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Agronomic strategies for improving rice protein quality through integrated nitrogen and water management under SRI

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Abstract

Rice is a staple food for more than half of the global population, yet its protein quality remains a nutritional concern due to its limited lysine content and overall low protein concentration. Agronomic practices, particularly nitrogen (N) fertilization and irrigation management, play a pivotal role in determining not only rice yield but also its nutritional quality. This study investigates the impact of different irrigation regimes and nitrogen levels on the protein content and amino acid profile of rice grains under field conditions. Results indicate that moderate to high nitrogen application significantly enhances total grain protein content, in grain (7.89 and 7.92%) and straw (4.04 and 4.12%) was recorded with scheduling of irrigation at two days after disappearance of ponded water as compared to rest of the irrigation scheduling during both the years. Similarly, application of 100% RND + BGA recorded the maximum protein content and protein harvest over the other treatment but remained at par with 100% RDN + *Sesbania aculeata* co-culture in respect of protein content but significantly higher than 100% RDN alone treatment during both the years of study. The findings suggest that water and nitrogen management strategies can be optimized to improve both yield and protein quality of rice, contributing to nutritional security and sustainable rice cultivation. This study underscores the importance of agronomic interventions in enhancing the functional quality of rice grains beyond mere yield optimization.

Keywords: Rice protein quality, nitrogen management, irrigation, and nutritional quality

Introduction

Rice (*Oryza sativa* L.) production is a key to world food security. As it is the staple food in most parts of India and there is a need to increase production of rice and productivity of land under rice cultivation. India ought to add 1.7 million tonnes of additional rice every year to ensure national food security (Dass and Chandra, 2013)^[2]. Rice (*Oryza sativa* L.) is the staple food for more than half of the world's population, particularly in Asia, where it constitutes a major component of daily caloric intake. While the emphasis in rice cultivation has historically been placed on maximizing yield, recent years have witnessed growing concern over the nutritional quality of rice, particularly its protein content and quality. From an agronomic standpoint, nitrogen (N) and irrigation management are among the most influential factors affecting rice growth, yield, and grain quality. Nitrogen is a fundamental nutrient directly involved in amino acid synthesis, protein accumulation, and overall grain development. However, the form, timing, and rate of nitrogen application, as well as its interaction with irrigation practices, significantly influence not just the protein concentration in rice grains but also the balance between yield and quality. Irrigation, a key input in rice production, plays a vital role in regulating soil moisture regimes and nutrient availability. Water management strategies, such as alternate wetting and drying (AWD), continuous flooding, and saturated soil culture, can modify root-zone oxygenation, soil microbial activity, and nutrient dynamics—particularly nitrogen transformation and uptake efficiency. These factors collectively affect protein biosynthesis and partitioning in rice grain.

Materials and Methods

A field experiment was conducted during the rainy (*khari*) seasons of 2014-15 and 2015-16 at

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Agricultural Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (25°18' N, 83°03' E, 75.7 m above the mean sea-level) situated in the Northern-Gangetic alluvial plains having characteristics of sub-tropical climate. Soil of the experimental field was sandy-clay loam (typic Ustochrepts) with 0.39 and 0.41% organic carbon, 210.1 and 212.0 kg/ha available nitrogen, 24.30 and 26.2 kg/ha available phosphorus and 214.3 and 209.6 kg/ha available potassium during the respective years. The treatments consisted 3 irrigation scheduling in the main-plots (irrigation at 2 DADPW, 5 DADPW and 8 DADPW) and 5 nitrogen-management practices in the sub-plots [Recommended dose of nitrogen (RDN), RDN + *Sesbania aculeata* as co-culture with rice, 75% RDN + *Sesbania aculeata* as co-culture with rice, RDN+BGA and 75% RDN+ BGA] were tested in a split plot design with 3 replications.

Results and Discussion

Perusal of the data manifested significant effect of irrigation scheduling on protein content in grain as well as in straw. The protein content in grain (7.89 and 7.92%) and straw (4.0 and 4.12% during the two consecutive years) was significantly higher when scheduling of irrigation at two days after disappearance of ponded water, as compared to the other irrigation scheduling during both the years. However, scheduling of irrigation at two days after disappearance of ponded water being at par with five days after disappearance of ponded water in respect of protein content in grain and straw during both the years except protein content in grain during the second year. Significantly higher protein content in grain (7.89 and 7.92%) and straw (4.04 and 4.12%) was recorded with scheduling of irrigation at two days after disappearance of ponded water as compared to rest of the irrigation scheduling during both the years. Similarly, protein harvest by grain, straw and total harvest was also higher with scheduling of irrigation at two days after disappearance of ponded water than scheduling of irrigation at five days after disappearance of ponded water and scheduling of irrigation at eight two days after disappearance of ponded water. The per cent protein content in grain was significantly decreased with delay in irrigation scheduling of rice from scheduling of irrigation at two days after disappearance of ponded water to scheduling of irrigation at eight days after disappearance of ponded water by 7.89 and 7.48% in grain and 4.04% and 3.83% in straw during the first and second year, respectively which might be due to optimum soil moisture result more nitrogen

absorption by the roots of the plant ultimately increase the protein content, because of nitrogen is primary constituent of protein. Similar findings have also been reported by Singh *et al.* (1997) [1]. Perusal of the data manifested significant effect of irrigation scheduling on protein harvest by grain, straw as well as total harvest. The total protein harvest was significantly higher with scheduling of irrigation at two days after disappearance of ponded water, which was 854 kg ha⁻¹ and 892 kg ha⁻¹ in grain and straw during the respective years, while it was at par with scheduling of irrigation at five days after disappearance of ponded water, however scheduling of irrigation at eight days after disappearance of ponded water, produced the lowest total protein harvest during both the years.

It was observed in the protein content in grain and straw of hybrid rice. It significantly increased with the application of 100% RDN+BGA followed by 100% RDN + *Sesbania aculeata* co-culture, but 100% RDN + *Sesbania aculeata* co-culture, remained at par with 75% RDN+ *Sesbania aculeata* as co-culture and 75% RDN +BGA during the both years. The application of 100% RDN exhibited the minimum protein content in grain and straw as compared to other nitrogen management practices during both the years. Application of integrated nitrogen management significantly influenced the protein content and protein harvest during both the years of study. Application of 100% RDN + BGA recorded the maximum protein content and protein harvest over the other treatment but remained at par with 100% RDN + *Sesbania aculeata* co-culture in respect of protein content but significantly higher than 100% RDN alone treatment during both the years of study. This may be due to the increased concentration of N in the grains, which might have modified the proportion of grain constitutions. These results are in close conformity with the findings of Tripathi and Verma (2008) [5]; Hossain *et al.* (2009) [3].

Amongst nitrogen management options, application of 100% RDN + BGA proved significantly superior over rest of the nitrogen management treatment during both the years in respect of protein harvest by grain and straw and total protein harvest. The minimum protein harvest by grain and straw and total protein harvest were observed with application of 100% RDN alone. However, application of 100% RDN + *Sesbania aculeata* co-culture, proved superior to other nitrogen management practices but remained at par with 75% RDN+ *Sesbania aculeata* as co-culture and 75% RDN +BGA during both years of experiment

Table 1: Protein content (%) and protein harvest (kg ha⁻¹) of hybrid rice as influenced by irrigation scheduling and nitrogen management under SRI

Treatment	Protein content (%)				Protein harvest (kg ha ⁻¹)				Total protein harvest (kg ha ⁻¹)	
	Grain		Straw		Grain		Straw		Grain + Straw	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Irrigation scheduling										
Irrigation at 2 DADPW	7.89	7.92	4.04	4.12	519	537	334	354	854	892
Irrigation at 5 DADPW	7.65	7.59	4.03	4.07	485	508	316	329	801	837
Irrigation at 8 DADPW	7.48	7.41	3.83	4.02	424	450	288	312	711	761
S.Em±	0.074	0.082	0.027	0.019	8.61	8.81	5.43	6.63	13.54	14.61
LSD (P=0.05)	0.29	0.32	0.010	0.076	34.05	34.62	21.34	26.05	53.18	57.39
Nitrogen management										
100% RDN	7.20	7.08	3.80	4.01	419	436	278	313	697	749
100% RDN + <i>S. aculeata</i> as co-culture	7.74	7.67	3.97	4.08	480	499	315	333	795	831
75% RDN + <i>S. aculeata</i> as co-culture	7.68	7.62	3.98	4.04	472	493	302	319	774	812
100% RDN + BGA	7.91	7.99	4.11	4.16	537	570	353	366	890	935
75% RDN + BGA	7.67	7.61	3.97	4.05	474	495	315	328	789	823
S.Em±	0.077	0.084	0.039	0.019	11.26	11.47	6.75	5.26	14.96	14.81
LSD (P=0.05)	0.22	0.24	0.11	0.056	32.86	33.50	19.68	15.37	43.67	43.25

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