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PERFORMANCE OF VARIOUS RICE (*Oryza sativa* L.) VARIETIES UNDER VARIABLE NITROGEN LEVELS IN THE EASTERN UTTAR PRADESH

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ABSTRACT

A field experiment was conducted at the Indo Gangetic plain of Varanasi in 2017 during the rainy season. The study was conducted in a split-plot design with three main plots treatments viz. three rice varieties (V1- BPT-5204, V2- Rajendra Kasturi and V3- HUBR 2-1) and four subplots treatments viz. nitrogen levels (N1- 100, N2- 120, N3- 140 and N4- 160 kg ha^{-1}). Each treatment was replicated three times. The results of the study revealed that the BPT-5204 variety had significantly higher growth attributes as compared to the other two varieties, including plant height (104.92 cm), leaf area index (5.26), tiller hill^{-1} (8.25), and dry matter production (46.59 g hill^{-1}), similarly yield and yield parameters were highest in BPT- 5204 rice variety viz. the number of panicles m^{-2} (352.50), grains panicle^{-1} (177.08), panicles weight (3.51g), panicle length (23.67 cm), grain yield (50.73q ha^{-1}), biological yield (112.90 q ha^{-1}) and harvest index (0.45) but HUBR 2-1 variety gave significantly higher straw yields (62.17q ha^{-1}) and test weight (20.91 g). For the subplots treatments, nitrogen (N) level 160 kg ha^{-1} gave the significantly highest growth parameters, yield and yield parameters.

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1 Introduction

Rice (*Oryza sativa* L.), a staple food crop of South Asia, is grown under various agro-ecological conditions and makes large energy and protein contributions to the human diet (Prasad et al., 2014). Rice is grown on 43.79 million hectares in India, with a production of 116.42 million tonnes in 2018-2019 (Anonymous, 2019). In India, more than 40% of food grains production comes from rice which provides direct employment to about 70% of working rural people in the country.

After West Bengal, Uttar Pradesh is the country's second-largest rice-growing state, with a total area of 5.75 million hectares, a production of 15.54 million tonnes, and a productivity of 2.70 tonnes ha^{-1} (Anonymous, 2019). However, low rice productivity in Eastern Uttar Pradesh could be attributable to vagaries of monsoon, inefficient fertilizer use, particularly nitrogenous fertilizer, and poor crop management practices. Rice yield can be increased by new high-yielding varieties, appropriate cultural practices including judicious application of nitrogenous fertilizers. Rice new varieties can produce 10-15% yield over inbred varieties. BPT 5204 is a semi-dwarf, high-yielding and long-duration variety that is suitable for irrigated conditions (Kiran et al., 2019). While, Rajendra Kasturi is an aromatic, semi-dwarf, high yielding and suitable for the medium upland ecosystem , and HUBR 2-1 is basmati rice, semi-dwarf, short duration, high yielding and suitable for irrigated ecosystem (Sen et al., 2011). When a new variety is released, it requires appropriate agronomic practices to maximize its yield like planting time and seedling age of the new variety while optimum use of nitrogenous fertilizer for optimum yield of the variety is yet to be determined.

Nitrogen is one of the major plant nutrients, it's required for plant growth for maximizing the yield and encourages above-ground vegetative growth of plants. A good supply of nitrogen stimulates important compounds found in the living cell, including amino acid, protein, enzymes, nucleic acid, hormones, vitamins, and chlorophyll (Yang et al., 2010). Nitrogen is the most limiting nutrient among the primary nutrient in irrigated rice cultivation around the world (Samonte et al., 2006). Therefore, nitrogen fertilizer is required for current rice varieties to reach their full yield potential (Chamely et al., 2015). When compared to other nutrients, it is needed in greater amounts for rice crop growth and productivity (Djaman et al., 2018). Nitrogen influences rice yield by playing a vital function in photosynthesis, biomass buildup, effective tillering, and spikelet formation (Yoshida et al., 2006). Modern rice varieties with high yields respond better to applied nitrogen, but their N demand varies and depending on genotype and agronomic traits under different climatic conditions (Rahman et al., 2007). On the other hand, managing nitrogenous fertilizer in transplanted rice fields is a huge challenge for farmers due to various kinds of losses, including denitrification 20 to 40% (Abichandani & Patnaik, 1995), ammonia volatilization 10–60% (Liang et al., 2007), leaching losses 0.1-4.9% (Zhao et al., 2012), low N recovery (30%) and low N use efficiency (about 35%) in rice (Cao et al., 2013). Excessive nitrogen application can pollute groundwater, increase the cost of cultivation, lower yield, and pollute the environment (Djaman et al., 2018). However, the optimum N required rate varies depending on soil type, variety yield potential, soil phosphorus (P) and potassium (K) levels, water management techniques, and insect-pest-and-disease intensity. Therefore, variety-specific N fertilizer recommendations in Eastern Uttar Pradesh could be a useful choice for better N management under transplanted conditions.

2 Materials and Methods

This experiment was conducted at Banaras Hindu University, Varanasi during *kharif* season of 2017. The farm is located at 25º18'N latitude and 88º 03'E longitude on the Northern Gangetic Alluvial Plains, at an elevation of 128.93 m above mean sea level. The highest monthly rainfall of 139.8 mm was recorded by the South-West monsoon in July, with a maximum temperature of 40.10°C in June and a minimum temperature of 16.8°C in November. Soil samples (0-15 cm depth) were collected and analyzed for mechanical and physicochemical properties at the experimental site. The soil texture was sandy clay loam (USDA), with a neutral reaction pH of 7.2, low organic carbon of 0.43 percent (Jackson, 1973), low available nitrogen of 202.7 kg ha^{-1} (Subbiah & Asija, 1956), medium phosphorus (P_2O_5) 22.45 kg ha^{-1} (Olsen et al., 1954), and potassium (K_2O) of 209.2 kg ha^{-1} (Jackson, 1973). Three rice varieties (V1- BPT-5204, V2- Rajendra Kasturi and V3- HUBR 2-1) in main plots and four nitrogen levels (N1- 100, N2- 120, N3- 140 and N4- 160 kg ha^{-1}) in sub-plots were studied in split-plot design and replicated three times. The recommended fertilizer dose for N, P_2O_5, and K_2O for the Varanasi region is (120-60-60 kg ha^{-1}). The ratio of grain yield (economic yield) to biological yield is used to express it. The following formula was used to calculate the harvest index:

$$\text{Harvest index} = \frac{\text{Economic yield} \times 100}{\text{Biological Yield}}$$

The collected biometric data was evaluated using standard statistical analysis of variance approach, as suggested by Gomez & Gomez (1984).

3 Results and Discussion

3.1 Growth attributes

Growth of the rice varieties was ascribed by plant height, dry matter production, tiller number, and leaf area index under variable nitrogen rates. Plant height is influenced by various nitrogen levels due to its association with plant metabolism (Table 1). Among the varieties, BPT-5204 recorded significantly higher plant height

(104.92 cm) at the level of (160 kg N ha^{-1}) followed by HUBR 2-1 (87.67 cm) while the shortest plant height (78.00 cm) was recorded in the Rajendra Kasturi variety in all the growth stages at the level of 100 kg N ha^{-1}. Similarly, Chou et al. (2020) reported that higher doses of nitrogen fertilizer would lead to the elongation of various internodes of stems, thus increasing the plant height of rice.

Tillering is an important trait for grain production of rice and it is, therefore, an important aspect in rice yield. The number of tillers production hill^{-1} was significantly influenced by different varieties and nitrogen levels at all growth stages (Table 1). The variety BPT-5204 had a significantly higher number of tillers (8.25) at a level of 160 kg N ha^{-1}, whereas the variety Rajendra Kasturi had the lowest number of tillers (6.83) at a level of 100 kg N ha^{-1}. Tiller mortality due to intra-plant competition for growth resources could explain the decrease in tiller per plant at later stages of growth. The positive response of rice to applied nitrogen was also reported by Anil et al. (2014).

Different varieties and nitrogen rates have a significant effect on the leaf area index (LAI). Leaf area index (Table 2) progressively increased and achieved its maximum value in variety BPT 5204 (5.26) with applied 160 kg N ha^{-1} and the Rajendra Kasturi variety was observed lowest (3.17) at the level of 100 kg N ha^{-1}. Leaves are vital organs that play an important role in photosynthesis. The crop's leaf area must be maximized to achieve a high yield. Increases LAI with increase the nitrogen rate, a similar result was also found by Maqsood et al. (2005).

Table 1 Effect of nitrogen levels on plant height and number of tillers of various rice varieties

Treatment	Plant height (cm)				Number of tiller hill^{-1}		
	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT
Variety							
BPT- 5204	48.98	82.45	104.58	104.92	9.17	9.58	8.25
Rajendra Kasturi	39.94	62.36	76.92	78.00	5.42	5.92	6.83
HUBR 2-1	43.40	68.48	87.06	87.67	6.25	6.83	7.75
SEm±	0.80	0.89	0.90	0.84	0.16	0.18	0.17
CD (*P*=0.05)	3.15	3.48	3.52	3.31	0.64	0.72	0.68
Nitrogen level (kg ha^{-1})							
100	41.09	64.26	79.76	81.00	5.89	5.89	6.11
120	43.08	68.55	86.76	86.44	6.56	7.00	7.22
140	45.08	73.34	92.20	93.11	7.22	7.89	8.00
160	47.19	78.23	99.36	100.22	8.11	9.00	9.11
SEm±	0.68	1.21	1.31	1.26	0.21	0.18	0.16
CD (*P*=0.05)	2.03	3.60	3.91	3.74	0.63	0.54	0.48

Table 2 Effect of nitrogen levels on leaf area index and dry matter accumulation of various rice varieties

Treatment	Leaf area index (LAI)			Dry matter accumulation (g hill^{-1})		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Variety						
BPT- 5204	1.64	4.33	5.26	4.24	15.71	46.59
Rajendra Kasturi	1.57	3.34	3.71	3.05	12.20	30.84
HUBR 2-1	1.60	3.70	4.21	3.38	12.86	33.20
SEm±	0.00	0.08	0.05	0.07	0.15	0.32
CD (*P*=0.05)	NS	0.32	0.19	0.26	0.60	1.27
Nitrogen level (kg ha^{-1})						
100	1.58	3.33	4.02	3.25	12.41	34.66
120	1.60	3.60	4.21	3.44	13.19	36.09
140	1.61	3.90	4.49	3.66	13.97	37.50
160	1.63	4.33	4.85	3.87	14.79	38.99
SEm±	0.00	0.09	0.12	0.06	0.25	0.47
CD (*P*=0.05)	NS	0.26	0.35	0.18	0.73	1.40

Rice crop dry matter production increased with the progression of growth phases and peaked at maturity (Table 2). Dry matter production was significantly higher in variety BPT 5204 (46.59 g hill^{-1}) at the level of (160 kg N ha^{-1}) while, lowest in the Rajendra Kasturi variety (30.84 g hill^{-1}) at level (100 kg N ha^{-1}). These findings are similar to the findings of Haque et al. (2016).

3.2. Yield attributes and Yield

The length of the penical was significantly influenced by different rice varieties and nitrogen levels (Table 3). The maximum panicle length was observed in the variety BPT 5204 (23.67 cm) at a dose of 160 kg N ha^{-1} as compared to other variety and the lowest panicle length was observed in variety Rajendra Kasturi (20.0) at level 100 kg N ha^{-1}. Similarly, Hossain et al. (2008) reported that panicle length is influenced by variety. The number of grain panicles^{-1} was significantly higher in BPT 5204 variety (177.08) at a dose of 160 kg N ha^{-1}and lowest (156.00) in the Rajendra Kasturi variety at the level of 100 kg N ha^{-1}. These results were also supported by Singh & Gangwar (1989) who stated that varietal differences regarding the number of grains per panicles might be due to their genetic constituents. Panicle weight was significantly higher in the BPT 5204 variety (3.51) at dose 160 kg N ha^{-1} and at a level of 100 kg N ha^{-1}, while the lowest panicle weight (3.12) was reported in the Rajendra Kasturi variety. Increased panicle weight at higher nitrogen doses could be attributable to increased photosynthetic rate and photosynthates translocation from source to sink (Singh et al., 2014; Srivastava et al., 2014). The number of panicle m^{-2} was significantly higher in the variety of BPT 5204 (352.50) and the lowest was recorded in the Rajendra Kasturi (285.17). Test weight (Table 3) was recorded significantly higher in the variety HUBR 2-1 (21.40) with 160 kg N ha^{-1} and this was at par with BPT 5204 (20.91) while the lowest test weight of grain was observed in variety Rajendra Kasturi (19.19) at the level of 100 kg N ha^{-1}. A significant difference was found in test weight among various genotypes due to genetic variability (Mannan et al., 2010).

The grain yield of rice revealed that the crop responded significantly with the varieties and nitrogen levels (Table 4). The highest grain yield was obtained in the BPT 5204 variety (50.73 q ha^{-1}) at a dose of 160 kg N ha^{-1}, followed by HUBR 2-1 (38.92 q ha^{-1}) and Rajendra Kasturi (32.67 q ha^{-1}) at the level of 100 kg N ha^{-1}. Grain yield is determined by the combined action of different yield attributes like the number of panicle, panicle length, filled grain, and 1000 grain weight (Saha et al., 2017). At the level 160 kg N ha^{-1}, the highest straw yield found in variety HUBR 2-1 (78.58 q ha^{-1}) at 160 kg N ha^{-1} treatment, followed by Rajendra Kasturi (72.08 q ha^{-1}) and BPT 5204 (62.17 q ha^{-1}) at 100 kg N ha^{-1} levels. Different rice varieties and nitrogen levels also had a significant impact on biological yield. Among the variety, BPT 5204 was produced the highest biological yield (112.90) at a dose of 160 kg N ha^{-1}, while the Rajendra Kasturi variety (104.75) produced the lowest biological yield at the dose of 100 kg N ha^{-1}. Increased LAI boosted dry matter production and higher grain and straw yields, which might be linked to increased photosynthetic activity as a result of increased LAI. These results were supported by Singh et al. (2013). The harvesting index was significantly higher in variety BPT- 5204 (0.45) at the level of 160 kg N ha^{-1} and lowest in the Rajendra Kasturi (0.31) at the level of 100 kg N ha^{-1}. Differences in a variety had a significant impact on the harvest index Hossain et al. (2008).

Table 3 Effect of nitrogen levels on panicle length, number of panicles, number of grains panicle^{-1}, test weight, and panicle weight of various rice varieties

Treatment	Panicles length (cm)	Number of panicles (m^{-2})	Number of grains (panicle^{-1})	Test weight (g)	Panicle weight (g)
Variety					
BPT- 5204	23.67	352.50	177.08	20.91	3.51
Rajendra Kasturi	20.00	273.33	156.00	19.19	3.12
HUBR 2-1	21.17	285.17	161.17	21.40	3.21
SEm ±	0.24	1.87	0.80	0.25	0.01
CD (*P*=0.05)	0.94	7.33	3.14	1.00	0.03
Nitrogen level(kg ha^{-1})					
100	20.44	295.78	160.00	19.67	3.21
120	21.11	298.78	163.00	20.23	3.26
140	22.11	306.56	167.11	20.75	3.30
160	22.78	313.56	168.89	21.35	3.36
SEm ±	0.31	1.73	0.94	0.29	0.01
CD (*P*=0.05)	0.92	5.15	2.78	NS	0.04

Table 4 Effect of nitrogen levels on grain yield, straw yield, biological yield, and harvest index of various rice varieties

Treatment	Grain yield (qha^{-1})	Straw yield (qha^{-1})	Biological yield (qha^{-1})	Harvest index
Variety				
BPT -5204	50.73	62.17	112.90	0.45
Rajendra Kasturi	32.67	72.08	104.75	0.31
HUBR 2-1	38.92	78.58	117.50	0.33
SEm±	0.84	0.72	0.93	0.01
CD (*P*=0.05)	3.31	2.84	3.64	0.02
Nitrogen level (kg ha^{-1})				
100	37.03	67.22	104.26	0.35
120	39.17	69.89	109.06	0.36
140	42.22	72.22	114.44	0.37
160	44.67	74.44	119.11	0.37
SEm±	0.66	0.69	0.96	0.00
CD (*P*=0.05)	1.98	2.04	2.85	NS

Conclusion

Based on the findings of the research trial, the variety BPT-5204 was found to be superior with the combination of the nitrogen 160 kg ha^{-1} under Eastern Uttar Pradesh conditions. But it needs further research because the trial was conducted only for one season.

Conflict of interest

The authors would like to state that there are no conflicts of interest that may occur.

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