



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

ANJALI BAHUGUNA<sup>1</sup>, D K SINGH<sup>1</sup>, SUPRIYA<sup>2\*</sup>, AMIT KUMAR<sup>3</sup>, KAMAL GARG<sup>2</sup>, PARKASH VERMA<sup>2</sup>, SHASHANK PATEL<sup>3</sup> and SUDARSHAN S<sup>3</sup>

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 (*khari*) 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): F<sub>1</sub>, Control; F<sub>2</sub>, 100% RDF (120 kg N, 60 kg P<sub>2</sub>O<sub>5</sub> and 40 kg K<sub>2</sub>O/ha); F<sub>3</sub>, 150% RDF (180 kg N, 90 kg P<sub>2</sub>O<sub>5</sub> and 60

kg K<sub>2</sub>O/ha) and sub plot: G<sub>1</sub>, IET-27263; G<sub>2</sub>, IET-26418; G<sub>3</sub>, IET-26420; G<sub>4</sub>, NDR-359; G<sub>5</sub>, PD-19; G<sub>6</sub>, 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/m<sup>2</sup> 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%

<sup>1</sup>G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand; <sup>2</sup>ICAR-National Dairy Research Institute, Karnal, Haryana; <sup>3</sup>ICAR-Indian Agricultural Research Institute, New Delhi. \*Corresponding author email: supriya.ndri5@gmail.com

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

Treatment	Panicles no./m <sup>2</sup>	Panicle length (cm)	Grain weight (g/panicle)	1000-grain weight	Yield (t/ha)			Harvest index
					Grain	Straw	Total	
<i>Fertilizer level</i>								
Control	188	21.2	1.93	25.3	2.56	2.94	5.50	0.48
100% RDF	232	23.8	2.06	25.2	4.15	4.57	8.72	0.48
150% RDF	248	25.4	2.26	25.6	4.73	5.18	9.91	0.48
SEm±	2	0.27	0.02	0.14	0.17	0.19	0.32	0.05
LSD (P=0.05)	10	1.08	0.12	NS	0.44	0.58	1.01	NS
<i>Genotype</i>								
IET-27263	238	23.6	2.20	27.4	4.30	4.67	8.97	0.48
IET-26418	207	22.6	1.99	23.8	3.53	3.93	7.46	0.47
IET-26420	217	23.0	1.82	23.2	3.42	3.67	7.09	0.48
NDR-359	221	23.7	2.11	24.5	4.22	4.66	8.88	0.48
PD-19	231	24.3	2.06	27.3	3.82	4.34	8.16	0.47
PD-26	219	23.2	2.18	25.5	3.61	4.12	7.73	0.47
SEm±	2	0.21	0.005	0.4	0.06	0.09	0.21	0.05
LSD (P=0.05)	6	0.70	0.080	1.2	0.23	0.25	0.65	NS
CV (%)	14.3	6.9	6.58	3.9	8.3	11.3	12.63	4.6

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.

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

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

Genotype	Grain yield (t/ha)			Straw yield (t/ha)		
	Control	100% RDF	150% RDF	Control	100% RDF	150% RDF
IET-27263	2.80	4.77	5.33	3.50	5.12	5.39
IET-26418	2.48	3.60	3.53	2.68	4.05	5.06
IET2-2420	2.38	3.46	3.42	2.30	3.85	4.86
NDR-359	2.73	4.63	4.22	3.26	5.30	5.42
PD-19	2.68	4.33	3.82	3.13	4.66	5.23
PD-26	2.35	4.13	3.61	2.86	4.43	5.07
<i>Treatment</i>		<i>SEm±</i>	<i>LSD (P=0.05)</i>		<i>SEm±</i>	<i>LSD (P=0.05)</i>
Fertilizer level		0.04	0.13		0.04	0.13
Genotype		0.05	0.17		0.06	0.18
Comparing two genotypes at same fertilizer rate		0.25	0.43		0.07	0.24
Comparing two fertilizer rates at same or different genotypes		0.18	0.36		0.08	0.26
CV (%) based on error (b)			11.75			10.3

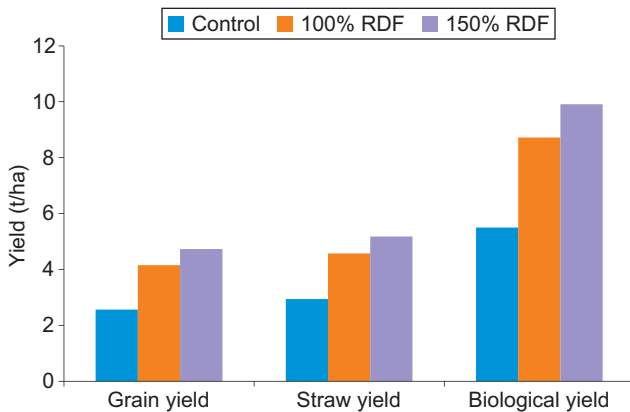


Fig 1 Yield as influenced by level of fertilizers.

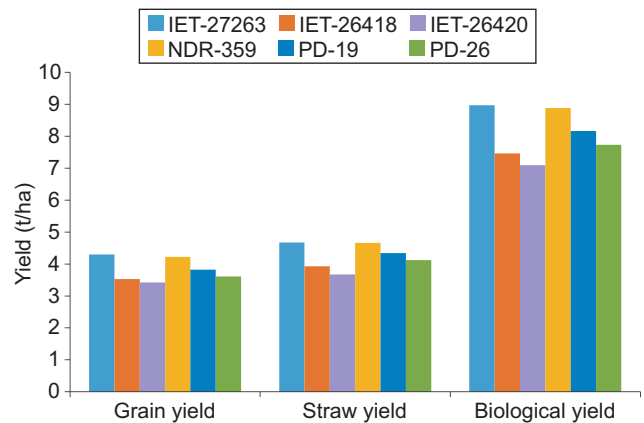


Fig 2 Yield as influenced by genotypes.

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% 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

Table 3 Cost of cultivation, gross return, net return and B:C ratio as influenced by levels of fertilizer and genotypes

Treatment	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
<i>Fertilizer level</i>				
Control	26606	44858	18252	0.68
100% RDF	32614	81811	49197	1.50
150% RDF	35606	93064	57458	1.61
SEm±		2842	2661	0.03
CD (P=0.05)		8526	7985	0.09
<i>Genotype</i>				
IET-27263	31608	80458	48850	1.54
IET-26418	31608	67068	35460	1.12
IET-26420	31608	65056	33448	1.05
NDR-359	31608	78256	46648	1.47
PD-19	31608	74836	43228	1.36
PD-26	31608	73801	42193	1.33
SEm±		337	326	0.01
CD (P=0.05)		1012	1003	0.03

the highest achieved from 150% RDF treatment (₹93064) (Table 3). Similar findings were reported by Kumari *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

- Ananthi T, Amanullah M M and Subramanian K S. 2014. Influence of mycorrhizal and synthetic fertilizers on soil nutrient status and uptake in hybrid maize. *Madras Agriculture Journal* **97**: 374–78.
- Chaturvedi S. 2001. 'Agronomic evaluation of some new promising varieties of hybrid rice in Uttaranchal Tarai'. M. School. Thesis, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand *Journal of Plant Nutrition and Soil Science* **168**(2005): 521–30.
- Das S, Kumar R, Singh J P and Mani N. 2008. Effect of nitrogen and potassium levels on yield, N K-uptake and economics of hybrid rice (*Oryza sativa* L.). *Environment and Ecology* **26**(4A): 1917–18.
- FAO. 2016. Trends of rice paddy production: Monitoring the market.
- Gomez K A and Gomez AA. 1984. *Statistical Procedures for Agricultural Research*, 2<sup>nd</sup> edn. John and Wiley Sons, New York.
- Janaki Jana K, Mallick G K, Das S K, Biswas B, Kundu M K, Koireng R J and Puste A M. 2017. Evaluation of potential rice (*Oryza sativa* L.) genotypes with different levels of N under rainfed shallow lowland situation. *Archives of Agriculture and Environmental Science* **2**(3): 202–05.
- Javeed A, Gupta M, Choudhary K and Bazgalia K. 2018. Effect of graded levels of N, P and K on yield and nutrient uptake of fine rice (*Oryza sativa*) under sub-tropical conditions. *International Journal of Modern Agriculture* **6**(5): 2420–23.
- Kumar S, Kour S, Gupta M and Choudhary K. 2018. Balance sheet of soil nutrients as influenced by soil fertility levels in different varieties of rice (*Oryza sativa* L.). *Journal of Soil and Water Conservation* **17**(2): 154–59.
- Kumar R, Mishra J S, Kumar S, Hans H, Bhatt B P, Srivastava A K and Singh S. 2019. Production potential, economics and energetics of rice (*Oryza sativa* L.) genotypes as influenced by varying levels of nitrogen. *The Indian Journal of Agricultural Sciences* **89**(11): 1846–49.
- Kumar S, Srinivasa G, Raju M and Mahendra Kumar R. 2014. Growth characteristics, yield attributes, grain yield and quality of rice hybrids as influenced by nitrogen fertilization. *Progressive Agriculture* **14**(1): 125–29.
- Kumari N, Pal S K and Barla S. 2013. Effect of organic nutrient management on productivity and economics of scented rice. *ORYZA-An International Journal on Rice* **50**(3): 249–52.
- Mehta J L, Deshpande V N, Dalvi V V, Bendale and Kunkerkar R L. 2004. Sahyadria promising rice hybrid of India. *Madras Agriculture Journal* **91**: 158–60.
- Mondal S, Bauri A, Pramanik K, Ghosh M, Malik G C and Ghosh D C. 2013. Growth, productivity and economics of rice as influenced by fertility level and plant density. *International Journal of Bio-resource and Stress Management* **4**(4): 547–54.
- Njinju S M, Samejima H, Katsura K, Kikuta M, Gweyi-Onyango J P, Kimani J M, Yamauchi A and Makihara D. 2018. Grain yield responses of lowland rice varieties to increased amount of nitrogen fertilizer under tropical highland conditions in central Kenya. *Plant Production Science* **21**(2): 59–70.
- Paramasivan M J G and Kumar N S. 2018. Effect of levels of nitrogen, phosphorus and potassium on productivity, nutrient uptake and soil fertility in rice (*Oryza sativa*) in an Alfisols of Tambiraparani tract. *Indian Journal of Agronomy* **63**(1): 50–54.
- Rao J, Zhou Q and Tang H. 2014. Effects of various applying ratios of N, P and K on the yielding and quality of upland rice. *Journal of Hunan Agricultural University* **29**(3): 199–203.
- Renuka Devi K, Sudhakar P and Sivasankar A. 2013. Evaluation of physiological efficiency and yield potential of rice under aerobic condition. *Bioinfolet* **10**(1B): 209–13.
- Salahuddin K M, Chowdhury S H, Muniram S, Islam M and Parvin S. 2009. Response of nitrogen and plant spacing of transplanted aman rice. *Bangladesh Journal of Agriculture Research* **34**: 279–85.
- Singh P, Singh P and Singh S S. 2007. Response of aromatic rice (Pusa Basmati 1) to establishment methods, fertility levels and weed management practices. *Indian Journal of Weed Science* **39**(1 and 2): 32–35.
- Sultana R and Islam M K. 2014. Performance evaluation of two rice varieties under different levels of salinity stress. *Bangladesh Research Publication Journal* **2**: 61–64.
- Yoshida S, Forno D A, Cock J H and Gomez K A. 1976. Laboratory manual for physiological studies of rice. The International Rice Research Institute, Philippines.
- Yoshida S. 1981. *Fundamental of Rice Crop Science*, 1<sup>st</sup> edn, pp. 269. International Rice Research Institute: Los Banos, Laguna, Philippines.
- Zahid A M M, Akhtar M L and Sabar G A. 2005. Interrationship among yield and economic traits in fine grain rice. *Proceedings of the International Seminar on Rice Crop* **10**(2-3): 21–24.