (80:40:20 kg NPK/ha)	190.90	517.33	1094.00	1338.33	10.88	20.39	6.98
75% RDF + 25% N through FYM	200.26	512.67	1075.67	1333.33	10.41	19.93	7.42
RDF + 25% N through FYM	203.20	567.67	1158.67	1406.67	12.15	19.70	8.27
LCC based Nitrogen application	200.61	564.67	1153.33	1403.67	12.14	19.62	8.34
Control (No fertilizer)	149.30	291.33	494.33	670.33	4.73	6.77	5.87
CD (p=0.05)	25.90	40.64	55.37	64.29	1.17	2.43	NS
CV%	14.10	8.51	5.72	5.37	11.90	14.44	44.73

Table 3. Yield attributing characters, yield and total N, P and K uptake of rice as influenced by establishment methods and nutrient management practices

Treatments	Panicles /m^2	Panicle wt. (g)	Total grains/ panicle	1000 grain wt.(g)	Yield (q/ha)		Total nutrient uptake (kg/ha)		
					Grain	Straw	Nitrogen	Phosphorou	Potassiun
Establishment methods									
Normal transplanting	248	3.29	111	24.22	39.49	61.89	88.52	15.23	88.84
Wet direct seeding using drum seeder	251	3.38	117	24.26	42.19	65.22	96.13	16.47	95.42
Aerobic rice	219	3.24	102	24.05	32.65	52.40	72.04	12.57	73.82
CD (p=0.05)	15.88	0.13	4.08	NS	4.43	5.21	9.01	1.74	9.74
Nutrient management practices									
RDF (80:40:20 kg NPK/ha)	251	3.35	111	24.15	41.32	66.32	92.17	16.11	94.57
75% RDF + 25% N through FYM	241	3.29	106	24.21	38.98	61.39	84.42	14.85	86.89
RDF + 25% N through FYM	277	3.60	120	24.36	46.33	71.53	107.34	18.46	105.28
LCC based nitrogen application	273	3.57	118	24.23	45.10	68.72	106.38	17.89	100.05
Control (No fertilizer)	154	2.70	94	23.95	18.80	31.22	37.51	6.48	43.33
CD (p=0.05)	19.22	0.12	4.71	NS	2.93	4.61	5.97	1.46	6.82
CV%	8.25	3.59	4.41	3.20	7.90	7.92	7.17	10.18	8.15

enhanced more photosynthates production and the translocation from source to sink and improved the yield attributing characters (Ramamoorthy et al 2000). Various nutrient management treatments also did not influence the 1000 grain weight.

Grain and straw yield: The rice establishment methods through wet direct seeding using drum seeder recorded pronounced effect on grain and straw yield of rice over aerobic rice (Table 3). However, the grain (42.19 q/ha) and straw yield (65.22 q/ha) was obtained with wet direct seeding using drum seeder was statistically at par with normal transplanting. The higher yield under wet direct seeding using drum seeder was due to adequate supply of resources which contributed towards higher dry matter accumulation and better portioning of photosynthate resulting in higher yield traits and ultimately the yield. Among the nutrient management practices, treatment with RDF +25% N through FYM produced highest grain (46.33 q/ha) and straw yield (71.53 q/ha), which was at par with LCC based N application. These two treatments produced significantly higher grain and straw yield than RDF (41.32 q/ha and 66.32 q/ha), 75% RDF + 25% N through FYM) and control. This might be due to favourable soil conditions and synchronized release of nutrients throughout the crop growth period resulted in enhanced growth and yield attributes which in turn increased grain and straw yield (Murali and Setty 2004).

Nutrient uptake: The rice establishment through wet direct seeding using drum seeder being comparable to normal transplanting led to significantly higher uptake of nitrogen, phosphorus and potassium than aerobic as the establishment of rice through drum seeding and transplanting removed higher amount of nutrients because of better environment available around the eco-rhizosphere as a result of pulverization of soil under a film of water and transplanting of rice seedlings in such an ideal environment might have enabled the crop to absorb native as well as applied nutrients incessantly to give an early lead to the growth of individual plants as well as higher nutrient content that resulted in higher nutrient uptake by transplanted and drum seeded rice (Kanthi et al 2014). Total nitrogen, phosphorus and potassium uptake were higher when the rice crop was raised with RDF + 25% N through FYM (107.34 kg/ha, 18.46 kg/ha and 105.28 kg/ha) and LCC based N application (106.38 kg/ha, 17.89 kg/ha and 100.05 kg/ha) which were statistically at par between themselves but, recorded significantly more total nitrogen, phosphorus and potassium uptake than rest of the nutrient management practices and control. Increase uptake of nutrient with higher nutrient doses was owing to increased availability of nutrients facilitating better root growth and as such better nutrient uptake (Singh et al 2011)

CONCLUSION

The wet direct seeding of rice using drum seeder is the most suitable method of rice establishment and application of RDF (80:40:20 kg NPK/ha) + 25% N through FYM or LCC based N application are the most suitable nutrient management practices having the potential to enhance the rice productivity and serve as a better alternative to rice growing farmers.

REFERENCES

Alam M, Ladha JK, Rahaman KS, Foyjunnessa HR, Khan AH and Buresh RJ 2005. Leaf color chart for managing nitrogen fertilizer in lowland rice (*Oryza sativa* L.) in Bangladesh. *Indian Journal of Agronomy* **97**(3): 949-959.

Chatterjee Kaushik, Singh CS, Singh AK, Singh AK and Singh SK 2016. Performance of wheat cultivars at varying fertility levels under system of wheat intensification and conventional method of wheat production system. *Journal of Applied and Natural Science* **8**(3): 1427-1433.

Directorate of Economics 7 Statistics 2017 in Pocket Book of Agricultural Statistics, Government of India Ministry of Agriculture & Farmers Welfare Department of Agriculture, Cooperation & Farmers Welfare, New Delhi.

FAOSTAT 2018 .FAOSTAT database.Food and Agriculture Organization of the United Nations (FAO).

Gangwar KS, Chaudhary VP, Gangwar B and Pandey DK 2009. Effect of crop establishment and tillage practices in rice (*Oryza sativa*) – based cropping systems. *Indian Journal of Agricultural Sciences* **79**(5): 334-339.

Kanthi M Sandhya, Ramana AV and Murthy KV Ramana 2014 .Effect of different crop establishment techniques and nutrient doses on nutrient uptake and yield of rice (*Oryza sativa* L.). *Karnataka Journal of Agricultural Sciences* **27**(3): 293-295

Murali MK and Setty RA 2004. Effect of levels of NPK, vermicompost and growth regulator (Triacontanol) on growth and yield of scented rice (*Oryza sativa*). *Mysore Journal of Agricultural Sciences* **34**(4): 335-339.

Rajvanshi S, Singh Ghanshyam, Suryavanshi Priyanka, Singh Satyaveer and Prasad Rajendra 2021. Effect of crop establishment methods and weed management practices on yield and economics of rice (*Oryza sativa* L.). *Indian Journal of Ecology* **48**(3): 866-871.

Ramamoorthy K, Thiyagarajan TM and Subbaiah SV 2000. Integrated nitrogen management through grain legumes and green manures in irrigated tropical rice-based cropping systems: A review. *Agriculture Review* **22**(3/4): 141-162.

Ravi S, Ramesh S and Chandrasekaran B 2007. Exploitation of hybrid vigour in rice (*Oryza sativa* L.) through green manure and leaf colour chart (LCC) based N application. *Agronomy Journal* **99**(3): 929-932.

Singh CS, Singh AK and Singh AK 2011. Growth and yield response of rice to varying levels of fertility, Sulphur and zinc under transplanted condition. *Environment and Ecology* **29**(3): 978-984.

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