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# EFFECT OF NITROGEN LEVELS ON GROWTH ATTRIBUTES, YIELD AND NUTRIENT UPTAKE OF DIFFERENT RICE (*Oryza sativa* L.) VARIETIES UNDER THE TRANSPLANTED CONDITION

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Grain yield

**ABSTRACT**

Rice is very responsive to nitrogen fertilization under transplanted conditions; however N use efficiency and uptake by different varieties may vary. A field study was conducted during the rainy season of 2017 to assess the effect of four nitrogen levels in three rice varieties under the transplanted condition at Agricultural Research Farm, Banaras Hindu University, Varanasi, Uttar Pradesh. The experiment was carried out in a split-plot design (SPD) with three replications. The total number of treatments was twelve involving 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. Rice variety BPT- 5204 recorded significantly higher growth parameters viz. leaf number $hill^{-1}$(37.17), SPAD value (chlorophyll content 31.83), the higher number of days taken to 50 percent flowering (103 days), maturity (130.17 days), grain yield (50.73 q $ha^{-1}$), biological yield (112.90 q $ha^{-1}$) and harvest index (0.45) as well as NPK uptakes by grain (60.96, 13.01 & 10.95 kg $ha^{-1}$) and straw (29.72, 7.15 & 101.55 kg $ha^{-1}$) as compared to other varieties. However, straw yield (62.17 q $ha^{-1}$) was reported higher under HUBR 2-1 as compared to the rest varieties. Among the nitrogen levels, N4-160 kg N $ha^{-1}$ was recorded significantly higher above the same parameter as compared to other nitrogen levels. Hence, the application of N @ 160 kg $ha^{-1}$ along with rice variety BPT- 5204 can be recommended for achieving higher rice yield, nutrient uptake, and efficiency in Eastern Uttar Pradesh.

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## 1 Introduction

Rice (*Oryza sativa* L.) is a staple food for more than half of the world's population, including two-thirds of the population of India (Sahu et al., 2015). After China, India is the world's second-largest rice producer. Rice is grown on 43.79 million hectares in India, with a yield of 116.42 million tonnes in 2018-2019 (Anonymous, 2019). Uttar Pradesh is the second largest rice growing state after West Bengal in the country, where it is grown over an area of about 5.75 m ha with the production of 15.54 million tons (Anonymous, 2019). The world's rice demand is projected to increase by 25% from 2001 to 2025 keeping pace with population growth and as a result, satisfying ever-increasing rice demand in a sustainable manner with depleting natural resources is a great challenge (Singh et al., 2016). In this endeavor, in addition to high-yielding rice varieties, efficient use of nutrients play an important role. Among the major plant nutrients, nitrogen is most important for augmenting rice yield.

Rice requires nitrogen in a higher amount than any other nutrient and so it has become a limiting factor that influences the grain yield of rice (Siddiqui et al., 2008). Application of optimum dose of nitrogen to rice is gaining importance because nitrogen is a key nutrient in crop production that it can never be ignored. It is crucial for the individual farmer as well as the country to get the maximum economic benefit out of the huge recurring expenditure. Under these circumstances, using suitable nitrogen management strategies to increase rice yield per unit area has become a vital component of current rice production technology (Fageria & Baligar, 2001). The fertility and imbalanced fertilizer application coincide with maximum use of traditional varieties are the main constraints in rice production.

Identification and use of high yielding potential cultivars, though ensures higher yields, the actual yield advantage depends on the agronomic management including that of nitrogenous fertilizer management. The yield potential of a cultivar could be exploited to a maximum extent by judicious management of applied nitrogen as nitrogen deficiency is common in Indian soil. In general, 10-12 kg of rice is produced per kg of applied nitrogen but the degree of the response varies according to the season, soil qualities, variety, and cultural practices (Pillai et al., 1976). Rice varieties differ in their ability to uptake nitrogen from the soil as well as applied nitrogenous fertilizer and its distribution to different plant parts. Understanding nitrogen uptake and assimilation are critical in any strategy to maximize the efficiency of absorbed nitrogen for grain production. It is important to increase the efficiency of soil and applied nitrogen fertilizer by using nutrient-efficient varieties.

After the identification and release of high-yielding rice varieties, it became necessary to compare the results of growth studies and their impact on grain production under various nutrient combinations. Therefore, this study was carried out to evaluate the effect of nitrogen levels on growth attributes, yield, and nutrient uptake of different rice varieties under transplanted conditions.

## 2 Materials and Methods

The trial was conducted during the wet seasons of 2017 at Banaras Hindu University, Varanasi. The farm is on the Northern Gangetic Alluvial plains at 25º18'N latitude and 88º 03'E longitude and an altitude of 128.93 m above the mean sea level. The meteorological data of weather parameters, viz. rainfall and temperature were recorded during the experiment. The highest amount of rainfall 139.8 mm by southwest monsoon was recorded in July and the maximum temperature was 40.1$^{o}$C in June while the minimum temperature16.8$^{o}$C in November. Soil samples (0-15 cm depth) were collected from the experimental site before sowing and after harvesting, analyzed for mechanical and physicochemical properties. The soil texture was sandy clay loam (USDA), neutral in reaction pH 7.2, low organic carbon 0.43% (Jackson, 1973), low in available nitrogen 202.7 kg ha$^{-1}$ (Subbiah & Asija, 1956), medium in phosphorus pentoxide ($P_2O_5$) 22.45 kg ha$^{-1}$(Olsen et al., 1954), and potassium oxide ($K_2O$) 209.2 kg ha$^{-1}$ (Jackson, 1973).

The experiment was laid out in a split-plot design with three rice varieties (V1- BPT-5204, V2- Rajendra Kasturi and V3- HUBR 2-1 with durations of 150, 130 and 130 days respectively) in main plots and four nitrogen levels (N1- 100, N2- 120, N3- 140 and N4- 160 kg ha$^{-1}$) in sub-plots with three replications and twelve treatment combinations. For the Varanasi region, the recommended dose of fertilizer (RDF) for N, $P_2O_5$ and $K_2O$ (120-60-60 kg ha$^{-1}$) was used to compute various NPK levels. Half dose of nitrogen and a full dose of phosphorus, potassium were applied basal and the remaining half dose of nitrogen was applied in two equal splits at active tillering and panicle initiation stages as per treatments to their respective plots. Fertilizer sources used for NPK were urea (46% N), diammonium phosphate (18% N and 46% $P_2O_5$), and muriate of potash (60% $K_2O$).

The nursery area was plowed once with disk plow followed by puddling and planking then desired seedbed was prepared. The twenty days seedling was transplanted at the spacing of 20 cm (R x R) and 10 cm (P x P). Two seedlings at the depth of 2-3 cm were transplanted. Five cm water level was continuously maintained till flowering there after field was kept under saturated condition. Recommended agronomic practices were followed to raise the rice crop.

The data collected were chlorophyll content , number of leaves, number of days taken to 50% flowering and maturity, grain, straw, biological yield, and harvest index. The N content in grain and straw was analyzed by the micro Kjeldahl method. The Vanadomolybdo phosphoric acid yellow color method was used to determine phosphorus, while the flame photometer was used to determine potassium (Jackson, 1973). Individual treatment nutrient uptake was computed by multiplying the grain and straw yield with respective nutrient content. The ratio of grain yield to biological yield was calculated by using the following formula:

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

While nutrient uptake in grain and straw of the crops were calculated in kg ha$^{-1}$ concerning yield ha$^{-1}$ by the following formula:

Nutrient uptake (kg ha$^{-1}$) = Nutrient content (%) × yield (q ha$^{-1}$)

The data recorded were analyzed following standard statistical analysis of variance procedure as suggested by (Gomez & Gomez, 1984).

## 3 Results and Discussion

### 3.1 Effect of nitrogen level and varieties on growth attributes and phenology

Results of the current study revealed that the number of leaves hill$^{-1}$ was significantly influenced by different varieties and nitrogen levels (Table 1). Variety BPT-5204 recorded a significantly higher number of leaves (37.17 hill$^{-1}$) at the level (160 kg N ha$^{-1}$) followed by HUBR 2-1 (34.50 hill$^{-1}$) and the lowest number of leaves hill$^{-1}$ was observed in the variety Rajendra Kasturi (32.92) at (100 kg N ha$^{-1}$). An increase in the leaves number hill$^{-1}$ means an increase the photosynthesis because the leaf is the factory for the conversion of light energy into chemical energy by the process of photosynthesis. These results are in agreement with the findings of Singh & Kumar (2014).

Similarly, chlorophyll content (SPAD value) was also significantly influenced by the nitrogen level and the highest chlorophyll content was observed in the variety BPT-5204 (31.83) at level 160 kg N ha$^{-1}$ and the lowest SPAD value was observed in the variety Rajendra Kasturi (30.65) at 100 kg N ha$^{-1}$ (Table 1). Chlorophyll content increased with an increase in nitrogen levels because nitrogen is an integral part of chlorophyll. An increase in the nitrogen rate increased the chlorophyll content of rice. A similar result was found by Bala subramaniyan & Palaniappan (1991). Table 2 shows that plant population (m$^{-2}$) was not significantly influenced by different varieties and nitrogen levels.

Days taken to 50% flowering and maturity were significantly influenced by different rice varieties and nitrogen levels (Table 2). Among the varieties, BPT- 5204 significantly took a higher number of days taken to 50% flowering (103 days) and maturity (130.17 days) at the level 160 kg N ha$^{-1}$ as compared to HUBR 2-1 and the lowest number of days taken to 50% flowering (92.33 days) and maturity (119.17 days) was observed in Rajendra Kasturi variety at the level of 100 kg N ha$^{-1}$. However, nitrogen levels 140 and 120 kg N ha$^{-1}$ had statistically at par for the number of days taken for the maturity of rice.

Table 1 Effect of nitrogen levels on chlorophyll content (SPAD value) and number of leaves hill$^{-1}$ of different rice varieties

| Treatment | eulav DAPS | | Number of leaves hill$^{-1}$ | | | |
|---|---|---|---|---|---|---|
| | 30 DAT | 60 DAT | 30 DAT | 60 DAT | 90DAT | tsevrah tA |
| yteiraV | | | | | | |
| TPB5204 | 31.61 | 31.83 | 31.83 | 40.83 | 39.08 | 37.17 |
| irutsaK ardnejaR | 28.48 | 30.65 | 27.58 | 37.42 | 34.83 | 32.92 |
| RBUH2-1 | 29.78 | 31.33 | 28.83 | 39.08 | 36.92 | 34.50 |
| SEm± | 0.08 | 0.12 | 0.74 | 0.48 | 0.35 | 0.25 |
| CD (*P*=0.05) | 0.32 | 0.49 | 2.89 | 1.87 | 1.38 | 1.00 |
| Nitrogen level (kg ha$^{-1}$) | | | | | | |
| 100 | 28.88 | 30.47 | 28.22 | 37.89 | 35.67 | 33.78 |
| 120 | 29.50 | 30.84 | 29.11 | 38.78 | 36.44 | 34.44 |
| 140 | 30.28 | 31.36 | 29.78 | 39.67 | 37.33 | 35.11 |
| 160 | 31.17 | 32.41 | 30.56 | 40.11 | 38.33 | 36.11 |
| SEm± | 0.20 | 0.11 | 0.54 | 0.53 | 0.49 | 0.48 |
| CD (*P*=0.05) | 0.58 | 0.31 | 1.61 | 1.59 | 1.47 | 1.42 |

Table 2 Effect of nitrogen levels on the number of days taken to 50% flowering, maturity, and plant population of different rice varieties

| Treatment | Day to 50% flowering | Day to maturity | Plant population ( $m^{-2}$) | |
|---|---|---|---|---|
| | | | Initial | Final |
| yteiraV | | | | |
| TPB5204 | 103.00 | 130.17 | 49.58 | 49.00 |
| Rajendra Kasturi | 92.33 | 119.17 | 48.42 | 48.25 |
| RBUH2-1 | 94.67 | 121.67 | 49.00 | 48.42 |
| SEm± | 0.56 | 0.52 | 0.33 | 0.22 |
| CD (*P*=0.05) | 2.18 | 2.03 | 1.31 | 0.86 |
| Nitrogen level (kg $ha^{-1}$) | | | | |
| 100 | 94.67 | 121.78 | 48.67 | 48.33 |
| 120 | 96.00 | 123.11 | 48.67 | 47.89 |
| 140 | 97.33 | 124.22 | 49.44 | 49.33 |
| 160 | 98.67 | 125.56 | 49.22 | 48.67 |
| SEm± | 0.42 | 0.44 | 0.50 | 0.53 |
| CD (*P*=0.05) | 1.26 | 1.32 | 1.47 | 1.58 |

Table 3 Effect of nitrogen levels on grain yield, straw yield, biological yield and harvest index of different rice varieties

| Treatment | Grain yield (q $ha^{-1}$) | Straw yield (q $ha^{-1}$) | Biological yield (q $ha^{-1}$) | 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 |

**3.2 Effect of nitrogen level and varieties on yield**

The grain yield of rice is significantly influenced by different varieties and nitrogen levels (Table 3). The grain yield of BPT 5204 (50.73 q $ha^{-1}$) at a level of 160 kg N $ha^{-1}$ was recorded significantly superior followed by HUBR 2-1(38.92 q $ha^{-1}$) with the same level of nitrogen and lowest grain yield was observed in Rajendra Kasturi variety (32.67 q $ha^{-1}$) at the level 100 kg N $ha^{-1}$. Nitrogen is one of the most important nutrients in increasing the yield component of rice which leads to increased yield. Mrudhula & Suneetha (2020) reported that increased nitrogen levels up to 320 kg N $ha^{-1}$ significantly increased the grain yield of rice. However, the straw yield was significantly higher in HUBR 2-1 variety (78.58 q $ha^{-1}$) at the level 160 kg N $ha^{-1}$ as compared to

Rajendra Kasturi and the minimum straw yield was observed in BPT- 5204 (62.17 q $ha^{-1}$) at the level 100 kg N $ha^{-1}$. The biological yield was significantly influenced by different rice varieties and nitrogen levels. The highest biological yield (112.90 q $ha^{-1}$) at level 160 kg N $ha^{-1}$ was recorded in variety BPT 5204 and the lowest was found in the Rajendra Kasturi (104.75 q $ha^{-1}$) at level 100 kg N $ha^{-1}$. Higher grain and straw yields might be attributed to a higher photosynthetic rate as a result of enhanced LAI, which in turn boosted dry matter formation, resulting in higher grain and straw yields. The findings of the previous study were supported by these findings by Davari & Sharma (2010) and Murthy et al. (2012) who reported that increasing levels of nitrogen progressively enhanced yield attributes, grain, and straw yield of rice. Harvest index was significantly influenced by different rice varieties but did not significantly influence due to nitrogen levels. The harvest index was highest recorded in variety BPT- 5204 (0.45) followed by HUBR 2-1 (0.33) and lowest was found in the Rajendra Kasturi (0.31) at the dose 100 kg N $ha^{-1}$ however, harvest index was statistically at par HUBR 2-1 and Rajendra Kasturi variety. Hossain et al. (2008) reported that the difference of variety had a great influence on the harvest index.

### 3.3 Effect of nitrogen level and varieties on N, P, K content and uptake in grain and straw

Nitrogen content in grain and straw was significantly influenced by different varieties and nitrogen levels (Table 4). At a level of 160 kg N $ha^{-1}$, the variety BPT-5204 produced significantly higher nitrogen content in grain (1.20) and straw (0.48) as compared to HUBR 2-1 and the lowest nitrogen content was observed in Rajendra Kasturi in grain (1.10) and straw (0.39) at level 100 kg N $ha^{-1}$. Among the nitrogen level significantly highest nitrogen content was found with 160 kg N $ha^{-1}$ and the lowest was found with 100 kg N $ha^{-1}$ in both grain and straw. Variation in nitrogen content in grain was at par with the level of 120 to 100 kg N $ha^{-1}$. About 73% of nitrogen translocated to grain in non-aromatic rice varieties, with the rest remaining in the straw, whereas only 47% of nitrogen translocated to grain in aromatic varieties (De et al., 2002). However, P and K content was not significantly influenced by different varieties and nitrogen levels in both grain and straw.

The amount of N, P and K uptake by grain and straw was significantly influenced by different varieties and nitrogen levels (Table 5). Among the varieties, BPT- 5204 at a level of 160 kg N $ha^{-1}$ recorded significantly higher NPK uptake in grain and the lowest nitrogen uptake was observed in Rajendra Kasturi at level 100 kg N $ha^{-1}$. Among the varieties, K uptake in grain was statistically at par with HUBR 2-1 and Rajendra Kasturi variety. Among the nitrogen level, 160 kg N $ha^{-1}$ have significantly higher N (52.23 kg $ha^{-1}$) and P (11.17 kg $ha^{-1}$) uptakes in grain and lowest N, P uptakes were observed at level 100 kg N $ha^{-1}$ (40.34) and (8.33) kg $ha^{-1}$ respectively, while K uptake in grain was not significantly influenced due to nitrogen level. N uptake in straw was significantly higher in HUBR 2-1 variety and lowest observed in Rajendra Kasturi. While N uptake in straw by HUBR 2-1 and BPT- 5204 variety statistically at par the higher uptake of N with 160 kg N $ha^{-1}$ might be due to application of more amount of N in more number of splits leading to increased uptake. Similarly,

Table 4 Effect of nitrogen levels on N, P and K content (%) in grain and straw of different rice varieties

| Treatment | N content (%) | | P content (%) | | K content (%) | |
|---|---|---|---|---|---|---|
| | Grain | Straw | Grain | Grain | Straw | Grain |
| yteiraV | | | | | | |
| TPB- 5204 | 1.20 | 0.48 | 0.22 | 1.63 | 0.22 | 1.63 |
| irutsaK ardnejaR | 1.05 | 0.36 | 0.20 | 1.56 | 0.20 | 1.56 |
| RBUH2-1 | 1.10 | 0.39 | 0.21 | 1.59 | 0.21 | 1.59 |
| SEm± | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| CD (*P*=0.05) | 0.03 | 0.02 | NS | NS | NS | NS |
| Nitrogen level (kg $ha^{-1}$) | | | | | | |
| 100 | 1.08 | 0.37 | 0.22 | 0.08 | 0.21 | 1.57 |
| 120 | 1.10 | 0.39 | 0.23 | 0.09 | 0.21 | 1.58 |
| 140 | 1.13 | 0.43 | 0.24 | 0.10 | 0.21 | 1.60 |
| 160 | 1.16 | 0.45 | 0.25 | 0.10 | 0.20 | 1.62 |
| SEm± | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 |
| CD (*P*=0.05) | 0.02 | 0.02 | NS | NS | NS | NS |

Table 5 Effect of nitrogen levels on N, P and K uptake (kg ha$^{-1}$) in grain and straw of different rice varieties

| Treatment | N uptake (kg ha$^{-1}$) | | P uptake (kg ha$^{-1}$) | | K uptake (kg ha$^{-1}$) | |
|---|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | Grain | Straw |
| yteiraV | | | | | | |
| TPB- 5204 | 60.96 | 29.72 | 13.01 | 7.15 | 10.95 | 101.55 |
| irutsaK ardnejaR | 34.41 | 26.26 | 7.03 | 5.16 | 6.35 | 112.52 |
| RBUH2-1 | 42.88 | 30.94 | 8.94 | 6.78 | 8.06 | 124.90 |
| SEm± | 0.95 | 0.56 | 0.29 | 0.11 | 0.50 | 1.51 |
| CD (*P*=0.05) | 3.72 | 2.19 | 1.12 | 0.42 | 1.96 | 5.92 |
| Nitrogen level (kg ha$^{-1}$) | | | | | | |
| 100 | 40.34 | 24.81 | 8.33 | 4.96 | 7.63 | 105.45 |
| 120 | 43.53 | 27.35 | 9.01 | 5.93 | 8.15 | 110.59 |
| 140 | 48.23 | 30.49 | 10.13 | 6.87 | 8.90 | 115.49 |
| 160 | 52.23 | 33.25 | 11.17 | 7.70 | 9.14 | 120.41 |
| SEm± | 0.80 | 0.59 | 0.16 | 0.13 | 0.32 | 1.28 |
| CD (*P*=0.05) | 2.39 | 1.74 | 0.48 | 0.38 | NS | 3.79 |

statistically significant N uptake was reported with the increasing levels of N (Marlar et al., 2007). Furthermore, among varieties, BPT- 5204 (7.15 kg ha$^{-1}$) was recorded a significantly higher uptake of P in straw, and the lowest was observed in Rajendra Kasturi (6.78 kg ha$^{-1}$). The uptake of K was significantly higher in HUBR 2-1 as compared to other varieties. On the other hand, the uptake of N, P and K in straw was significantly higher at the application of 160 kg N ha$^{-1}$ and 100 kg N ha$^{-1}$, the lowest uptake was recorded. The higher N, P and K uptake may be due to more available nutrients, and better translocation of the nutrients in prolong submergence situations resulted in higher yield recorded in these treatments (Sathish et al., 2011; Ramalakshmi et al., 2012).

**Conclusion**

Considering the results obtained from the study it can be concluded that BPT-5204 variety was superior over the rest of the varieties and among nitrogen levels the best level was 160 kg N ha$^{-1}$.

**Conflict of interest**

The authors would hereby like to declare that there is no conflict of interests that could arise.

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