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# EFFECT OF DIFFERENT SPACING AND FERTILIZER LEVELS ON QUALITY OF NEW PADDY VAR. SAHYADRI SINDHURA

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**ABSTRACT**

A field experiment was conducted to evaluate the effect of plant spacing and fertilizer levels on the quality of new paddy (*Oryza sativa* L.) var. Sahyadri Sindhura. Three spacing levels (20 cm × 10 cm, 25 cm × 10 cm and 30 cm × 10 cm) and three fertilizer doses (75 %, 100 % and 125 % recommended dose of fertilizer) were assessed under RCBD with Factorial concept. Results showed that quality parameters like protein content (9.38 g/100g), fat (1.85 g/100 g), ash (1.61 g/100 g), iron (33.04 ppm) and zinc (27.48 ppm) were more under wider spacing and higher fertilizer (125 %) application (protein - 9.60 g/100g, ash – 1.64 g/100g, iron – 34.26 ppm and zinc – 27.42 ppm), while carbohydrate and amylose contents were maximum at narrow spacing *i.e.*, 20 cm × 10 cm (67.86 g/100 g and 17.93 g/100 g, respectively) and lower fertilizer level (75 % RDF; 68.28 g/100 g and 17.91 g/100 g), reflecting enhanced nutrient uptake and assimilate partitioning. Fibre and moisture content were largely unaffected by spacing or fertilizer levels. Interaction effects between spacing and fertilizer levels were non-significant for all traits, suggesting that grain quality parameters are predominantly governed by intrinsic physiological and genetic factors. These findings indicate that optimizing plant spacing and fertilizer management can enhance quality of paddy in terms of protein, fat, ash, carbohydrate, amylose and micronutrient accumulation without compromising moisture content, providing practical strategies for producing nutritionally superior rice grains. From this study, it can be concluded that by adopting the wider spacing of 30 cm × 10 cm along with application of 125 per cent recommended dose of fertilizers had significantly improved the nutritional quality of paddy var. Sahydari Sindhura.
***Keywords* :** Paddy, quality, spacing and fertilizer levels.

## Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crop globally, cultivated in more than 168.4 million hectares with an annual production of about 541.6 million tonnes (Anon., 2025). It is the staple food for over 3.5 billion people worldwide**,** contributing nearly 20 per cent of global dietary energy and 31 per cent of calorie intake in India (Chandel *et al*., 2010). In South and Southeast Asia alone, rice provides more than 50 per cent of daily calorie intake for the population. Thus, any improvement in rice yield and nutritional quality has significant implications for food and nutritional security.

Grain quality in rice is determined by multiple nutritional and physicochemical attributes. Protein content is of particular significance as rice provides the main source of dietary protein for millions of people in Asia and Africa (Mondal *et al.,* 2023). Carbohydrate content, primarily starch, influences energy supply, cooking characteristics and consumer acceptability. Fibre contributes to digestive health and reduces the risk of chronic diseases, while ash content serves as an indicator of the overall mineral content of the grains (Abdelsalam *et al*., 2025). Beyond macronutrients, micronutrients such as iron (Fe) and zinc (Zn) are of paramount importance. Deficiencies of these minerals are widespread, leading to "hidden hunger" in rice-consuming populations.

In many rice-dependent regions, rice serves not only as the major source of calories but also as the foundation of daily nutrition. However, its grains are often characterized by low levels of essential nutrients, making populations highly vulnerable to dietary imbalances (Anon, 2004). Enhancing grain quality traits such as protein, mineral elements (iron, zinc and others), fibre and the balance of carbohydrate fractions (amylose and amylopectin) is therefore of critical importance. Even incremental improvements in these nutritional attributes can substantially reduce the prevalence of "hidden hunger" and contribute to better food and nutritional security in communities where rice is consumed as the principal staple food. (Bouis and Saltzman, 2017; Smith *et al.,* 2019; Das *et al*., 2023).

Agronomic practices strongly influence these nutritional traits. Plant spacing regulates plant population, canopy structure and resource use efficiency. Wider spacing reduces intra-specific competition, enhances tillering and improves photosynthetic activity, thereby supporting greater assimilate partitioning towards grain filling. Similarly, fertilizer management, particularly nitrogen, has a pronounced effect on protein content. Studies have shown that increasing nitrogen application can raise grain protein, while also influencing carbohydrate accumulation and micronutrient enrichment (Chandel *et al*., 2010; Kandil *et al*., 2022). However, excessive fertilizer uses without considering plant density often leads to lodging, nutrient imbalance and environmental hazards, underlining the importance of optimizing spacing-fertilizer interactions.

The rice genotype Jyothi Biliya (var. Sahyadri Sindhura), developed at Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga from the local varieties Jyothi and Biliya. It is a red, fine grain rice with dark green, non-pigmented foliage and is well adapted to the Southern Transitional Agro-climatic Zone of Karnataka. To fully utilize the potential of this variety, it is necessary to determine the best plant spacing and fertilizer management, which can support improved grain quality and higher productivity for farmers. Given these facts, the present investigation was conducted to assess the effect of spacing and fertilizer levels on grain quality attributes of rice.

## Materials and Methods

The field experiment was conducted at the College of Agriculture, Shivamogga during *Kharif* - 2024.The experimental site comes under Southern Transition Zone of Karnataka (Zone 7) with sandy loam soil and acidic pH (5.91). Total rainfall received during months June to November was 1195.8 mm, which is above the normal levels and supported healthy crop growth. Throughout this period, temperatures fluctuated between 18.9 ºC and 30.4 ºC, with relative humidity levels ranging from 78.6 per cent to 88.75 per cent. The warm and humid weather during the crop's growth period contributed positively to its overall growth and development.

The experiment was laid out in RCBD with Factorial concept with nine treatments in three replications. The experimental plot was divided into three blocks. Each block was subdivided into nine plots. Blocks were separated from each other by 0.8 m wide drains. Seedling of 25 days old were transplanted at three different spacing (Factor A) *viz*., 20 cm × 10 cm, 25 cm × 10 cm and 30 cm × 10 cm. Fertilizers were applied at three different levels (Factor B) *viz*., 75 % RDF (75:37.5:37.5 kg NPK ha$^{-1}$), 100 % RDF (100:50:50 kg NPK ha$^{-1}$) and 125 % RDF (125:62.5:62.5 kg NPK ha$^{-1}$). The fertilizers were applied in splits half N, full P and K at transplanting and remaining N was applied at 35 DAT (days after transplanting). Treatment combinations of the experiment are as follows:

$T_1$: 20 cm × 10 cm with 75 % RDF

$T_2$: 20 cm × 10 cm with 100 % RDF

$T_3$: 20 cm × 10 cm with 125 % RDF

$T_4$: 25 cm × 10 cm with 75 % RDF

$T_5$: 25 cm × 10 cm with 100 % RDF

$T_6$: 25 cm × 10 cm with 125 % RDF

$T_7$: 30 cm × 10 cm with 75 % RDF

$T_8$: 30 cm × 10 cm with 100 % RDF

$T_9$: 30 cm × 10 cm with 125 % RDF

### Quality parameters

### Protein (g/100g)

Nitrogen content in rice grain was estimated by Kjeldahl's method, further protein content in grains was calculated by multiplying the nitrogen content with a correction factor of 6.25.

### Carbohydrates (g/100g)

Carbohydrate content in rice grain was estimated by using Anthrone method. Carbohydrates were first hydrolysed into simple sugars using dilute hydrochloric acid. In hot acidic medium, glucose is dehydrated to hydroxymethly furfural. This compound forms a green coloured product with anthrone with an absorption maximum at 630 nm.

**Fibre (g/100g)**

The crude fibre of each sample was determined according to (AOAC, 2005). Freshly prepared sulfuric acid (1.25 %, 200 ml) was added to 2 g of the sample ($W_1$) in a 500 ml conical flask. The mixture was boiled gently for 30 min using cooling finger to maintain a constant volume. The mixture was then filtered using a muslin cloth and the residue washed until it was free of acid. Two hundred milli liters of 1.25 per cent NaOH was added and the mixture is boiled for 30 min. The mixture was again filtered using a muslin cloth and then washed thoroughly with hot distilled water (four times) and rinsed once with 10 % HCl and four times with hot distilled water. The residue was further rinsed with ethanol and three times with petroleum ether (40-60 ºC) boiling range and was allowed to drain and transferred to a silica dish previously ignited at 600 ºC and cooled. The dish and its content were then dried to a constant weight ($W_2$) at 105 ºC, the organic matter of the residue was then burnt off by igniting in a muffle furnace at 600 ºC for 30 min, cooled in a desiccator and weighed ($W_3$). The loss in ignition was reported as crude fibre which was calculated by using formula:

$$\%\text{Crude fibre} = \frac{W_2 - W_3}{W_1} \times 100$$

Where,

$W_1$ = Initial weight of sample

$W_2$ = Dried weight of sample

**Fat (g/100g)**

The crude fat of each of the sample was determined according to (AOAC, 2005) using Soxhlet extractor. Two grams of each of the sample was weighed and placed in filter paper, then placed in an extraction thimble. The thimble was placed in an extractor, extraction was carried out with petroleum ether (boiling point 40-60 ºC) for 5 hr after that the filter papers were carefully removed and dried in an air oven at 106 ºC for 30 min, allowed to cool in the desiccator and the weight noted. The crude fat percentage was calculated as follows:

$$\%\text{Crude fat} = \frac{\text{Loss in weight}}{\text{Weight of the sample}} \times 100$$

**Ash (g/100g)**

The percentage ash content was determined in a hot muffle furnace. Two grams of each of the sample was weighed into a dish and the organic matter is burned off by ignition in muffle furnace at 550 °C for 5 hr. Ashing continued till a constant weight obtained. The dish containing the residue is cooled in a desiccator and the percentage of ash calculated from the following equation:

$$\%\text{Ash} = \frac{\text{Weight of the ash}}{\text{Weight of the sample}} \times 100$$

**Iron (ppm)**

Make suitable dilutions of tri or di acid extract and feed standard or sample to AAS having appropriate hallow cathode lamps. Record values and plot on graph paper.

$$\text{Iron (ppm)} = \frac{\text{Graph ppm} \times \text{Vol. of digested sample}}{\text{Weight of sample}}$$

**Zinc (ppm)**

Make suitable dilutions of tri or di acid extract and feed standard or sample to AAS having appropriate hallow cathode lamps. Record values and plot on graph paper.

$$\text{Zinc (ppm)} = \frac{\text{Graph ppm} \times \text{Vol. of digested sample}}{\text{Weight of sample}}$$

**Moisture (%)**

Per cent moisture present in rice grain was measured by using moisture meter.

## Results and Discussion

**Effect of different spacing levels on paddy quality**

The quality parameters like protein, carbohydrates, amylase, fat, ash and micronutrients (iron and zinc) content in rice grains were significantly influenced by different plant spacing levels. Among the different spacing, the wider spacing of 30 cm × 10 cm recorded the maximum protein content (9.38 g 100 $g^{-1}$), which was markedly higher than the values observed under 25 cm × 10 cm and 20 cm × 10 cm. The enhancement in protein concentration at wider spacing may be attributed to reduced competition among plants for growth resources, which allowed for greater nitrogen uptake and its efficient translocation to the developing grains. Nitrogen is primary determinant of grain protein synthesis and better root activity coupled with improved availability of assimilates under wider spacing appears to have favored higher accumulation of protein.

Fat and ash contents followed a trend similar to protein (Table 1), with maximum values of 1.85 g 100 $g^{-1}$ and 1.61 g 100 $g^{-1}$ respectively, being recorded under 30 cm × 10 cm spacing. The lowest values were observed under the narrow spacing of 20 cm × 10 cm. The improvement in fat and mineral (ash) content under wider spacing may be linked to better root proliferation, enhanced photosynthate supply and more efficient absorption of minerals, which are ultimately reflected in the ash fraction of the grain. Wider spacing may have also provided a more favorable environment for the translocation and deposition of energy-rich compounds and minerals in the developing grains. Similar findings were reported by Chen *et al.* (2024); Dong *et al.* (2025).

Wider spacing also promoted the enrichment of micronutrients in rice grains (Table 2). At 30 cm × 10 cm spacing, the highest levels of iron (33.04 ppm) and zinc (27.48 ppm) were obtained, which were significantly superior to those obtained under other two spacing. This trend could be ascribed to increased soil exploration by roots, better nutrient absorption efficiency per plant and reduced plant density-related stress, which together facilitated greater uptake and deposition of these vital micronutrients. Since Fe and Zn are also involved in enzymatic activity and protein stability, their enhanced availability at wider spacing may have further reinforced storage protein accumulation in the grains (Gong *et al.*, 2025).

In contrast, carbohydrate and amylose contents exhibited an opposite pattern. The maximum carbohydrate concentration (67.86 g 100 $g^{-1}$) and amylose content (17.93 g 100 $g^{-1}$) were recorded under the spacing of 20 cm × 10 cm, with values declining as spacing increased (Tables 1). This suggests that under narrow spacing, higher plant population per unit area encouraged greater carbohydrate accumulation in the grains, possibly due to more vigorous competition for light and a tendency for assimilates to be channeled towards starch deposition. On the other hand, in wider spacing, improved nitrogen uptake and assimilation appeared to shift the metabolic balance in favor of protein synthesis, thereby reducing starch accumulation. Such a trade-off between protein and carbohydrate concentration in grains under varying nitrogen availability and nutrient partitioning has been reported in earlier studies as well by Borah *et al.*, 2018 and Gong *et al.*, 2025.

Overall, the results indicate that wider spacing (30 cm × 10 cm) was advantageous for improving protein, fat, ash, Fe and Zn concentrations in rice grains, while narrow spacing (20 cm × 10 cm) favored carbohydrate and amylose accumulation. These findings demonstrate a clear trade-off between macronutrient (carbohydrate vs. protein) and micronutrient enrichment under different plant population densities, emphasizing the importance of optimizing spacing for both yield and grain quality

**Effect of different fertilizer levels on paddy quality**

Application of fertilizers significantly altered the nutritional composition of rice grains. Protein concentration increased progressively with higher levels of recommended dose of fertilizers (RDF), reaching its peak at 125 per cent RDF (Table 1). This trend is consistent with the central role of nitrogen in amino acid synthesis and protein assembly, where enhanced nitrogen availability promotes greater incorporation into storage proteins (Choudhury and Kennedy, 2005; Gomez *et al.*, 2021).

**Table 1:** Quality parameters of new paddy var. Sahyadri Sindhura as influenced by different spacing and fertilizer levels

| Treatments | g per 100 g | | | | | |
|---|---|---|---|---|---|---|
| | Protein | Carbohydrate | Fibre | Amylose | Fat | Ash |
| **Spacing levels (S)** | | | | | | |
| $S_1$ | 8.43 | 67.86 | 1.15 | 17.93 | 1.64 | 1.41 |
| $S_2$ | 8.92 | 65.39 | 1.03 | 17.13 | 1.74 | 1.52 |
| $S_3$ | 9.38 | 62.65 | 0.99 | 16.34 | 1.85 | 1.61 |
| S. Em. (±) | 0.15 | 0.81 | 0.02 | 0.25 | 0.03 | 0.03 |
| CD @ 5 % | 0.45 | 2.43 | NS | 0.77 | 0.09 | 0.08 |
| **Fertilizer levels (F)** | | | | | | |
| $F_1$ | 8.56 | 68.28 | 1.13 | 17.91 | 1.74 | 1.44 |
| $F_2$ | 9.25 | 65.74 | 1.03 | 17.11 | 1.96 | 1.59 |
| $F_3$ | 9.60 | 64.11 | 0.93 | 16.62 | 1.88 | 1.64 |
| S. Em. (±) | 0.15 | 0.81 | 0.02 | 0.25 | 0.03 | 0.03 |
| CD @ 5 % | 0.45 | 2.43 | NS | 0.77 | 0.09 | 0.08 |
| **Interaction (S×F)** | | | | | | |
| $S_1F_1$ | 8.36 | 68.42 | 1.15 | 18.05 | 1.58 | 1.28 |
| $S_1F_2$ | 9.01 | 66.73 | 1.06 | 17.63 | 1.88 | 1.45 |
| $S_1F_3$ | 9.24 | 65.43 | 1.02 | 17.27 | 1.72 | 1.57 |

| | | | | | | |
|---|---|---|---|---|---|---|
| $S_2F_1$ | 8.57 | 67.91 | 1.12 | 17.90 | 1.62 | 1.35 |
| $S_2F_2$ | 9.11 | 66.04 | 1.03 | 17.44 | 1.94 | 1.52 |
| $S_2F_3$ | 9.67 | 63.73 | 0.94 | 16.83 | 1.78 | 1.68 |
| $S_3F_1$ | 8.73 | 67.23 | 1.07 | 17.78 | 1.66 | 1.40 |
| $S_3F_2$ | 9.55 | 64.46 | 0.97 | 17.07 | 2.06 | 1.64 |
| $S_3F_3$ | 9.87 | 63.18 | 0.89 | 16.67 | 1.83 | 1.80 |
| S. Em. (±) | 0.26 | 1.40 | 0.03 | 0.45 | 0.05 | 0.05 |
| CD @ 5 % | NS | NS | NS | NS | NS | NS |

**Note:** $S_1$- 20 cm × 10 cm; $S_2$- 25 cm × 10 cm; $S_3$- 23 cm × 10 cm; $F_1$- 75 % RDF; $F_2$-100 % RDF; $F_3$- 125 % RDF

In contrast, carbohydrate and amylose content declined under higher fertilizer inputs, with maximum value observed at 75 per cent RDF (Table 1). This reduction may be explained by a nutrient dilution effect, wherein increased protein synthesis occurs at the expense of starch accumulation in the grain endosperm (Panda *et al.*, 2021).

Fat content exhibited a different pattern, attaining its highest value under 100 per cent RDF (Table 1). This suggests that balanced fertilization supports optimal enzymatic functioning and energy metabolism required for lipid biosynthesis (Nayak *et al.*, 2020). A notable effect of higher fertilizer application was also observed on starch composition, as amylose content declined under elevated RDF levels (Table 1). This shift may be linked to nitrogen-induced promotion of amylopectin synthesis over amylose, thereby altering grain cooking and processing properties (Perez *et al.*, 1996).

**Table 2:** Iron, Zinc and Moisture content of new paddy var. Sahyadri Sindhura as influenced by different spacing and fertilizer levels

| Treatments | Iron (ppm) | Zinc(ppm) | Moisture (%) |
|---|---|---|---|
| **Spacing levels (S)** | | | |
| $S_1$: 20 cm × 10 cm | 29.75 | 24.60 | 11.73 |
| $S_2$: 25 cm × 10 cm | 31.36 | 26.10 | 11.53 |
| $S_3$: 30 cm × 10 cm | 33.04 | 27.48 | 10.83 |
| S. Em. (±) | 0.53 | 0.45 | 0.27 |
| CD @ 5 % | 1.56 | 1.36 | NS |
| **Fertilizer levels (F)** | | | |
| $F_1$: 75 % RDF | 30.92 | 24.19 | 12.23 |
| $F_2$: 100 % RDF | 33.09 | 26.17 | 11.13 |
| $F_3$: 125 % RDF | 34.26 | 27.42 | 10.83 |
| S. Em. (±) | 0.53 | 0.45 | 0.27 |
| CD @ 5 % | 1.56 | 1.36 | NS |
| **Interaction (S×F)** | | | |
| $S_1F_1$ | 28.45 | 22.73 | 12.81 |
| $S_1F_2$ | 30.82 | 25.16 | 11.31 |
| $S_1F_3$ | 32.72 | 26.82 | 11.06 |
| $S_2F_1$ | 29.37 | 23.88 | 12.62 |
| $S_2F_2$ | 32.03 | 25.73 | 11.22 |
| $S_2F_3$ | 34.20 | 28.90 | 10.74 |
| $S_3F_1$ | 29.84 | 24.36 | 11.27 |
| $S_3F_2$ | 33.43 | 27.63 | 10.85 |
| $S_3F_3$ | 35.86 | 30.45 | 10.38 |
| S. Em. (±) | 0.92 | 0.77 | 0.47 |
| CD @ 5 % | NS | NS | NS |

Mineral accumulation, expressed as ash content, increased consistently with increased fertilizer levels, reflecting improved nutrient uptake and translocation to the grain (Singh *et al.*, 2018). Similarly, micronutrient enrichment was evident at higher fertilizer dosage, with iron and zinc contents attaining their maximum values at 125 per cent RDF (Table 2). The increase in micronutrient content may be attributed to greater root proliferation, enhanced nutrient mobility in the rhizosphere and efficient partitioning into developing grains (Fageria *et al.*, 2011 and Swamy *et al.*, 2016).

Moisture and fibre content were not significantly influenced either by different spacing levels or fertilizer levels. However, grains harvested from wider spacing plots exhibited a slightly higher fibre content and lower grain moisture compared with those from narrower spacing (Table 1 and 2). Although these differences were statistically non-significant, they are agronomically relevant, as higher fibre enhances grain nutritional value while lower moisture percentage favors safe storage and reduces post-harvest losses (Nath *et al*., 2022; Patra, *et al*., 2024).

Overall, these findings suggest that higher fertilizer application, particularly 125 per cent RDF, substantially improves protein, ash and micronutrient content in rice grains, although it tends to reduce carbohydrate and amylose concentrations. This trade-off underscores the importance of balanced nutrient management strategies to simultaneously enhance yield potential and nutritional quality in rice.

The interaction between plant spacing and fertilizer levels did not show any significant influence on rice grain quality traits such as protein, carbohydrate, fibre, fat, amylose, ash, iron, zinc and moisture content. This stability indicates that intrinsic nutritional and compositional characteristics of rice grains are largely unaffected by moderate agronomic variations. Juliano (1993) also emphasized that grain quality is predominantly controlled by genetic factors rather than cultural practices. Swamy *et al*. (2016) further reported that micronutrient traits like zinc and iron are strongly determined by genetic background and breeding efforts, with limited scope for alteration through management. Collectively, these findings suggest that rice grain quality is primarily governed by genotype and inherent physiology, with plant spacing and fertilizer exerting only marginal effects.

## Conclusion

The study revealed that plant spacing and fertilizer levels significantly influenced rice yield and nutritional quality, though their interaction had no major effect on grain composition. Wider spacing (30 cm × 10 cm) enhanced protein, fat, ash, iron and zinc contents, while narrow spacing (20 cm × 10 cm) favored higher carbohydrate and amylose levels. Higher fertilizer application (125 % RDF) also further improved protein, ash and micronutrient concentrations, underscoring the role of nitrogen and balanced nutrition. Fibre and moisture contents remained largely unaffected, indicating their stability across treatments. Overall, while agronomic practices contributed to certain quality improvements, the inherent stability of grain traits highlights the dominant role of genetics and physiology. These results suggest that integrating optimal crop management with genetic improvement is essential for achieving higher yield and enhanced nutritional quality in rice.

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