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Growth, productivity and profitability of direct seeded rice (*Oryza sativa*) as influenced by integrated nutrient management

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Abstract
A field experiment on direct seeded rice was conducted during *Kharif* 2017 and 2018 at Rice Research Farm, Birsa Agricultural University, Kanke, Ranchi to evaluate the effect of integrated nutrient management in direct seeded rice (*Oryza sativa*). The soil was clay loam in texture, acidic in nature with mean pH 5.97, mean EC 0.30, low in available N (mean value 223.81 kg/ha), medium in P (mean value 23.35 kg/ha) & K (mean value 169.44 kg/ha) and low in organic carbon (mean value 0.39%). The experiment comprised ten treatments viz. control (no fertilizer or manure), 50% RDF, 75% RDF, 100% RDF, 50% RDF +50% N through FYM, 50% RDF + 50% N through vermi compost, 75% RDF +25% N through FYM, 75% RDF+25% N through vermin-compost, 100% RDF +25% N through FYM and 100% RDF +25% N through vermin-compost were laid out in randomized block design with three replications. Pooled data of two years experimentation indicated that the application of various integrated nutrient management practices significantly increased growth parameters (plant height, Leaf area index and total tillers/m^2) and yield attributes viz. no. of panicles/ square meter, no. of grains/ panicle and 1000- grain weight. Yield and monetary income of rice crop were significantly influenced by application of integrated nutrient management practices. Among all treatments, application of 100% RDF + 25% N through vermin-compost resulted in higher no. of effective tillers/m^2 (276.33), the maximum grain yield (43.90 t/ha) and net return (`48946/ha) but B:C ratio (2.60) is less than 75% RDF + 25% N through vermin-compost (2.63) which was superior to rest of the treatments. Two year study indicates that the application of 75% RDF + 25% N through vermin- compost was the best for higher yield and monetary benefit from rice.

Keywords: FYM, INM, LAI, net return, RDF, yield

Introduction
Rice is the staple food for more than 65% of the people and it provides employment and livelihood security to 70% of Indian population. India grows rice in highly diverse conditions starting from below sea levels to hill as high as > 2000 meters. Major share of rice is cultivated during *kharif* season. A small share of rice is grown in *rabi/* summer season with assured irrigation. It is cultivated in an area of 43.2 million ha, with a production of 110.15 million tonnes and an average productivity of 2.55 t/ ha during 2016-17 (Economic Survey 2017-18). In Jharkhand, it is the most widely cultivated cereal crop during rainy season Food grain production has to be doubled by 2050 to meet the needs of ever increasing population. Out of targeted requirement, share of rice has been estimated 120 -125 million tonnes with 4.5 tonnes/ha productivity (Anonymous, 2013). It means there is need to give more emphasis for increasing productivity of rice in sustainable way. Green revolution has essentially brought spectacular increase in food grain production, but continuous use of NPK fertilizers had developed secondary and micro nutrient deficiencies due to lesser/restricted use of organic manures.

Since last few decades, intensive cropping systems with the use of high yielding varieties of crops harnessed the native soil fertility, which is posing a threat to the sustainable crop production, besides rampant nutrient deficiencies. Farmers generally use high analysis fertilizers, which add a few major nutrient into the soil, whereas, plants absorb all necessary nutrients for their growth and development. However, farmers are using the sub-optimal levels of fertilizers. This results in poor soil fertility with varied degree of deficiency of nutrients. It is well documented that organic manures are good complimentary sources of nutrients and improve the efficiency of the applied mineral nutrients on one hand and improve soil physical

and biological properties on the other hand (Chaudhary *et al.* 2004). Hence, the integrated nutrient management is need of the hour to increase the productivity by maintaining the soil health. Moreover, soil and crop management practices that utilize organic amendments, such as animal and crop residues have the potential to increase the organic carbon and microbial activities in the soil besides increasing crop productivity and sustainability.

Considering all these aspects, the field experiment was conducted to see the effect of integrated nutrient management on growth, productivity and profitability of direct seeded rice in medium land under irrigated condition of Jharkhand.

Materials and Methods

A field experiment on direct seeded rice was conducted during *kharif* 2017 and 2018 at Rice Research Farm, Birsa Agricultural University, Kanke, Ranchi. Soil samples from 1-50 cm were collected from different locations of the experimental plot and analyzed. The soil was clay loam in texture, acidic in nature with mean pH 5.97, mean EC 0.30, low in available N (mean value 223.81 kg/ha), medium in P (mean value 23.35 kg/ha) & K (mean value 169.44 kg/ha) and low in organic carbon (mean value 0.39%). The experiment comprised ten treatments viz. control (no fertilizer or manure), 50% RDF, 75% RDF, 100% RDF, 50% RDF +50% N through FYM, 50% RDF + 50% N through vermi-compost, 75% RDF +25% N through FYM, 75% RDF+25% N through vermin-compost, 100% RDF +25% N through FYM and 100% RDF +25% N through vermin-compost were laid out in randomized block design with three replications. Rice (*var*. - Sahbhagidhan) was sown by using seed rate of 60 kg/ha on 22 June and 24June in 2017 and 2018 respectively at 20 cm x 10 cm spacing. The seed was placed at about 3-4 cm depth. A week after sowing of rice crop, gap sowing was done wherever it was felt necessary. Well decomposed FYM and vermin-compost were incorporated in soil 15 days before sowing of rice as per treatment. The quantity of organic manure was calculated on the basis of nitrogen content (%). The crop was fertilized with recommended doses of fertilizers viz. 80: 40 :20 kg N, P_2O_5, K_2O /ha. Half dose of N and full dose of P_2O_5 and K_2O were applied as per treatment through Urea, DAP and MOP as basal application just before sowing of rice and balance N were top – dressed in 2 equal splits – one fourth at active tillering (30- 35 DAS) and the remaining one – fourth at panicle – initiation (60- 65 DAS) stage of the crop. During course of investigation, the plant height was taken from 5 randomly selected and tagged plants from each plot at 30, 60, 90 days after sowing (DAS) and at harvest. Tiller count was taken from a fixed one meter row length at 30, 60, 90 and at harvest, which was converted to per meter square. Leaf area was recorded from one meter row length at 30, 60 and 90 DAS, using leaf area meter. Net plots were harvested after removing the border rows on 16 and 18 October during 2017 and 2018, respectively. The harvested produce was tied into bundles, numbered and left out in the field to dry for a week. After threshing, proper cleaning and winnowing, the grain weight of each plot was recorded at 14% moisture. All the data were subjected to analysis of variance (ANOVA) as per the standard procedures and comparison of treatment means was made by critical difference (CD) at 5% probability.

Results and Discussion

Effect on growth attributes

The results given in Table.1 indicate some of the important parameters viz. plant height (cm), leaf area index and total tillers/m ^{2} of rice crop. At maturity stage, 100% RDF +25% RDN through vermi compost (VC) produced the tallest plant (104.09 cm) which was significantly higher than other treatments except 100% RDF + 25% RDN through FYM, 75% RDF + 25% RDN through VC, and 100% RDF. Different treatments of integrated nutrient management affected the leaf area index (LAI) significantly at different growth stages. At 30 DAS, 100% RDF + 25% RDN through VC gave the highest value o LAI (2.26), which was significantly *at par* with 100% RDF, 75% RDF + 25% RDN through VC and 100% RDF + 25% RDN through FYM. While at 60 DAS, 100% RDF +25% RDN through VC (3.44) was also significantly *at par* with 50% RDF + 50% RDN through VC besides 100% RDF, 100% RDF +25% RDN through FYM and 75% RDF + 25% RDN through VC. At 90 DAS, trend of increase in LAI value was found same as 30 DAS. In control treatment, the lowest LAI was noted throughout the crop growth period i.e. 1.69, 2.77 and 3.26 at 30 DAS, at 60 DAS and 90 DAS respectively.

Periodical total no. of tillers /m^2 of rice as influenced by different treatment of integrated nutrient management under study were presented in Table.1. At 30 DAS, the application of 100% RDF + 25% RDN through VC recorded significantly higher no. of tillers /m^2 (205.5) and remained *at par* with other treatments except control, 50% RDF, 75% RDF and 50% RDF +50% RDN through FYM. While at 60 DAS, the application of 100% RDF + 25% RDN through VC recorded maximum no. of total tillers /m^2 (345.1) which was *at par* with 100% RDF, 75% RDF + 25% RDN through FYM or VC and 100% RDF + 25% RDN through FYM. At 90 DAS, trend of increase in the no. of total tillers/m^2 was found similar as 60 DAS. Minimum number of tillers observed with control throughout the growth period. This might be due to balanced nutrition through organic manures and enhanced availability of macro & micro nutrients. Similar results were reported by Kumar *et al*. (2012) [6] and Jaykumar *et al*. (2014) [5].

Table 1: Effect of integrated nutrient management on plant height, leaf area index and total tillers of direct seeded rice (pooled data over two years)

Treatments	Plant height at maturity (cm)	Leaf area index			Total tillers /m^2		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1: Control	86.78	1.69	2.77	3.26	179.1	214.1	190.65
T_2: 50% RDF	96.38	1.83	2.92	3.68	190.7	250.7	236.65
T3: 75% RDF	97.65	1.91	2.95	3.73	193.8	273.7	261.45
T4: 100% RDF	101.63	2.02	3.12	4.08	198.1	303.5	287.50
T5 : 50% RDF+50%N FYM	98.27	1.93	3.03	3.82	193.9	284.7	265.90
T6 : 50% RDF+ 50% N VC	98.78	1.96	3.06	3.82	194.6	292.9	277.70
T7: 75%RDF+25%N FYM	99.35	2.03	3.17	3.89	197.1	302.9	285.30
T8:75%RDF+25%N VC	102.92	2.11	3.20	4.12	197.8	327.3	310.10
T9:100%RDF+25%N FYM	103.56	2.21	3.33	4.18	202.5	333.5	318.20

T10:100%RDF+25%N VC	104.09	2.26	3.44	4.28	205.5	345.1	333.10
SE m±	1.58	0.09	0.13	0.13	3.66	15.35	17.81
CD at 5%	4.71	0.28	0.38	0.39	10.88	45.60	52.91

Effect on yield attributes and yield

Adequate nutrient management in rice either with inorganic sources or their combined use significantly increased the yield attributing parameters compared to no nutrition (Table. 2). No. of effective tillers/m^2 (276.33), panicle length (21.60 cm), panicle weight (3.13 g) and no. of filled grains /panicle (117.50) were the highest under the combined application of 100% RDF + 25% RDN through VC. In case of effective tillers/m^2 and no. of filled grains/panicle, 100% RDF +25% RDN through VC was *at par* with 100% RDF + 25% RDN through FYM and 75% RDF +25% RDN through VC, while 100% RDF was also *at par* with that treatment in case of panicle length and panicle weight. Minimum value of effective tillers/m^2 ((148.00), panicle length (19.67 cm), panicle weight (1.69 g) and no. of filled grains/panicle (93.33) was recorded under control. Sterility % and 1000-grain weight of rice were analyzed and found to be statistically on par due to integrated nutrient management which was ranged from 6.42 to 9.17 and 22.85 to 24.34 respectively. Further, the yields were significantly superior under the combined use of inorganic fertilizers and organic manures over the use of inorganic fertilizers (Table. 3). The grain and straw yield were significantly influenced by integrated nutrient management practices. The average grain yields ranged from 17.59 q/ha in the control treatment to 43.90 q/ha in 100% RDF + 25% RDN through VC and straw yields ranged from 28.69 q/ha to 64.05 in the control and 100% RDF + 25% RDN through FYM respectively. The maximum grain yield (43.90 q/ha) was recorded from 100% RDF + 25% RDN through VC, which was significantly higher to other treatments except 100% RDF + 25% RDN through FYM, 75% RDF + 25% RDN through FYM or VC. 100% RDF + 25% RDN through FYM produced maximum straw yield which was significantly *at par* with 100% RDF + 25% RDN through VC and 75% RDF + 25% RDN through FYM or VC. Harvest index was also significantly influenced by integrated nutrient management under pooled analysis. It happened mainly due to increased number of panicles/$m^2$and grains/panicle was mainly responsible for higher grain yield with increased supply of nitrogen. It is also important to note that better and increased availability of nitrogen under integrated use of inorganic fertilizers and organic manures may perhaps led to increased to number of panicle/m^2 and number of filled grains/panicle, and hence grain yield. The results are in conformity with those obtained by Naing *et al.* (2010) [7] and Das *et al.* (2010) [3].

Table 2: Effect of integrated nutrient management on yield attributes of direct seeded rice (Pooled data over two years)

Treatments	Effective tillers /m^2	Panicle length (cm)	Panicle wt. (g)	No. of filled grains /panicle	Sterility %	1000 grain wt.
T_1: Control	148.00	19.67	1.69	93.33	9.17	22.85
T_2: 50% RDF	175.50	20.90	2.33	102.33	8.78	23.21
T3: 75% RDF	202.50	20.97	2.39	106.33	8.27	23.23
T4: 100% RDF	224.83	21.27	2.84	107.83	7.72	23.91
T5 : 50% RDF+50%N FYM	211.66	21.10	2.36	106.16	8.14	23.34
T6 : 50% RDF+ 50% N VC	223.50	21.11	2.51	109.50	8.08	23.55
T7: 75% RDF+25%N FYM	233.83	21.24	2.90	108.50	7.27	23.71
T8:75% RDF+25%N VC	252.00	21.46	2.99	111.50	6.87	23.97
T9:100% RDF+25%N FYM	265.82	21.57	3.06	114.50	6.36	24.15
T10:100% RDF+25%N VC	276.33	21.60	3.13	117.50	6.43	24.34
SE m±	13.74	0.11	0.07	2.22	0.92	0.50
CD at 5%	40.83	0.34	0.23	6.68	NS	NS

Table 3: Effect of integrated nutrient management on yield and economics of direct seeded rice (Pooled data over two years)

Treatments	Yield and harvest index			Economics		
	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)	Total cost of cultivation (`/ha)	Net returns (`/ha)	B:C ratio
T_1: Control	17.59	28.69	37.99	22583	9541	1.42
T_2: 50% RDF	30.38	45.99	39.77	24845	29923	2.20
T3: 75% RDF	34.49	51.67	40.03	25576	36502	2.43
T4: 100% RDF	36.92	54.44	40.41	27107	39169	2.44
T5 : 50% RDF+50% N FYM	35.04	53.17	39.72	32091	31103	1.97
T6 : 50% RDF+ 50% N VC	36.01	54.13	39.95	31492	33358	2.05
T7: 75% RDF+25% N FYM	40.11	60.93	39.69	29599	42753	2.44
T8:75% RDF+25% N VC	42.49	63.18	40.21	29299	47581	2.63
T9:100% RDF+25% N FYM	43.17	64.05	40.26	30730	47336	2.53
T10:100% RDF+25% N VC	43.90	63.88	40.73	30430	48946	2.60
SE m±	1.92	2.34	0.17	--	1339	0.03
CD at 5%	5.69	6.95	0.53	--	3977	0.09

Effect on economics

Amongst the different treatments of integrated nutrient management, 100% RDF + 25% RDN through VC fetched maximum gross return (`79,376/ha) and net return (`48496/ha), but the highest benefit – cost ratio was obtained under 75% RDF + 25% RDN through VC. However, the gross return and net return was at par with 100% RDF + 25% RDN through FYM and 75% RDF + 25% RDN through VC, while the benefit – cost ratio was at par with 100% RDF + 25% RDN through VC.

Conclusion

On the basis of above findings, it may be concluded that the application of 75% RDF + 25% N through vermi-compost was the best for significantly higher growth, yield and monetary benefit from direct seeded rice.

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