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Effect of different nitrogen levels on growth, yield and economics of red rice cultivars (*Oryza sativa* L.)

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Abstract
The experiment entitled "study the different nitrogen levels on growth, yield and economics of red rice cultivars" was carried out at College of Agriculture, IGKV, Raipur (C.G.) during *kharif* season in split plot design within three replications by taking five red rice cultivars *viz*., Bantha luchai, Shrikamal, Kankadiya, Khuddi and Jyothi in main plots and four nitrogen levels *i.e*. 0, 60 kg, 80 kg N ha^{-1} and 25 kg N ha^{-1} as basal dose + LCC (Leaf colour chart) based N management in sub-plots. Analysis revealed that cultivar Shrikamal recorded maximum plant height at harvest and maximum number of tillers $plant^{-1}$ recorded with variety Jyothi which was closely followed by Khuddi at harvest. Among nitrogen levels, significantly higher plant height and number of tillers were recorded with application of 80 kg N ha^{-1}. Significant higher grain yield, net return and benefit-cost ratio was recorded with variety Jyothi and in case of different nitrogen levels, application of 80 kg N ha^{-1} and 25 kg N ha^{-1} + LCC based nitrogen management produced significantly higher grain yield. However, by the application of 80 kg N ha^{-1}, higher net return and benefit-cost ratio was obtained which was comparable with 25 kg N ha^{-1} + LCC based nitrogen management. The maximum straw yield was recorded with 80 kg N ha^{-1} and it was not influenced by cultivars. Significant interaction effect was noted in plant height, number of tillers $plant^{-1}$ and grain yield.

Highlight
- Performance of red rice cultivars under different levels of nitrogen
- Optimize the dose for different red rice cultivars
- Choose a good yield and economics providing cultivars

Keywords: Yield, Leaf colour chart (LCC), net returns, tillers, nitrogen

Introduction
Rice (*Oryza sativa* L.) is a cereal crop, which is also a staple food for people in Asia- pacific region. Approximately 520.4 million metric tons milled rice accounted for total global consumption (Shahbandeh, 2022-23) [12]. The statistic shows the world rice acreage in crop year 2022 there were around 165 million hectares of rice-cultivated area worldwide. Chhattisgarh is known as 'Rice bowl of India' and about 80 per cent population of the state is dependent on agriculture for their livelihood. The total rice grown area in Chhattisgarh is 3.7 million hectares with an average productivity is about 1.3 tonnes ha^{-1} (Ministry of Agriculture and farmers welfare, 2025) [8].

Red rice is characterized by a red bran layer in which most of the micronutrients are concentrated. Rice contains tannin pigment which gives the hulled rice a red or brown colour to the rice. After black rice, red rice is the most abundant source of phyto-chemicals (Pengkumsri *et al*., 2015) [10]. The health advantages of its phytochemicals, particularly phenolic compounds and their antioxidant qualities, are given extremely healthy attention (Liu, 2017) [7]. Proteins, minerals, fibre and vitamin B are all abundant in red rice. Minerals that are selenium can increase endurance, as well as fibre can prevent constipation and vitamin B can nourish the digestive system and nerve cells. Red rice contains high iron and zinc. The zinc and iron content of red rice is two to three times higher than white rice (Ramaiah and Rao, 1953) [2]. The primary elements of red rice (nonspecific genotype) include zinc 3.3%, iron 5.5% mg 100 g^{-1} rice, fibre 2.0% and protein 7.0% (Patel and Singh, 2023) [9].

Nitrogen is major nutrient which limit the yield potential of rice cultivars. Rice crops especially prefer nitrogen fertilizer in ammonical form during the early stage and nitrate form during later stages of growth period, as nitrogen plays a key role in providing luxuriant vegetative growth, increase the herbage quality and growth of plants. Nitrogen fertilization at beginning of panicle differentiation is more advantageous to red rice than to rice, due to its higher efficiency on nitrogen uptake and utilization (Eberhardt *et al*., 1999) [1]. Nitrogen fertilizers applied to soil undergo physical, chemical and biological transformation which ultimately becomes available to crops. The application of N fertilizer has become one of the inevitable ways to increase rice yield due to insufficient soil N content. However, in order to achieve stable and high yield, farmers usually increase N fertilizer input without hesitation, resulting in a series of problems such as environmental pollution, energy waste and low production efficiency. Due to various losses and increase in cost, the efficient use of nitrogenous fertilizer is a challenge. Keeping this in view the present study was undertaken to find out the optimum level of nitrogen for enhance the growth and yield and economy of red rice cultivars.

Materials and Methods

The experiment was carried out at Instructional cum Research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *Kharif* season, 2018 to study the different nitrogen levels on qualities of red rice cultivars. The experiment was carried out in split plot design with three replications. A combination of five cultivar *viz*., Bantha luchai, Shrikamal, Kankadiya, Khuddi and Jyoti with four nitrogen levels 0, 60 kg N ha^{-1}, 80 kg N ha^{-1} and 25 kg N ha^{-1} + LCC (Leaf colour chart) based nitrogen management was taken in main plot and sub plot respectively. The recommended dose of fertilizer for red rice cultivar was 80 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1}. At the time of transplanting complete dose of phosphorus and muriate of potash were applied as basal and nitrogen was applied as per treatments by keeping three splits in ratio of 50:25:25. Plant height and number of tillers $plant^{-1}$ were taken as pre harvest observation. The crop from each net plot was harvested separately and grain and straw weight were recorded and expressed in t ha^{-1}. Net returns and B:C ratio were calculated with the help of following formula:

$$\text{Net returns (Rs ha}^{-1}) = \text{Gross returns (Rs ha}^{-1}) - \text{Cost of cultivation(Rs ha}^{-1})$$

$$\text{Benefit: cost ratio} = \frac{\text{Net returns (Rs ha}^{-1})}{\text{Cost of cultivation (Rs ha}^{-1})} \times 100$$

Results and Discussion

Growth

Significant higher plant height was recorded with cultivar Shrikamal. Among the different nitrogen levels, maximum plant height was recorded under application of 80 kg N ha^{-1} at harvest. The increase in plant height with increased in nitrogen level might be primarily due to enhanced vegetative growth with more supply of nitrogen to the plant (Table 1). Ahmed *et al*. (2005) [3] also reported the similar results. The interaction effect of rice cultivars and nitrogen levels on plant height was found significant on cultivars Shrikamal with application of 80 kg N ha^{-1} over rest of the treatment combination, presented in table 2. Maximum number of tillers $plant^{-1}$ was recorded under Jyothi variety. However, it was statistically at par with Khuddi at harvest. Significant interaction effect was obtained in number of tillers $plant^{-1}$ with the treatment combination of Khuddi with 80 kg N ha^{-1} at harvest.

Yield

Grain yield was significantly influenced by different red rice cultivars and nitrogen levels (Table 1). Significantly higher grain yield was recorded with the variety Jyothi (3.92 t ha^{-1}). However, straw yield was not affected by different red rice cultivars. Among nitrogen levels, application of 80 kg N ha^{-1} produced significantly higher grain yield (3.38 t ha^{-1}) and closely followed by 25 kg N ha^{-1} + LCC based nitrogen management. Similarly, maximum straw yield (4.26 t ha^{-1}) was recorded with 80 kg N ha^{-1} which was analogous to 60 kg N ha^{-1} and 25 kg N ha^{-1} + LCC based nitrogen management. The reason behind these results might be due to maximum growth and yield attributing characters with nitrogen levels and genetic characters of cultivars ultimately it increased grain and straw yield. Similar results have also been reported by Awan *et al*. (2011) [4] and Kumar *et al.* (2015) [6].

The analysis of variance showed a highly significant interaction between nitrogen levels and red rice cultivars that indicate cultivar were influenced with the application of different levels of nitrogen. Hence, variety Jyothi fertilized with 80 kg N ha^{-1} produced maximum higher grain yield (4.50 t ha^{-1}) which was statistically at par with treatment combination of variety Jyothi and 25 kg N ha^{-1} as basal + LCC based nitrogen management (4.13 t ha^{-1}), presented in table 2.

Economics

The maximum net returns and B:C ratio were recorded with variety Jyothi among all the cultivars. Among nitrogen levels, maximum net returns (₹ 43091 ha^{-1}) and B:C ratio (1.31) were recorded with application of 80 kg N ha^{-1} which was followed by 25 kg N ha^{-1} + LCC based nitrogen management (Table 1).

Table 1: Effect of nitrogen levels on growth, yield and economics of red rice cultivars

Treatment	Plant height (cm)	Number of tillers $plant^{-1}$	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
Cultivars						
Bantha luchai	145.85	10.88	2.76	3.27	22784	0.89
Shrikamal	162.82	12.32	2.77	4.05	22978	0.90
Kankadiya	146.99	11.65	2.80	3.62	23462	0.92
Khuddi	150.78	14.47	3.29	3.82	32038	1.25
Jyothi	91.63	15.09	3.92	4.55	43091	1.68
S.Em±	3.47	0.32	0.16	0.39	2769.7	0.11
CD (p=0.05)	11.30	1.06	0.52	NS	9032.5	0.36
Nitrogen levels						
N_0	127.75	10.51	2.63	3.30	21274	0.86
N_{60}	154.80	12.18	3.14	3.96	29359	1.15
N_{80}	166.85	15.18	3.38	4.26	33542	1.31
N_{25}+LCC	158.16	13.66	3.28	3.92	31306	1.20
S.Em±	1.65	0.15	0.07	0.18	1304.8	0.05
CD (p=0.05)	4.78	0.44	0.22	0.52	3768.6	0.15

Table 2: Interaction effect of red rice cultivars and different nitrogen levels on plant height, number of tillers and grain yield of red rice cultivars

Cultivars	Plant height (cm)				Number of tillers plant^{-1}				Grain yield (t ha^{-1})			
	Nitrogen levels				Nitrogen levels				Nitrogen levels			
	N_0	N_{60}	N_{80}	N_{25}+LCC	N_0	N_{60}	N_{80}	N_{25}+LCC	N_0	N_{60}	N_{80}	N_{25}+LCC
Bantha luchai	123.7	152.3	152.4	155.0	9.67	10.40	11.80	11.67	2.34	2.93	3.13	2.62
Shrikamal	145.8	164.0	182.8	158.6	9.89	11.50	14.33	13.55	2.19	2.86	3.02	3.01
Kankadiya	113.7	148.1	165.3	160.9	10.13	11.67	12.97	11.83	2.54	3.01	2.62	3.01
Khuddi	131.7	147.4	163.0	161.1	11.53	12.34	19.00	15.00	2.86	3.04	3.64	3.61
Jyothi	85.3	89.6	93.8	97.8	11.33	14.98	17.78	16.27	3.21	3.84	4.50	4.13
			S.Em±	**CD (p=0.05)**			**S.Em±**	**CD (p=0.05)**			**S.Em±**	**CD (p=0.05)**
Comparison of two main plots			3.46	11.74			0.32	1.07			0.15	0.52
Comparison of two sub plots			1.65	4.80			0.15	0.44			0.07	0.21
Comparison of subplots at same level of main plots			6.93	11.55			0.64	1.06			0.31	0.52
Comparison of main plots at same level of sub plots			4.72	14.73			0.43	1.36			0.21	0.66

Conclusion

In this study results showed that cultivar Shrikamal observed as heighted plant and variety Jyothi as short heighted plant. Variety Jyothi recorded maximum number of tillers plant^{-1} and grain yield. In case of nitrogen levels, plant fertilized with 80 kg N ha^{-1} showed maximum plant height number of tillers plant^{-1}, grain and straw yield. Significant interaction effect was observed in plant height, number of tillers plant^{-1} and grain yield. Maximum economy was recorded under Jyothi variety followed by Khuddi. In case of different nitrogen levels, application of 80 kg N ha^{-1} showed maximum economy which was at par with 25 kg N ha^{-1} as basal + LCC based nitrogen management.

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