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EFFECT OF ESTABLISHMENT METHODS AND NUTRIENT MANAGEMENT PRACTICES ON GROWTH, YIELD, NUTRIENT UPTAKE, QUALITY AND ECONOMICS OF RICE (*ORYZA SATIVA* L.)

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ABSTRACT

An experiment was conducted during 2017-18 and 2018-19 at the Rice Research Farm of Birsa Agricultural University, Ranchi, Jharkhand to study the effect of establishment methods and nutrient management practices on growth, yield, nutrient uptake, quality and economics of rice. The pooled data revealed that significantly maximum grain (42.19 q/ha) and straw yield (65.22 q/ha) was recorded under wet direct seeding using drum seeder and RDF + 25% N through FYM (46.33 q/ha and 71.53 q/ha). Wet direct seeded rice using drum seeder also recorded maximum net return (58337 `/ha) and B:C ratio (2.00) which is significantly at par with aerobic rice. Among the various nutrient management practices, the higher net return (64030 `/ha) and B:C ratio (2.28) was recorded with LCC based N application. Establishment methods and nutrient management practices did not bring any significant change in the quality parameters of rice.
***Keywords*:** Crop establishment, Farm Yard Manure, Leaf Colour Chart, Transplanting, Wet direct seeding.

Introduction

Rice (*Oryza sativa* L.) is a major food of the world and more than half of the population is dependent on it. The most common method of rice cultivation in India is transplanting which is very laborious and time-consuming job. The high farm labor cost invariably delays transplanting and often leads to the use of old aged seedling. The delay in sowing result in the poor emergence and reduced heading panicle per meter square and spikelets per panicle and ultimately the yield is affected (Hayat *et al*., 2003). In order to overcome these problems, the method of direct seeding is evolved. Direct seeding is a sustainable alternative to traditional transplanting of rice which offers such advantages as faster and easier planting, reduced farm labor, earlier maturity of crop by 7– 10 days, more efficient use of water and higher tolerance of water deficit, reduced methane emission and often higher profit in areas with an assured water supply. Direct seeded rice, if managed properly, can yield as high as that of transplanted rice (Ali *et al*., 2007). Recently, an effort has been made to include very simple machine which is manually operated and low-cost drum seeder that serves as a most effective option for overcoming the disadvantages associated with the traditional broadcasting and also helps in reducing the labour cost for planting as it does not consume huge labour force. Drum seeder is an effective method of rice establishment for timely sowing of rice in areas where farmers face the problem of shortage of labour during peak periods (Subbaiah *et al*., 2002). Nitrogen is one of the most important elements contributing for higher productivity of cereal crops and a major factor that limits agricultural productivity (Balasubramanian *et al*., 2000 and Islam, 2009). During the vegetative growth stages, nitrogen absorbed by rice contributes in growth during reproduction and grain-filling through translocation. The fertilization of nitrogen either in excess or less than optimum rate affects both growth, yield and quality of rice to remarkable extent, hence proper management of nutrition of crop is of immense importance (Manzoor *et al*., 2006). Intensive agriculture and decreased use of organic material, has led to severe degradation of soil fertility and productivity of rice based cropping systems. Imbalanced and indiscriminate use of high analysis fertilizers has developed many problems like decline in organic matter content, increase in soil salinity, sodicity, soil pollution and pest hazards**.** The indiscriminate use of high analysed fertilizers often leads to imbalance in nutrients especially micronutrients, which ultimately cause deterioration of soil physio-chemical properties and steadily decreases crop yield (Gupta *et al*., 2002). Continuous use of inorganic fertilizers has brought loss of vital soil fauna and flora which calls for the development of effective system where reduced amount of chemical fertilizer is supplemented through organic sources for improvement of soil quality and maintenance of soil fertility leading to sustained crop production, as organic manures modify the soil physical behaviour and increases the efficiency of applied nutrients (Pandey *et al*., 2007). The importance of rice in India is such that even a minor fluctuation in productivity brings about a major change in Indian economy. Thus, if the productivity of rice in India in general and Jharkhand in particular is raised by different establishment methods, it can bring about tremendous change in agricultural scenario and on rural economy. The present study was therefore conducted to evaluate the effect of different establishment methods and nutrient management practices on yield, nutrient uptake, quality and economics of rice.

Materials and Methods

Study site and soil

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% sand, 29.7% silt and 33.2% clay textural composition and slightly acidic (6.2) in reaction, low in organic carbon (4.3 g/kg), 230.00 kg/ha available soil nitrogen, 36.80 kg/ha available phosphorous, 161.20 kg/ha of available potassium content.

Treatments and experimental design

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 (M1), wet direct seeding of sprouted seeds in puddle field using drum seeder (M2) and aerobic rice (M3) assigned to main plots and five nutrient management practices *viz.,* recommended dose of fertilizer (RDF - 80:40:20 Kg NPK/ha) (F1), 75% RDF + 25% N through farm yard manure (FYM) (F2), RDF + 25% N through FYM (F3), leaf colour chart (LCC)based nitrogen application (F4)and control (no fertilizer) (F5) assigned to sub plots.

Crop management

Seed rate and crop geometry

High yielding rice variety (Naveen) @ 50 kg/ha were soaked in water for 24 hours, sieved and then were wrapped in wet gunny bags for 36 hours for incubation. In drum seeding methods, sprouted seeds were used for sowing. Sprouted seeds were used for direct seeding by drum seeding with 20 cm row spacing. Direct seeding was done on the exact same day i.e., the dry seeds were placed in nursery.

Water management

During both years of rice experimentation, a satisfactory/sufficient monsoon showers was received. Total rainfall and distribution were more uniform during the second year as compared to first year during the crop period. However, during first year two irrigation were provided one as pre-sowing irrigation and another at grain filling stage. During second year, no irrigation was provided to the field.

Nutrient management

Well rotten farm yard manure was applied prior to sowing or transplanting of rice crop, as per the treatment and thoroughly mixed. Full dose 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 splits: at tillering (50% in aerobic and wet-direct seeded treatments and 25% in transplanted rice) and at panicle initiation stage, 25%N was applied 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 23^{rd}, 45^{th} and 61^{st} days after sowing or transplanting when color of 6 out of 10 leaves fall below a threshold level of shade 4 on the leaf color chart.

Results and Discussion

Growth parameters

The rice established through wet direct seeding using drum seeder recorded comparable growth parameters viz. total tillers/m^2, leaf area index and dry matter accumulation as of transplanting method. However, both of these treatments establish significant superiority over aerobic rice in respect of tiller number/m^2 and dry matter accumulation. The rice established through wet direct seeding through drum seeder recorded significantly higher leaf area index at 90 days after sowing over aerobic rice. The higher leaf area index was recorded in transplanted rice which was significantly higher over dry seeded rice at harvest stage (Rajvanshi *et al*., 2021). The normal transplanting failed to exert significant variation in leaf area index with aerobic rice and remained statistically at par between themselves. This might be due to profuse tillering due to better availability of space, nutrients and light (Kumar *et al*., 2018).

Among nutrient management practices, application of RDF + 25% N through FYM and LCC based N application being similar between themselves in respect of tillers/m^2, leaf area index and dry matter accumulation but, both of the nutrient management practices showed their significant superiority over application of RDF and 75% RDF+ 25% N through FYM as well as control in respect of tiller number/m^2, leaf area index at 90 DA/DAT and dry matter accumulation at maturity. The inorganic nitrogen nourished the plant at initial stage and boosted the growth, while the incorporated FYM released the nutrients slowly and made available up to reproductive stages of crop thereby improved the growth attributes of rice (Dahiphale *et al*., 2003).

Yield attributes

Significant improvement in yield attributes i.e. number of panicles per meter square, fertile grains/panicle and 1000 grain weight was recorded under wet direct seeding using drum seeder as compared with aerobic rice (Table-1). The wet direct seeding using drum seeder also registered significantly higher fertile grains/panicle than normal transplanting. However, wet direct seeding using drum seeder and normal transplanting method being *at par* among themselves in respect of number of panicles per meter square. 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 was significantly superior to RDF and 75% RDF+ 25% N through FYM as well as control in respect of number of panicles per meter square and fertile 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 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-2). However, the grain and straw yield 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. The rice establishment methods failed to exert significant statistical differences in harvest index although, the rice establishment through wet direct seeding using drum seeder recorded the higher harvest index while, the lowest harvest index was found with aerobic rice.

Among the nutrient management practices, RDF +25% N through FYM produced highest grain and straw yield, which was at par with LCC based N application. These two treatments produced significantly higher grain and straw yield than RDF, 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). The nutrient management practices were unable to exert significant statistical variation in harvest index and remained comparable among themselves as well as no fertilizer treatments.

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 rice 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 (Kanthiet al 2014). Total nitrogen, phosphorus and potassium uptake were higher when the rice crop was raised with RDF + 25% N through FYM and LCC based N application 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 (Table 3). 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. Rice establishment methods and nutrient management practices did not influence the soil fertility status after harvest.

Economics

The net return with wet direct seeding using drum seeder was significantly higher than other establishment methods (Table 2). Although the benefit: cost ratio was also found highest under drum seeded rice but, it failed to exert significant statistical variation with aerobic rice and remained comparable between themselves. However, rice established through drum seeder and aerobic rice resulted in significantly higher benefit: cost ratio than normal transplanting. The higher net return under drum seeded and transplanted rice was due to higher grain and straw yield of the rice crop. This confirms the findings of Bhardwaj et al 2018.

The different mode of nutrient application caused significant variation in net return as application of RDF + 25% N through FYM recorded the highest net return which was significantly higher than the other nutrient management practices except the LCC based nitrogen application whereas, the benefit: cost ratio under LCC based nitrogen application was found significantly higher than all other nutrient management practices.

Quality Parameters

The rice establishment methods did not bring any significant change in respect of hulling, milling, head rice recovery, protein content and amylose percent in rice (Table 4). The nutrient management practices also did not exhibit any significant differences in all these characters except protein content where control plots recorded significantly lower protein content. However, all the quality parameters recorded higher value in LCC based nitrogen application.

Conclusions

Wet direct seeding of sprouted seeds of rice using drum seeder in puddled soil produced at par yield with normal transplanting method but fetched significantly more net return and B:C ratio. LCC based N application also produced higher yield, net profit and B:C ratio. Hence, wet direct seeded rice using drum seeder and LCC based N application can be a feasible alternative of conventional transplanting in respect of establishment methods and nutrient management practices.

Table 1: Growth and yield attributes on rice as influenced by establishment methods and nutrient management practices (Pooled data of two years)

Treatment	Growth attributes			Yield attributes		
	Tillers/ m^2	Dry matter accumulation (g/m^2)	Leaf area index at 90 DAS/T	Panicles $/m^2$	Fertile Grain/ panicle	1000 grain weight (g)
Establishment Methods						
M1-Normal Transplanting	257	1249	3.48	248	103	24.22
M2-Wet direct seeding using drum seeder	267	1292	3.58	251	109	24.26
M3-Aerobic rice	227	1150	3.29	219	101	24.05
SEm±	6.21	11.80	0.05	4.04	1.09	0.05
CD(P=0.05)	24.40	46.34	0.18	15.88	4.28	NS
Nutrient management practices						
F1-RDF (80:40:20 kg NPK/ha)	259	1338	3.51	251	105	24.15
F2-75% RDF + 25% N through FYM	254	1333	3.52	241	98	24.21
F3-RDF + 25% N through FYM	284	1407	3.77	277	118	24.36
F4-LCC based Nitrogen application	283	1404	3.75	273	118	24.23
F5-Control (No fertilizer)	172	670	2.71	154	83	23.95
CD(P=0.05)	23.77	64.29	0.22	19.22	5.15	NS
CV%	9.76	5.37	6.62	8.25	5.07	3.20

Table 2 : Yield and economics of rice as influenced by establishment methods and nutrient management practices (Pooled data of two years)

Treatment	Yield (q/ha)			Economics (`/ha)		
	Grain	Straw	Grain	Cost of cultiv-ation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Establishment Methods						
M1-Normal Transplanting	39.49	61.89	38.80	29426.36	47845	1.39
M2-Wet direct seeding using drum seeder	42.19	65.22	39.26	23816.40	58337	2.00
M3-Aerobic rice	32.65	52.40	37.97	18416.40	44987	1.93
SEm±	1.13	1.33	0.74	-	2208	0.09
CD(P=0.05)	4.43	5.21	NS	-	8670	0.34
Nutrient management practices						
F1-RDF (80:40:20 kg NPK/ha)	41.32	66.32	38.37	21473.95	57446	2.09
F2-75% RDF + 25% N through FYM	38.98	61.39	38.80	22705.26	51126	1.77
F3-RDF + 25% N through FYM	46.33	71.53	39.29	24473.95	64258	2.10
F4-LCC based Nitrogen application	45.10	68.72	39.60	21982.75	64030	2.28
F5-Control (No fertilizer)	18.80	31.22	37.31	17398.80	15088	0.64
CD(P=0.05)	2.93	4.61	NS	-	5886	0.18
CV%	7.90	7.92	6.68	-	12.01	12.17

Table 3 : Soil fertility status after harvest and Total N, P and K Uptake of rice as influenced by rice establishment methods and nutrient management practices (Pooled data of two years)

Treatments	Total Uptake			Available nutrient status (kg/ha)		
	Nitrogen	Phosphorous	Potassium	Nitrogen	Phosphorous	Potassium
Establishment Methods						
M1-Normal Transplanting	88.52	15.23	88.84	211.87	33.06	162.20
M2-Wet direct seeding using drum seeder	96.13	16.47	95.42	204.45	31.56	157.40
M3-Aerobic rice	72.04	12.57	73.82	215.00	33.61	163.39
SEm±	2.29	0.44	2.48	6.28	0.86	1.77
CD(P=0.05)	9.01	1.74	9.74	24.66	3.36	6.97
Nutrient management practices						
F1-RDF (80:40:20 kg NPK/ha)	92.17	16.11	94.57	214.42	33.54	159.33
F2-75% RDF + 25% N through FYM	84.42	14.85	86.89	210.22	34.18	160.67
F3-RDF + 25% N through FYM	107.34	18.46	105.28	212.33	32.75	163.67
F4-LCC based Nitrogen application	106.38	17.89	100.05	214.67	32.31	165.67
F5-Control (No fertilizer)	37.51	6.48	43.33	200.56	30.94	155.66
CD(P=0.05)	5.97	1.46	6.82	20.39	3.24	11.42
CV%	7.17	10.18	8.15	9.96	10.18	7.29

Table 4 : Quality of rice as influenced by rice establishment methods and nutrient management practices (Pooled data of two years)

Treatment	Hulling (%)	Milling (%)	Head rice recovery (%)	Protein content (%)	Protein yield (kg/ha)	Amylose (%)
Establishment Methods						
M1-Normal Transplanting	74.67	65.30	61.91	7.73	307.65	22.21
M2-Wet direct seeding using drum seeder	75.26	64.65	63.09	7.62	323.88	23.00
M3-Aerobic rice	76.23	65.07	62.97	7.71	254.12	22.17
SEm±	1.98	1.39	1.22	0.06	18.75	2.35
CD(P=0.05)	NS	NS	NS	NS	NS	NS
Nutrient management practices						
F1-RDF (80:40:20 kg NPK/ha)	74.41	65.01	62.61	7.81	322.71	22.21
F2-75% RDF + 25% N through FYM	75.17	65.41	62.20	7.77	302.87	22.34
F3-RDF + 25% N through FYM	76.37	64.94	62.58	7.75	359.06	21.90
F4-LCC based Nitrogen application	76.79	65.19	63.13	7.90	356.29	22.76
F5-Control (No fertilizer)	74.19	64.70	62.55	7.19	135.17	23.10
CD(P=0.05)	NS	NS	NS	0.21	41.76	2.27
CV%	7.80	6.95	8.05	6.71	8.23	NS

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