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Effect of nitrogen splitting on yield, quality parameters, nutrient content and nutrient uptake of transplanted rice varieties

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Abstract
A field experiment was conducted at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C. G.) during *kharif* season of 2023. The experiment was laid out in split plot design with three replications. The treatment composed of three splitting of nitrogen in main plots (N_1-40% (B) + 30% (T) + 30% (PI), N_2-50% (B) + 25% (T) + 25% (PI) and N_3-30% (B) + 30% (T) + 30% (PI) + 10% (F),) and four different varieties (V_1-Vikram TCR, V_2-CG Devbhog, V_3-Rajeshwari and V_4-Protezin in sub-plots. The data revealed that significantly higher grain yield (5.69 t ha^{-1}), straw yield (6.19), protein content (8.62%), nitrogen content and uptake was recorded with nitrogen splitting of 30% basal + 30% tillering + 30% panicle initiation + 10% flowering. Among varieties, Vikram TCR produced higher grain yield (6.19 t ha^{-1}), straw yield (6.76 t ha^{-1}), quality parameters such as milling percent (71.06%), head rice recovery (60.31%), grain length breadth ratio (4.25) and nutrient uptake.

Keywords: Nitrogen splitting, transplanted rice, varieties, yield, quality and nutrient content and uptake

Introduction
Chhattisgarh is popularly known as the “Rice Bowl of India” because it conserves more than 23,250 rice accessions, including about 210 wild species. Rice cultivation in the state is mainly concentrated during the kharif season, as the region receives an average annual rainfall of 1200-1300 mm and largely depends on the monsoon. The crop covers nearly 3.6 million hectares in Chhattisgarh, with productivity ranging between 1.2 and 1.6 t ha^{-1} depending on rainfall (Jaiswal *et al*., 2022) [3]. Nitrogen plays a crucial role in enhancing rice yield since it is involved in photosynthesis, biomass production, effective tillering, and spikelet initiation (Yoshida *et al*., 2006) [12]. Application of nitrogen up to the panicle initiation stage is reported to improve protein concentration as well as grain yield (IRRI, 1964). Foliar spraying of urea at the heading stage also enhances the protein content of grains. Higher protein levels contribute to stronger grains, reduced breakage during milling, and improved head rice recovery (Nangju and De Datta, 1970; Leesawatwong *et al*., 2003) [6]. It is therefore important to identify genotypes that are efficient in remobilizing nitrogen from vegetative tissues to grains, leading to higher grain protein concentration. Split application of nitrogen also improves the availability of N, P, and K in the soil, which ultimately increases nutrient uptake by rice plants (Zaidi *et al*., 2007) [13]. Thus, effective nitrogen management is essential for boosting rice productivity, as its uptake is strongly influenced by cultivar differences, soil conditions, climate, and crop rotation practices.

Materials and Methods
An experiment was conducted at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C. G.) during *kharif* season of 2023. To determine the splitting of nitrogen effect on growth, yield and qualities of transplanted rice varieties. The plot was ploughed and prepared well by using tractor drawn cultivators and leveler. The soil was clay classified as *vertisol*. It was low in nitrogen (137.90 kg ha^{-1}) medium in phosphorus (13.81 kg ha^{-1}) and in potassium (309.56 kg ha^{1}), normal pH (7.21), EC (0.58 dSm^{1}) and organic carbon (0.40%).

Four weeks old seedlings were transplanted at 20 cm x 10 cm spacing. Two to three seedlings were planted per hill. The water level was maintained at 2 to 5 cm throughout the vegetative growth and reproductive stages. Pests and diseases were controlled whenever necessary. Weeds were controlled by hand weeding.

The treatments comprised of three splits of nitrogen under main plot-*i.e*. N-40% (Basal) + 30% (Tillering) + 30% (Panicle initiation), N_2-50% (Basal) + 25% (Tillering) + 25% (Panicleinitiation) and N_3-30% (Basal) + 30% (Tillering) + 30% (Panicle initiation) + 10% (Flowering)and four different varieties under subplot-*i.e*. V_1-Vikram TCR, V_2-CG Devbhog, V_3-Rajeshwariand V_4-Protezin. The experiment was conducted using split plot design with three replications. General fertilizer recommendation of 80, 60 and 40 N, P_2O_5 and K_2O kg ha^1 was applied. Phosphorus as single superphosphate and potash as muriate of potash were applied as basal. Nitrogen as urea was spllitted as per the treatments. Data on grain yield and straw yield were recorded from net plot. Different quality parameters *i.e*. milling percent, head rice recovery, protein content, grain length, breadth and length breadth ratio were recorded after harvest. The contents of nitrogen, phosphorus, and potassium in the samples were determined using the micro-Kjeldahl method, the vanadomolybdo-phosphoric yellow colour technique, and the flame photometer method, respectively. Based on these estimations, the nutrient uptake per hectare was calculated.

Results and Discussion

Yield and qualities

Grain yield (t ha^{-1}) and straw yield showed significant variation due to different nitrogen splitting and varieties and data are presented in table 1. Maximum grain yield (5.69 t ha^{-1}) and straw yield (6.19 t ha^{-1}) were recorded with splitting of 30% N at basal + 30% N at tillering + 30% N at panicle initiation + 10% at flowering which was statistically at par with 40% N at basal + 30% N at tillering + 30% N at panicle initiation. The minimum grain yield (5.57 t ha^{-1}) and straw yield (5.79 t ha^{-1}) were recorded with 50% N at basal + 25% N at tillering + 25% N at panicle initiation.This result may be attributed to the efficient utilization of nitrogen at critical crop growth stages, which promoted better vegetative growth and enhanced the number of productive tillers, panicle weight, and panicle length, ultimately leading to higher grain yield. Similar findings were reported by Singh and Singh (2005) [9], Sathiya and Rajesh (2009) [8], Hafeez *et al*. (2013) [2], and Amrutha *et al*. (2016) [1]. The improved performance under these treatments might be due to better crop growth, as reflected in increased plant height, higher dry matter accumulation, and greater tiller production. In case of varieties, higher grain yield (6.19 t ha^{-1}) and straw yield (6.76 t ha^{-1}) were recorded with variety Vikram TCR and minimum grain yield (4.82 t ha^{-1}) and straw yield (5.34 t ha^{-1}) with variety Protezin. However there was equal performance of variety Vikram TCR and CG Devbhog in straw yield.

Milling percent (%), head rice recovery (%) and grain length, breadth and L:B ratio showed non-significant variation due to different nitrogen splitting and data are presented in table 1. However, it was significantly affected due to different rice varieties. Higher milling percent (71.06%), head rice recovery (60.31%) and length breadth ratio (4.25) were recorded with variety Vikram TCR which was statistically at par with CG Devbhog (V_2) in head rice recovery and grain length breadth ratio. Whereas higher grain length (8.23 mm) and grain breadth (2.42 mm) were recorded with variety Protezin and Rajeshwari, respectively and lower milling percent (57.92%) and head rice recovery (44.69%) were noticed in variety Protezin, whereas grain length (7.73 mm), grain breadth (1.79 mm) and length breadth ratio (3.49) were noticed in variety, Vikram TC and Rajeshwari, respectively. Similar result was also reported by Korram *et al*. (2022) [5]. This result might be due to genetic character of the variety.

Protein content (%) was presented in table 1. Significant variation was found in protein content due to nitrogen splitting and varieties. Higher protein content (8.62%) was recorded with splitting of 30% N at basal + 30% N at tillering + 30% N at panicle initiation + 10% flowering. The minimum was recorded with 50% N at basal + 25% N at tillering + 25% N at panicle initiation. Splits application provides nitrogen at specific intervals, ensuring continuous supply of nitrogen during critical growth stages. This enhances the plant's ability to assimilate nitrogen and synthesize proteins, resulting in higher protein content (Jakhar *et al*. 2013) [4]. In case of varieties, higher protein content (9.65%) was recorded with variety Protezin and minimum protein content (6.57%) was recorded with variety Rajeshwari.

Table 1: Effect of splitting of nitrogen on yield and quality parameters of transplanted rice varieties

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Milling (%)	Head rice recovery (%)	Protein content (%)	Grain length (mm)	Grain breadth (mm)	Grain L:B ratio
Nitrogen splitting								
N_1-40% (B) + 30% (T) + 30% (PI)	5.60	5.94	69.33	58.12	8.29	8.01	2.11	3.82
N_2-50% (B) + 25% (T) + 25% (PI)	5.57	5.79	67.35	57.34	8.17	8.00	2.09	3.81
N_3-30% (B) + 30% (T) + 30% (PI) + 10% (F)	5.69	6.19	70.83	59.21	8.62	8.02	2.13	3.91
SEm±	0.05	0.07	0.74	0.24	0.10	0.01	0.001	0.04
CD (P= 0.05)	0.18	0.29	NS	NS	0.31	NS	NS	NS
Varieties								
V_1-Vikram TCR	6.19	6.76	71.06	60.31	8.89	7.73	1.79	4.25
V_2-CG Devbhog	5.68	5.96	67.82	57.24	8.04	7.90	1.91	4.08
V_3-Rajeshwari (R_1)	5.62	5.83	65.86	53.44	6.57	8.19	2.42	3.49
V_4-Protezin	4.82	5.34	57.92	44.69	9.65	8.23	2.32	3.55
SEm±	0.14	0.28	0.94	0.95	0.03	0.01	0.001	0.05
CD (P= 0.05)	0.42	0.84	3.20	3.74	0.28	0.03	0.02	0.17

B = Basal, T = Tillering, PI = Panicle initiation, F = Flowering

Nutrients content and uptake

Nitrogen content and uptake in grain and straw as influenced by different treatments are table 2. The data reveals that there was significant difference of nitrogen content in grain and straw due to varieties. Higher nitrogen content in grain (1.603%) and straw (0.631%) were recorded with variety Protezin and Vikram TCR,

respectively. Minimum nitrogen content was recorded with variety Rajeshwari and Protezin. However, significant variation was found in nitrogen uptake by grain and straw due to nitrogen splitting and varieties. Higher nitrogen uptake was recorded with splitting of 30% N at basal + 30% N at tillering + 30% N at panicle initiation + 10% at flowering (N_3) by grain (78.38 kg ha^{-1}) and straw (36.58 kg ha^{-1}) which was statistically at par with 40% N at basal + 30% N at tillering + 30% N at panicle initiation (N_1) due to straw. The minimum nitrogen uptake was recorded with 50% N at basal + 25% N at tillering + 25% N at panicle initiation (N_2) by grain (71.66 kg ha^{-1}) and straw (30.09 kg ha^{-1}). This might have reduced the loss of nitrogen and enhanced its absorption, thereby improving the utilization of applied nitrogen. This, in turn, resulted in higher dry matter accumulation and greater nitrogen uptake. Similar results were also reported by Zaidi *et al.* (2007) [13]. In case of varieties, higher nitrogen uptake was recorded with variety Vikram TCR (V_1) by grain (89.69 kg ha^{-1}) and straw (39.85 kg ha^{-1}) and minimum nitrogen uptake were recorded with variety Protezin by grain and straw. Varietal variation related to nitrogen uptake is a result of differences in genetic constituents of different rice varieties.

Phosphorus content and uptake in grain and straw as influenced by different treatments are table 2. The data reveals that there is no significant difference of phosphorus content in grain and straw due to nitrogen splitting and varieties. However, significant variation was found in phosphorus uptake by grain and straw due to nitrogen splitting and varieties. Higher phosphorus uptake was recorded with splitting of 30% N at basal + 30% N at tillering + 30% N at panicle initiation + 10% at flowering (N_3) by grain (6.53 kg ha^{-1}) and straw (3.56 kg ha^{-1}). Minimum phosphorus uptake was recorded with splitting of 50% N at basal + 25% N at tillering + 25% N at panicle initiation by grain (5.73 kg ha^{-1}) and straw (3.1 kg ha^{-1}). In case of varieties, higher phosphorus uptake was recorded with variety Vikram TCR (V_1) by grain (7.73 kg ha^{-1}) and straw (4.42 kg ha^{1}). Minimum phosphorus uptake was recorded with variety Protezin.

Potassium content and uptake in grain and straw as influenced by different treatments are table 2. The data reveals that there is no significant difference of potassium content in grain and straw due to nitrogen splitting and varieties. However, significant variation was found in potassium uptake by grain and straw due to nitrogen splitting and varieties. Higher potassium uptake was recorded with splitting of 30% N at basal + 30% N at tillering + 30% N at panicle initiation + 10% at flowering (N_3) by grain (71.84 kg h^{-1}) and straw (68.08 kg h^{-1}). The minimum potassium uptake was recorded with 50% N at basal + 25% N at tillering + 25% N at panicle initiation by grain (65.87 kg h^{-1}) and straw (62.71 kg h^{-1}). In case of varieties, higher potassium uptake was recorded with variety Vikram TCR by grain (80.43 kg ha^{-1}) and straw (84.66 kg ha^{-1}) and minimum potassium uptake was recorded with variety Protezin (V_4).

Table 2: Effect of splitting of nitrogen on nutrients content and uptake in grain and straw of transplanted rice varieties

Treatment	Grain						Straw					
	N content (%)	P content (%)	K content (%)	N uptake kg ha^{-1}	P uptake kg ha^{-1}	K uptake kg ha^{-1}	N content (%)	P content (%)	K content (%)	N uptake kg ha^{-1}	P uptake kg ha^{-1}	K uptake kg ha^{-1}
Nitrogen splitting												
N_1-40% (B) + 30% (T) + 30% (PI)	1.339	0.110	1.152	74.55	6.16	68.52	0.577	0.059	1.247	33.65	3.17	64.01
N_2-50% (B) + 25% (T) + 25% (PI)	1.322	0.104	1.112	71.66	5.73	65.87	0.553	0.057	1.243	30.09	3.11	62.71
N_3-30% (B) + 30% (T) + 30% (PI) + 10% (F)	1.385	0.115	1.193	78.38	6.53	71.84	0.605	0.061	1.251	36.58	3.56	68.08
SEm±	0.018	0.009	0.032	0.57	0.09	0.47	0.027	0.001	0.003	1.22	0.08	0.72
CD (P= 0.05)	NS	NS	NS	2.26	0.35	1.85	NS	NS	NS	4.82	0.31	2.83
Varieties												
V_1-Vikram TCR	1.452	0.126	1.266	89.69	7.73	80.43	0.631	0.072	1.364	39.85	4.42	84.66
V_2-CG Devbhog	1.294	0.123	1.253	77.39	6.61	71.22	0.611	0.068	1.356	35.48	3.54	67.29
V_3-Rajeshwari	1.045	0.102	1.210	73.69	5.72	68.00	0.554	0.056	1.256	32.42	3.11	61.29
V_4-Protezin	1.603	0.094	1.143	58.68	4.51	55.21	0.517	0.046	1.188	26.00	2.20	46.62
SEm±	0.028	0.002	0.010	2.38	0.17	1.90	0.017	0.002	0.037	1.04	0.12	3.00
CD (P= 0.05)	0.084	NS	NS	7.09	0.51	5.64	0.050	NS	NS	3.09	0.36	8.91

B = Basal, T = Tillering, PI = Panicle initiation, F = Flowering

Conclusion

Considering the results discussed above, it is evident that splitting of nitrogen 30% (B) + 30% (T) + 30% (PI) + 10% (F) gave promising results in respect to yield, quality and nutrients content and uptake. Among varieties, Vikram TCR produced higher yield and quality parameters and nutrients uptake.

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