Agronomic evaluation of rice (*Oryza sativa*) genotypes under varying fertility levels

ANJALI BAHUGUNA¹, D K SINGH¹, SUPRIYA²*, AMIT KUMAR³, KAMAL GARG², PARKASH VERMA², SHASHANK PATEL³ and SUDARSHAN S³

G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand 263 153, India

Received: 24 August 2023; Accepted: 18 September 2023

Keywords: Agronomic evaluation, Fertility levels, Rice genotypes

Rice (*Oryza sativa* L.) is a vital global crop, especially in Asia, where 90% of production and consumption occurs, sustaining over two billion people and meeting a significant portion of their energy needs. The challenge of a projected 50% increased demand by 2050 due to population growth prompts a need for improved production (FAO 2016). Despite progress, certain regions still face low rice yields compared to major producers like China and Japan. Enhancing yield and quality requires focusing on production technologies and agricultural input management, with proper fertilizer use being crucial.

Nitrogen, phosphorus, and potassium (NPK) fertilizers play essential roles in maximizing economic returns (Ananthi *et al*. 2014). Efficient fertilizer utilization is critical, especially in countries like India where nutrient use efficiency remains low. Genetic diversity could enhance soil and fertilizer efficiency by identifying genotypes with better nutrient absorption capabilities (Janaki *et al*. 2017). Thus, determining optimal NPK levels and high-yield genotypes is imperative. An experiment titled "Agronomic evaluation of rice genotypes under varying fertility levels" was conducted to address these concerns.

The experiment was conducted during the rainy (*kharif*) season of 2019 At the research farm of G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The experiment comprised 10 treatments tested in a split-plot design with 3 replications. The gross area and net area of the experimental plot were 5.0 m × 3.0 m and 3.4 m × 2.2 m, respectively. The inter-row spacing was 20 cm. The experimental details were – main plot; Fertilizer levels (3): F₁, Control; F₂, 100% RDF (120 kg N, 60 kg P₂O₅ and 40 kg K₂O/ha); F₃, 150% RDF (180 kg N, 90 kg P₂O₅ and 60 kg K₂O/ha) and subplot; G₁, IET-27263; G₂, IET-26418; G₃, IET-26420; G₄, NDR-359; G₅, PD-19; G₆, PD-26.

Panicle length was measured in 16 selected hills, averaging the length. Grain weight per panicle was found by dividing total grain weight by panicle no. Weight of 1000-grains from each plot was recorded. Harvesting occurred at 90% grain ripeness, followed by sun drying and manual threshing. Biological yield, combining grain and straw yield, was expressed in kg/ha. Harvest index was calculated as under:

\[
HI (%) = \frac{\text{Grain yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100
\]

The net return (₹/ha) and benefit cost ratio was calculated with the help of the following formula:

\[
\text{Net return (₹/ha)} = \text{Gross return (₹/ha)} - \text{Cost of cultivation (₹/ha)}
\]

\[
B:C = \frac{\text{Net return (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}
\]

The information was processed following the established protocol utilizing a split-plot design for "Analysis of Variance" (ANOVA), in accordance with Gomez and Gomez's methodology (1984). The Least Significance Difference (LSD) at a 5% probability level.

Yield attributing characters: Diverse fertilizer levels had a significant impact on rice panicle density, varying from 188 to 248/m² across treatments (Table 1). The increase, particularly in the 150% recommended dose of fertilizer (RDF) treatment, was attributed to effective NPK uptake during panicle initiation (Yoshida 1981). Insufficient nitrogen during this phase in the Control group led to fewer panicles due to increased tiller mortality, aligned with research of Paramasivan *et al*. (2018). Genotype differences also played a role, with IET-27263 showing the highest density (238), likely due to genetic variations affecting panicle formation. Such genetic influences contribute to 81%
Varying fertilizer levels notably impacted grain weight per panicle, with an increase from 1.93 g in the Control to 2.26 g at 150% RDF. Similar outcomes were found by Ninju et al. (2018). Genotypes also significantly influenced grain weight per panicle. IET-27263 had the highest weight (2.20 g), likely due to genetic changes. This genotype’s higher grain weight could stem from altered plant genetics, as grain weight per panicle contributes to 81% of rice’s yield variation (Yoshida et al. 1976).

The impact of varied fertilizer rates on 1000-grain weight was minimal, with N, P, and K fertilization not affecting it significantly. This result is likely due to genetic differences among varieties. This observation aligns with Singh et al. (2007) of rice’s variability in yield, supported by similar findings of Singh et al. (2007).

Both fertilizer rates and genotypes notably impacted rice panicle length (Table 1). Fertility levels increased panicle length, particularly at 150% RDF, possibly due to enhanced nutrient supply for panicle development. This aligns with Mondal et al. (2013) findings. Panicle length ranged from 21.2 cm in Control to 25.4 cm at 150% RDF. Rice genotypes also played a significant role; PD-19 displayed the longest panicles (24.3 cm). Genetic variations likely underlie differences in panicle length among diverse genotypes, consistent with Sultana (2014) observations in distinct genotypes.

Table 1 Effect of fertilizer rates and genotypes on yield attributing characters and yield of rice

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Panicles no./m²</th>
<th>Panicle length (cm)</th>
<th>Grain weight (g/panicle)</th>
<th>1000-grain weight</th>
<th>Yield (t/ha)</th>
<th>Harvest index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Grain</td>
<td>Straw</td>
</tr>
<tr>
<td>Fertilizer level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>188</td>
<td>21.2</td>
<td>1.93</td>
<td>25.3</td>
<td>2.56</td>
<td>2.94</td>
</tr>
<tr>
<td>100% RDF</td>
<td>232</td>
<td>23.8</td>
<td>2.06</td>
<td>25.2</td>
<td>4.15</td>
<td>4.57</td>
</tr>
<tr>
<td>150% RDF</td>
<td>248</td>
<td>25.4</td>
<td>2.26</td>
<td>25.6</td>
<td>4.73</td>
<td>5.18</td>
</tr>
<tr>
<td>LSD (P=0.05)</td>
<td>2</td>
<td>0.27</td>
<td>0.02</td>
<td>0.14</td>
<td>0.17</td>
<td>0.19</td>
</tr>
<tr>
<td>Genotype</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.44</td>
<td>0.58</td>
</tr>
</tbody>
</table>

Table 2 Interaction effect of fertilizer rates and rice genotypes on grain and straw yield

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Grain yield (t/ha)</th>
<th>Straw yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>100% RDF</td>
</tr>
<tr>
<td>IET-27263</td>
<td>2.80</td>
<td>4.77</td>
</tr>
<tr>
<td>IET-26418</td>
<td>2.48</td>
<td>3.60</td>
</tr>
<tr>
<td>IET2-2420</td>
<td>2.38</td>
<td>3.46</td>
</tr>
<tr>
<td>NDR-359</td>
<td>2.73</td>
<td>4.63</td>
</tr>
<tr>
<td>PD-19</td>
<td>2.68</td>
<td>4.33</td>
</tr>
<tr>
<td>PD-26</td>
<td>2.35</td>
<td>4.13</td>
</tr>
</tbody>
</table>

Comparing two genotypes at same fertilizer rate
Comparing two fertilizer rates at same or different genotypes
CV (%) based on error (b)
Renuka et al. (2013), emphasizing the role of genetics in rice test weight. However, rice genotypes exhibited significant 1000-grain weight variation. IET-27263 displayed notably higher weight (27.4 g) than others, in line with Zahid’s (2005).

Yield and harvest index: The impact of varying fertilizer doses on rice grain yield is evident from the data presented (Table 2). Increasing fertilizer levels significantly enhanced grain yield, peaking at 150% of the recommended dose (4.73 t/ha). Compared to the Control group's 2.56 t/ha yield, there was a 62.1% increase at 100% RDF and an 84.76% increase at 150% RDF. The substantial rise at 150% RDF was due to heightened fertility, promoting efficient vegetative growth and sink development (Salahuddin et al. 2009, Kumar et al. 2014). This leads to more panicles per unit area and heavier grains per panicle, ultimately boosting overall yield. Genetic diversity also played a significant role, likely due to variations in genetic makeup and nutrient absorption capabilities (Mehta et al. 2004). IET-27263 exhibited exceptional yield (4.30 t/ha), highlighting the influence of genetic factors, lined with the findings of Renuka et al. (2013).

The impact of diverse fertilizer doses on rice straw yield is evident in the data (Table 2). Increasing fertilizer levels significantly increased straw yield, peaking at 150% of the recommended dose of fertilizer (RDF) with 5.18 t/ha (Fig 1). Compared to the Control group's mean straw yield of 2.94 t/ha, there was a 55.4% increase at 100% RDF and a 76.1% increase at 150% RDF. Similar to grain yield, straw yield also notably rose up to 150% RDF, resulting in taller plants, increased tiller density, and greater biomass production (Kumar et al. 2018). Genotype variation played a role, with IET-27263 and NDR-359 exhibiting significantly higher straw yields.

Both fertilizer levels and genotypes significantly impacted biological yield (Table 2, Fig 2). Applying fertilizer at 150% recommended dose (RDF) notably increased biological yield to 9.91 t/ha due to enhanced vegetative growth, efficient resource allocation, and heightened photosynthesis. This parallels findings by Javeed et al. (2018) and Kumar et al. (2019). The increase at 100 and 150% RDF was 58.5 and 80.18% respectively, compared to Control's mean of 5.50 t/ha. IET-27263 excelled with a biological yield of 8.97 t/ha, attributed to its greater height, tiller count, and dry matter accumulation (Chaturvedi et al. 2001).

It is observed from the data that the variation in harvest index due to different levels of fertilizer was found to be non-significant. It might be due to the same proportion in which the grain and straw yield increased. The genotype IET-27263, IET-26420 and NDR-359 all had harvest index of 0.48.

Economic studies: The cultivation costs were highest at 150% recommended fertilizer dose (RDF) treatment (₹35606), followed by 100% RDF treatment (₹31608), while the lowest occurred in the zero fertility (control) treatment due to no fertilizer application. Gross returns were notably affected by fertilizer levels and rice genotypes, with 150% RDF treatment yielding the highest returns of ₹93064, followed by 100% RDF (₹81811) and Control (₹44858). The lowest was recorded at 0% RDF, ₹42193. The B:C ratio was calculated by dividing the gross return by the cost of cultivation. The highest B:C ratio of 1.61 was recorded at 150% RDF, followed by 100% RDF (1.50) and Control (0.68). The lowest was recorded at 0% RDF, 1.33. The genotype IET-27263 excelled with a B:C ratio of 1.54, followed by IET-26418 (1.50) and NDR-359 (1.47). The lowest was recorded at PD-19, 1.05. The B:C ratio was calculated by dividing the gross return by the cost of cultivation. The highest B:C ratio of 1.61 was recorded at 150% RDF, followed by 100% RDF (1.50) and Control (0.68). The lowest was recorded at 0% RDF, 1.33. The genotype IET-27263 excelled with a B:C ratio of 1.54, followed by IET-26418 (1.50) and NDR-359 (1.47). The lowest was recorded at PD-19, 1.05.
the highest achieved from 150% RDF treatment (₹93064) (Table 3). Similar findings were reported by Kumar et al. (2013). For rice genotypes, IET-27263 had the highest gross return (₹80458), followed by NDR-359 (₹78256). Net returns were significantly influenced by both fertilizer levels and genotypes, highest in the 150% RDF treatment (₹57458). Similar trends were seen in the study by Das et al. (2008). IET-27263 had the highest net return (₹48850), followed by NDR-359 (₹43228). Benefit-cost ratio was influenced by both factors, with 150% RDF treatment showing the highest ratio (1.61), consistent with Rao et al. (2014). IET-27263 had the highest ratio (1.54).

SUMMARY

The study suggests that rice varieties IET-27263 and NDR-359 can achieve increased yields by employing 150% of the recommended fertilizer dose (180:90:60 kg NPK/ha). Using 150% of the suggested nitrogen dose (RDN) results in notably elevated gross and net returns, as well as an improved benefit-to-cost ratio (B: C). Particularly, genotype IET-27263 exhibits significantly superior gross return, net return, and B: C ratio compared to other genotypes.

REFERENCES


