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Research Paper

Response of rice (*Oryza sativa*) hybrids to integrated nitrogen management under different methods of cultivation

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) seasons of 2012 and 2013 at Varanasi, Uttar Pradesh, to study the effect of integrated nitrogen management on performance of rice (*Oryza sativa* L.) hybrids under different methods of cultivation on sandy clay-loam soil. The experiment was laid out in a split-plot design with 2 crop-establishment methods and 2 hybrids assigned to main plots, and 6 integrated nitrogen-management treatments were allocated in subplots and replicated thrice. Transplanting of rice under system of rice intensification (SRI) and rice cv. 'Arize 6444' recorded significantly higher growth attributes, viz. plant height, tillers/hill, leaf-area index, and dry-matter accumulation/hill, with almost all yield-attributing characters and yield, except plant height and panicle length which were significantly higher 'PHB 71' than 'Arize 6444'. The SRI planting increased the grain and straw yield by 14.76% and 13.11% over normal transplanting. Similarly, SRI planting and 'Arize 6444' cultivar also gave significantly maximum benefit in respect to gross returns, net returns (₹66,138 and 61,535/ha) and benefit: cost ratio (1.86 and 1.66) over normal transplanting and 'PHB 71'. Among all the integrated nitrogen-management treatments, application of 50% recommended dose of nitrogen (RDN) + 50% N through FYM + *Azospirillum* recorded significantly higher growth attributes, yield attributes, grain yield (6.94 t/ha), straw yield (9.16 t/ha), harvest index, net monetary returns (₹68,064/ha), but application of 125% RDN was found economically feasible in respect to benefit: cost ratio (1.88) owing to lower cost of cultivation.

Key words : Crop-establishment methods, Economics, Hybrid rice, Monetary returns, Nitrogen management

Rice (*Oryza sativa* L.) is the staple food crop for more than half of the world's population and its cultivation supports livelihood for more than 2 billion people. With increasing population India will have to produce more rice to meet the growing demand which, likely to be 130 million tonnes (mt) of milled rice in 2030. Rice cultivation is a high water-demanding enterprize. It is estimated that around 50% of total irrigation water available is used for rice cultivation. Of late, water-table is going down at a very rapid rate throughout the globe which is an indicative of alarming threats, limiting the scope for cultivation of high-water requiring crops very seriously. System of rice intensification (SRI) has shown marked increase in yields by suitably modifying certain management practices such as controlled supply of water, planting of younger seedlings and providing wider spacing (Laulanie, 1993). This methodology is gaining momentum all over the world, although it is in a budding stage in India. In addition to genetic improvement in yield potential of rice cultivars, fertilizers constitute an important input for increasing the rice production. Recently released hybrids of rice have shown high responsiveness to heavy fertilizer incorporation. Integrated nutrient management in rice has played a very important role in increasing food supply and to sustain environmental concerns. Integrated nutrient management holds a great promise in maintaining yield stability and quality of produce through correction of marginal deficiencies of secondary and micronutrient, enhancing efficiency of applied nutrient and providing favourable soil physical condition. Therefore, present field experiment was planned to study the effect of integrated nitrogen management on performance of rice hybrids under different methods of cultivation for agro-climatic region of

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MATERIALS AND METHODS

The experiment was conducted during the rainy (*kharif*) season of 2012 and 2013 on sandy-clay loam soil at Agricultural Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (25°18' N, 83°03' E, 75.7 m above the mean sea-level). The soil had 0.34 and 0.35% organic carbon, 205.20 and 213.21 kg/ha available nitrogen, 25.30 and 25.86 kg/ha available phosphorus and 215.60 and 219.80 kg/ha available potassium before the transplanting of rice during 2012 and 2013 respectively. The experiment was laid out in a split-plot design, replicated thrice. The treatments comprised 2 crop-establishment methods (normal transplanting and system of rice intensification) with 2 hybrids ('PHB 71' and 'Arize 6444') as assigned to main plots. Each main plot were further divided into 6 subplots to accommodate 6 integrated nitrogen-management treatments, i.e. [100% recommended dose of nitrogen (RDN), 125% RDN, 50% RDN + 50% N through FYM, 50% RDN + 50% N through FYM + *Azospirillum*, 100% N through FYM, control/ no fertilizer]. Recommended dose of fertilizer, i.e. 150, 75 and 60 kg/ha N, P_2O_5 and K_2O, for rice were applied as per treatments. Phosphorus and potassium were made to all the plots except the control. For normal transplanting, 23-day-old seedlings were used; nursery bed was raised 14 days before the 10-day-old seedlings used for SRI to synchronize the transplanting of rice at a time. Two seedlings for normal transplanting and single seedling/hill for SRI along with soil was transplanted by using index finger and thumb and gently planting them at the spacing was maintained at 20 cm × 15 cm under normal transplanting plots and 25 cm ´ 25 cm under SRI plots in puddled soil on 5 July 2012 and 4 July 2013. Quantity of FYM was calculated and manually incorporated to plot wise as per their treatments. Fertilizer application was done as per treatments through urea, diammonium phosphate and muriate of potash. Weed management was done manually under normal transplanting method and cono-weeding under SRI at 20 and 35 days after transplanting (DAT) to reduce the weed infestation, favour root and plant growth and also maintain the soil root zone aerobic. Economics were also calculated and compared for the selection of superior treatment combination. All the data were statistically analysed to draw a valid conclusion.

RESULTS AND DISCUSSION

Growth parameters

In general, shoot elongation continued to increase with advancement in age of the plants (Table 1). Plant height, tillers/hill, leaf-area index (LAI) and dry-matter accumulation markedly increased with SRI planting over normal transplanting. Younger seedlings of SRI obtained sufficient nutrients for vegetative growth by effective utilization of phyllochronic concept. Transplanting of younger seedlings provided larger period for tiller production during vegetative growth as well as reproductive phase. Concomitantly leads to increased growth and yield attributes particularly enhanced grain and straw yields (Shekhar *et al*., 2009). Amongst hybrids, tillers/hill, leaf-area index and dry-matter accumulation/hill significantly increased owing to hybrid 'Arize 6444' over 'PHB 71'. However, significantly taller plant was recorded with 'PHB 71' than with 'Arize 6444'. High efficient photosynthetic performance of super high-yielding rice hybrids to produce more tillers/hill, resulting in more dry-matter synthesis is largely owing to the increased cytokinin content in their roots contributing to higher grain yield. These results confirm the findings of Singh *et al.* (2013) and Hardev Ram *et al*. (2014). In integrated nitrogen management, application of 50% recommended dose of nitrogen (RDN) + 50% N through FYM + *Azospirillum* produced higher plant height, tillers/hill, LAI and dry matter accumulation than rest of treatments, closely followed by application of 125% RDN. Combined application of inorganic fertilizer with FYM and biofertilizer facilitated better soil structure, texture and environment for root development and increased availability of nitrogen for longer period. Biofertilizer-containing *Azospirillum* providing 30–50% of the crops N requirement enhanced the crop growth and development as reported by Banayo *et al*. (2012).

Yield attributes

Transplanting of rice under SRI method significantly produced 11.68%, 8.66%, 12.76% and 8.26% more number of panicles/m^2, panicle length (cm), panicle weight (g) and, 1,000-grain weight (g), respectively, more over normal transplanted rice on pooled basis (Table 1). Manjunatha *et al*., (2010) also reported similar findings. This increase in yield attributes may be accounted due to concept of phyllochronic utilization by younger seedling of SRI together with practices associated with SRI management proved conducive for increasing rice yield attributes under irrigated production systems, i.e. single seedlings/hill, square planting and moderate wetting and drying soil conditions. These findings confirm those of Thakur *et al*. (2013). Improvement in these growth attributes proved instrumental for higher production of panicles/m^2, panicle length, panicle weight and 1,000-grain weight and resulted in higher grain and straw yields under system of rice intensification. Similarly, rice hybrids 'Arize 6444' recorded significantly more number of panicles/m^2, panicle weight, 1,000-grain weight than

'PHB 71' on pooled basis. However, significantly lengthy panicle was noted with 'PHB 71' over 'Arize 6444'. Inherent genetic capability of hybrid to produce higher growth attributes concurrently improved and resulted in increased yield attributes is well established. Genetic traits of hybrid 'Arize 6444' allowed the rice plant to transform more energy into the production of higher values of yield attributes proved advantageous in increasing the yield potential over 'PHB 71' (Choudhary *et al*., 2010). Application of 50% RDN + 50% N through FYM + *Azospirillum* brought marked improvement in panicles/m^2, panicle length, panicle weight, and 1,000-grain weight, closely followed by 125% RDN. Cumulative effect of organic sources combined with inorganic and biofertilizer proved much instrumental in effective photosynthesis. These results are in close conformity with the findings of Yadav and Meena (2014).

Yields and harvest index

The SRI planting utilized phyllochronic potential in providing significantly higher grain yield, straw yield and biological yield over normal transplanted rice (Table 2) coupled with improved agronomical practices associated with SRI management under irrigated production systems, like single seedling/hill, young seedling, and moderate wetting and drying soil conditions. These findings confirm the results of Thakur *et al*. (2013) and Jat *et al*. (2015). Rice hybrid 'Arize 6444' showed greater potential to exploit hybrid vigour in giving higher grain, straw, biological yields and harvest index and exhibited marked superiority to 'PHB 71'. Improvement in yield was mainly owing to the production of higher values of growth parameter and yield attributes by 'Arize 6444' than 'PHB 71' though efficient utilization and conversion of resources into assimilates resulted in higher yield (Singh *et al.,* 2013). Incorporation of 50% RDN + 50% N through FYM + *Azospirillum* revealed significantly higher grain yield, straw yield, biological yields and harvest index as compared to rest of the treatments. This might be owing to beneficial effect of organic sources combined with inorganic fertilizer and seedling inoculation by *Azospirillum* contributing efficient photosynthesis. The results are in agreement to those of Banayo *et al*. (2012) and Yadav and Meena (2014).

Monetary advantage

The SRI method of planting obtained significantly higher gross returns and monetary net returns with benefit:

Table 1. Effect of crop-establishment methods, hybrids and integrated nitrogen management on growth and yield attributes of rice (pooled data of 2 years)

Treatment	Plant height at 90 DAT (cm)	Tillers/ hill at 90 DAT	LAI at 60 DAT	Dry-matter accumulation at 90 DAT (g/hill)	Panicles/ m^2	Panicle length (cm)	Panicle weight (g)	1,000-grain weight (g)
Crop-establishment methods								
Normal transplanting	117.5	16.1	5.1	61.8	231.0	27.7	4.7	23.0
System of rice intensification	122.2	19.5	5.5	68.4	258.6	30.1	5.3	24.9
SEm±	0.9	0.2	0.1	0.9	3.4	0.3	0.1	0.1
CD (P=0.05)	2.6	0.7	0.2	2.9	10.4	1.0	0.2	0.5
Hybrids								
'PHB 71'	122.6	16.2	5.1	60.9	234.5	29.7	4.8	22.8
'Arize 6444'	117.2	19.4	5.5	69.3	255.1	28.0	5.2	25.1
SEm±	0.9	0.2	0.1	0.9	3.4	0.3	0.1	0.1
CD (P=0.05)	2.6	0.7	0.2	2.9	10.4	1.0	0.2	0.5
Integrated nitrogen management								
100% recommended dose of N (RDN)	123.2	18.5	5.3	69.3	258.7	28.9	5.1	24.1
125 % RDN	126.8	20.7	5.4	71.5	283.8	31.1	5.3	24.6
50% RDN + 50% N through FYM	118.3	17.7	5.2	68.2	240.1	27.9	4.9	23.9
50% RDN + 50% N through FYM + *Azospirillum*	127.4	21.0	5.6	72.7	291.5	32.2	5.5	25.5
100% RDN through FYM	112.8	16.3	5.2	61.4	227.7	27.6	4.9	23.3
Control (no fertilizer)	110.9	12.7	5.0	47.4	166.8	25.6	4.4	22.2
SEm±	1.0	0.2	0.04	1.0	2.6	0.3	0.1	0.2
CD (P=0.05)	2.8	0.6	0.1	2.8	7.4	0.8	0.2	0.5

DAT, Days after transplanting

Table 2. Effect of crop-establishment methods, hybrids and integrated nitrogen management on yield and economics of rice (pooled data of 2 years)

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Cost of cultivation (×10³₹/ha)	Gross returns (×10³₹/ha)	Net returns (×10³₹/ha)	Benefit: cost ratio
Crop establishment methods								
Normal transplanting	5.69	7.70	13.4	42.4	39.71	89.59	49.88	1.27
System of rice intensification	6.53	8.71	15.2	42.7	36.18	102.32	66.14	1.86
SEm±	0.06	0.06	0.1	0.2	-	0.79	0.79	0.02
CD (P=0.05)	0.18	0.19	0.3	NS	-	2.45	2.45	0.07
Hybrids								
'PHB 71'	5.86	7.99	13.9	42.2	37.95	92.43	54.48	1.47
'Arize 6444'	6.37	8.42	14.8	42.9	37.95	99.48	61.53	1.66
SEm±	0.06	0.06	0.1	0.2	-	0.79	0.79	0.02
CD (P=0.05)	0.18	0.19	0.3	0.6	-	2.45	2.45	0.07
Integrated nitrogen management								
100% recommended dose of N (RDN)	6.49	8.66	15.1	42.8	35.63	101.66	66.03	1.87
125 % RDN	6.60	8.77	15.4	42.8	36.14	103.27	67.13	1.88
50% RDN + 50% N through FYM	6.41	8.50	14.9	43.0	40.29	100.22	59.93	1.50
50% RDN + 50% N through FYM + *Azospirillum*	6.94	9.16	16.1	43.1	40.35	108.42	68.06	1.70
100% RDN through FYM	5.91	7.92	13.8	42.7	46.63	92.70	46.07	0.99
Control (no fertilizer)	4.33	6.23	10.6	41.0	28.63	69.46	40.82	1.44
SEm±	0.06	0.07	0.1	0.3	-	0.81	0.81	0.02
CD (P=0.05)	0.18	0.19	0.3	0.7	-	2.27	2.27	0.06

cost ratio than that from normal transplanting on pooled basis (Table 2). Lower cost of cultivation with higher grain and straw yields under SRI could have resulted in higher returns than normal transplanting. Our results confirm the findings of Shekhar *et al*. (2009). 'Arize 6444' recorded significantly higher gross and net returns than cultivar 'PHB 71'. Hybrid 'Arize 6444' showed mark improvement in grain and straw yields and thus gaining more profit in terms of net returns and benefit: cost ratio than 'PHB 71'. These results are in line with the findings of Obulamma *et al.* (2004). Application of 50% RDN + 50% N through FYM + *Azospirillum* showed significantly higher monetary advantage over rest of the treatments. It gave ₹38.96 × 10³/ha higher gross returns and fetched ₹27.99 × 10³/ha higher net returns over the control. While, higher benefit: cost ratios was noted under application of 125% RDN followed by 100% RDN probably owing to more amount of FYM required to supply respective amount of N and thus increased the cost of production, inorganic sources proved low-priced and recorded higher benefit: cost ratio. These results are in accordance with the findings of Gautam *et al*. (2013).

Thus, it can be concluded that SRI method of rice cultivation for hybrid 'Arize 6444' fertilized by 50% recommended dose of nitrogen and its combination with 50% N through FYM along with *Azospirillum* resulted in higher yield and monetary advantage.

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