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Effect of foliar application of nutrient on yield in different varieties of rice

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Abstract
The field experiment titled “Effect of foliar application of nutrients on yield in different rice varieties” was carried out at the Main Rice Research Centre, Soil and Water Management Research Unit, Navsari Agricultural University, Navsari, Gujarat, during 2021-22 to 2023-24. The study was conducted using a factorial randomized block design, with rice varieties assigned to the main plots and foliar sprays of urea and KNO_3 at the tillering and panicle initiation (PI) stages assigned to the subplots, each replicated three times.
The results indicated that the protein-rich variety GR-23 produced significantly greater plant height, higher panicle weight, and increased grain yield. Similarly, foliar application of 2% urea or 1% KNO_3 at tillering and PI stages resulted in significantly higher plant height, more panicles per square meter, longer panicles, and improved grain yield. Both variety GR-23 and the foliar application of 2% urea or 1% KNO_3 also recorded significantly higher protein content in both grain and straw.

Keywords: Rice, variety, urea, KNO3, foliar application, protein

1. Introduction
Rice is one of India’s most important kharif cereals and a major staple food. It is a rich source of starch and provides considerable amounts of protein, carbohydrates, minerals, and vitamins. Nitrogen plays a vital role in protein synthesis and is a key component of protoplasm and chloroplasts, making it one of the most critical elements for achieving higher yields in intensive farming systems (Mae, 2001) [12]. However, crops typically recover only about 25% of applied nitrogen, while the remaining 75% is lost through leaching, runoff, volatilization, reduced nitrification, and other pathways. Potassium also contributes significantly to plant functions including protein synthesis, enzyme activity, pH regulation, phloem transport, turgor maintenance, stomatal function, ionic balance, and stress tolerance (Wang *et al*., 2013) [19]. It supports photosynthesis, carbohydrate movement, and starch formation in storage organs, ultimately contributing to higher grain yield (Imas & Magen, 2007) [7].
Foliar nutrient application has become increasingly important because it reduces excess chemical fertilizer use, minimizes nutrient losses, enhances absorption, and supports a healthier soil environment. Aerial spraying often provides quicker and more efficient nutrient uptake compared to soil application (Jamal *et al*., 2006) [9]. Foliar urea application has been shown to significantly increase yield (Moeini *et al*., 2006) [14]. Therefore, applying nutrients through foliar sprays can improve yield while lowering production costs. Rice varieties differ widely in yield potential, grain quality, milling characteristics, texture, and suitability for various end uses. Grain protein content is influenced by genetic traits and environmental factors such as light, temperature, water, and nitrogen management. Inadequate nitrogen results in low protein levels, and previous research has shown that grain protein increases with higher nitrogen application, though responses vary depending on cultivar. Grain protein content is also affected by nitrogen rates, application methods, and other agronomic practices (Gomez & De Datta, 1975) [6]. For these reasons, this study was conducted to examine the impact of nutrient application on productivity and protein content across different rice varieties.

2. Materials and Methods

A field experiment was undertaken during the 2021-22 to 2023-24 kharif and rabi seasons. The soil at the experimental site was a vertisol, alkaline in reaction, low in available nitrogen, medium in phosphorus, and high in potassium. The experiment followed a factorial randomized block design with three replications. The main plot treatments were rice varieties:

- V1: GR-23 (12.13% protein),
- V2: GNR-3 (8.60% protein),
- V3: GAR-13 (5.42% protein).

Subplot treatments consisted of foliar nutrient applications:

- F0: No foliar spray,
- F1: 1% urea at tillering and PI,
- F2: 2% urea at tillering and PI,
- F3: 1% KNO_3 at tillering and PI,
- F4: 2% KNO_3 at tillering and PI.

Seedlings were transplanted at 20 × 15 cm spacing using 25 kg seed ha^{-1}. A recommended dose of 100:30:00 NPK kg ha^{-1} was applied, with nitrogen split between basal and topdressing at tillering and grain filling stages. Phosphorus was applied as a basal dose. All other agronomic, irrigation, and plant protection practices were carried out as recommended. Growth, yield, and quality parameters were recorded at harvest, and statistical analyses were performed following Panse and Sukhatme (1967) [15].

3. Results and Discussion

Tables 1 and 2 show that growth and yield attributes were significantly influenced by both variety and foliar nitrogen application.

Variety GR-23 (V1) recorded the highest plant height, panicles/m², panicle length, grains/panicle, and panicle weight. It was statistically at par with GAR-13 (V3) for plant height and with GNR-3 (V2) for panicle weight. GAR-13 exhibited the longest duration to 50% flowering, while GNR-3 recorded the highest test weight. These differences can be attributed to varietal genetics, as reported by Dey *et al*. (2006) [3], Islam *et al*. (2008) [8], Limochi *et al*. (2012) [11], and Tyeb *et al*. (2013) [18].

Among foliar treatments, 2% urea (F2) resulted in the tallest plants, highest panicle count, and longest panicles, and was statistically similar to other urea and KNO_3 sprays. Foliar nutrition did not significantly affect days to 50% flowering. The highest number of grains per panicle, greatest panicle weight, and highest test weight were recorded with 2% urea (F2), which was comparable to F3 and F4 for grains/panicle. These findings align with those of Alam *et al*. (2010) [1] and Al-Amin (2010) [2].

3.1 Grain and Straw Yield

Variety and foliar nitrogen treatments significantly influenced grain yield (Table 3). GR-23 (V1) produced the highest grain and straw yields, whereas GAR-13 (V3) recorded the lowest. Foliar spraying of 2% urea (F2) resulted in the highest grain yield, statistically similar to F3, F1, and F4. These results agree with Duraisami *et al*. (2002) [4], Sarandon & Asborno (1996) [16], and Khan *et al*. (2012) [10], who found that foliar urea or KNO_3 improves yield through enhanced grain development and panicle attributes.

3.2 Protein Content

Variety GR-23 (V1) recorded the highest protein content in both grain and straw, while GAR-13 (V3) recorded the lowest. Among foliar treatments, 2% urea (F2) resulted in significantly higher grain protein content, comparable to F1, F3, and F4. Straw protein content was highest under 2% KNO_3 (F3), similar to F4. These observations align with findings by Sarandon & Asborno (1996) [16], who reported improved grain protein with post-anthesis urea spray.

Table 1: Effect of different treatments on growth and yield attributes of rice (pooled over three years)

Treatments	Plant height (cm)	Panicles/m2	Panicle length (cm)	Days to 50% flowering
Variety				
V1: GR-23	133.3	326	26.54	99
V2: GNR-3	123.2	248	25.50	91
V3: GAR-13	130.1	288	23.79	106
S.Em.±	1.29	3.0	0.26	0.15
C. D. at 5%	3.63	9.0	0.72	0.42
Foliar application				
F0: No foliar spray	121.6	267	23.01	99
F1: 1% Urea spray at tillering and PI stage	128.5	287	25.24	99
F2: 2% Urea spray at tillering and PI stage	134.1	301	27.03	99
F3: 1% KNO3 spray at tillering and PI stage	130.1	290	25.43	99
F4: 2% KNO3 spray at tillering and PI stage	130.0	291	25.68	99
S.Em.±	2.88	7.0	0.57	0.34
C.D. at 5%	8.11	20.0	1.61	NS
CV%	6.71	7.49	6.78	1.02

Table 2: Effect of different treatments on yield attributes of rice (pooled over three years)

Treatments	Grain/panicle	Panicle weight (g)	Test weight (g)
Variety			
V1: GR-23	299	4.57	20.18
V2: GNR-3	242	4.48	31.17
V3: GAR-13	263	4.27	17.96
S. Em.±	3.05	0.04	0.25
CD (p = 0.05)	8.58	0.12	0.69
Foliar application			
F0: No foliar spray	246	4.06	21.23
F1: 1% Urea spray at tillering and PI stage	257	4.41	22.64
F2: 2% Urea spray at tillering and PI stage	288	4.63	25.23
F3: 1% KNO3 spray at tillering and PI stage	275	4.59	23.06
F4: 2% KNO3 spray at tillering and PI stage	272	4.52	23.36
S. Em. .±	6.82	0.10	0.55
C.D. at 5%	19.19	0.28	1.55
CV%	7.64	6.67	7.17

Table 3: Effect of different treatments on yields and protein content of rice (pooled over three years)

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Protein% grain	Protein% straw
Variety				
V1: GR-23	4572	6360	12.49	6.23
V2: GNR-3	4243	6139	8.66	5.35
V3: GAR-13	4044	6037	5.63	5.66
S. Em.±	69	78	0.05	0.07
C.D. at 5%	194	219	0.13	0.21
Foliar application				
F0: No foliar spray	3893	6010	8.63	5.08
F1: 1% Urea spray at tillering and PI stage	4229	6119	8.92	5.64
F2: 2% Urea spray at tillering and PI stage	4558	6192	9.06	5.74
F3: 1% KNO3 spray at tillering and PI stage	4517	6336	9.03	6.32
F4: 2% KNO3 spray at tillering and PI stage	4235	6236	8.99	5.96
S.Em.±	154	174	0.10	0.16
C.D. at 5%	433	NS	0.29	0.46
CV%	10.78	8.46	4.13	8.55
Sig. Interaction	V x F	-	Y x V V x F	Y x F

4. Conclusion

Based on the study results, growing the protein-rich rice variety GR-23 combined with foliar application of 2% urea or 1% KNO_3 at the tillering and panicle initiation stages is recommended for achieving higher yields and enhanced protein content in both grain and straw.

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