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Total chlorophyll of pigmented paddy under variable fertilizer doses

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Abstract

Rice (*Oryza sativa* L.) is one of the most important staple food crops worldwide. Pigmented rice varieties are rich in anthocyanins, phenolic compounds and antioxidants, making them nutritionally superior to conventional rice. Chlorophyll content is an important physiological parameter that determines photosynthetic efficiency and crop productivity. A field experiment was conducted during *Kharif*, 2025 at the Regional Agricultural Research Station (RARS), Polasa, Jagtial, Telangana. The experiment was laid out in a split-plot design with three replications comprising four fertilizer levels viz., M₁ - Control (0-0-0 NPK kg ha⁻¹), M₂ - 50% RDF (60-30-20 kg NPK ha⁻¹), M₃ - 75% RDF (90-45-30 kg NPK ha⁻¹) and M₄ - 100% RDF (120-60-40 kg NPK ha⁻¹) as main plots and four pigmented rice varieties viz., S₁ - Navara (Red), S₂ - Raktashali (Red), S₃ - Kalabatti (Black) and S₄ - Krishna Vrihi (Black) as subplots. Total Chlorophyll were estimated at 30, 60 and 90 DAT using Arnon's (1949) method. The results indicated that fertilizer application significantly influenced chlorophyll accumulation, whereas varietal differences were also evident throughout crop growth. Higher fertilizer levels recorded greater chlorophyll content owing to improved nutrient availability and enhanced photosynthetic activity. Among the varieties, significant variation in chlorophyll accumulation was observed due to genetic differences.

Keywords: Pigmented paddy, chlorophyll, fertilizer levels, photosynthesis, nitrogen

Introduction

Rice (*Oryza sativa* L.) is among the most extensively cultivated cereal crops in the world and constitutes the primary food source for over half of the global population. It is fundamental to achieving food and nutritional security, especially in Asian countries, which account for nearly 90-95 per cent of global rice production and consumption. India ranks among the world's leading rice-producing nations, cultivating rice over 49.15 million hectares with a total production of 140.64 million tonnes and an average productivity of 2861 kg ha⁻¹. In Telangana, rice is grown on 5.2 million hectares, producing 18.36 million tonnes with an average productivity of 3486 kg ha⁻¹. (www.indiastat.com, 2025-2026). These figures demonstrate the immense importance of rice as a staple crop and its significant contribution to sustaining food and nutritional security. Pigmented rice can be broadly categorized into three groups based on the location of pigmentation. The first group consists of rice with coloured grains, including red, brown, green, violet, black, and purple types, where pigmentation is mainly due to the accumulation of anthocyanins in the pericarp and seed coat (Abdel-Aal *et al.*, 2006) [1]. The second group comprises rice varieties with coloured foliage, which are primarily cultivated for ornamental and landscaping purposes, although some of these varieties also produce pigmented grains. The third group includes rice with coloured husks, where milling may result in either coloured or white kernels depending on the variety (Paiva *et al.*, 2016) [7].

In addition to their superior nutritional properties, red and black rice varieties possess greater resistance to storage pests and insect infestation than brown rice. Red rice is also known for its adaptability to a wide range of biotic and abiotic stresses, including drought, flooding, submergence, salinity, and alkalinity (Kitano *et al.*, 1993) [5], making it a valuable genetic resource for sustaining rice production under changing climatic conditions. Owing to these stress-tolerant characteristics, together with their exceptional nutritional composition and high antioxidant content, pigmented rice varieties have gained increasing recognition for their

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potential to contribute to climate-resilient and nutritionally secure food systems.

Chlorophyll is the primary photosynthetic pigment responsible for capturing light energy and driving photosynthesis in plants. Its concentration reflects the photosynthetic efficiency, nutritional status and growth potential of rice, ultimately influencing biomass production and grain yield.

Nitrogen is an essential constituent of chlorophyll and photosynthetic proteins, contributing significantly to chlorophyll synthesis, chloroplast development, and leaf expansion. Phosphorus plays an important role in ATP synthesis and energy transfer, whereas potassium activates enzymes, regulates stomatal activity, and facilitates the translocation of photosynthates. Thus, a balanced supply of Nitrogen, Phosphorus and potassium is crucial for maintaining optimal chlorophyll levels, enhancing photosynthetic efficiency, and improving crop productivity (Mengel and Kirkby, 1996) ^[6].

Despite extensive studies on fertilizer management in rice, limited information is available on chlorophyll accumulation in pigmented paddy varieties under varying fertilizer levels, particularly under Telangana conditions. Therefore, the present study was undertaken to assess the influence of different fertilizer doses on total chlorophyll content in pigmented paddy varieties.

Materials and Methods

A field experiment was carried out during the *Kharif* season of 2025 at the Regional Agricultural Research Station (RARS), Polasa, Jagtial, Telangana, located in the Northern Telangana Zone. The experimental site is situated at 18°50'26.8" N latitude and 78°57'1.6" E longitude, with an elevation of 243.4 m above mean sea level. The region is characterized by a semi-arid tropical climate.

The experimental field had clay loam soil with a neutral reaction and non-saline nature. The soil was low in organic carbon and available nitrogen, while it contained high levels of available phosphorus and potassium.

The experiment was conducted in a split-plot design with three replications. Four fertilizer levels were assigned to the main plots: M₁-Control (0-0-0 kg NPK ha⁻¹), M₂-50% RDF (60-30-20 kg NPK ha⁻¹), M₃-75% RDF (90-45-30 kg NPK ha⁻¹) and M₄-100% RDF (120-60-40 kg NPK ha⁻¹). The subplots consisted of four pigmented rice varieties, namely S₁ - Navara (Red), S₂ - Raktashali (Red), S₃ - Kalabatti (Black) and S₄ - Krishna Vrihi (Black).

Chlorophyll content was estimated at 30, 60 and 90 DAT following the method described by Arnon (1949) ^[2]. Fresh leaf samples were extracted using 80% acetone, and the absorbance was measured at 660 and 645 nm with a UV-visible spectrophotometer. Total chlorophyll content was calculated using standard equations and expressed as mg g⁻¹ fresh weight.

The experimental data were subjected to statistical analysis following the procedure for a split-plot design. Treatment means were compared using the critical difference (CD) test at the 5% level of significance.

Results and Discussion

Total Chlorophyll (mg g⁻¹)

The data pertaining to the total chlorophyll content of pigmented paddy varieties as influenced by variable fertilizer levels at different days after transplanting (DAT) are presented in Table 1.

Effect of variable fertilizer levels

Total Chlorophyll was significantly influenced by variable fertilizer levels. At 30 DAT, among variable fertilizer levels significantly higher Total Chlorophyll content was recorded with 100% RDF (2.39 mg g⁻¹) followed by 75% RDF (2.18 mg g⁻¹), 50% RDF (1.98 mg g⁻¹). While, control recorded significantly lower Total chlorophyll content (1.48 mg g⁻¹).

At 60 DAT, among variable fertilizer levels significantly higher Total Chlorophyll content was recorded with 100% RDF (2.72 mg g⁻¹) followed by 75% RDF (2.49 mg g⁻¹), 50% RDF (2.28 mg g⁻¹). While, control recorded significantly lower Total chlorophyll content (1.78 mg g⁻¹).

Similarly, at 90 DAT among variable fertilizer levels significantly higher Total Chlorophyll content was recorded with 100% RDF (2.57 mg g⁻¹) followed by 75% RDF (2.36 mg g⁻¹), 50% RDF (2.16 mg g⁻¹). While, control recorded significantly lower Total chlorophyll content (1.65 mg g⁻¹).

The higher total chlorophyll content observed under increased fertilizer levels might be attributed to an adequate supply of nitrogen, a major constituent of chlorophyll molecules. Nitrogen plays a crucial role in the synthesis of chlorophyll, proteins, nucleic acids, enzymes, and chloroplast membranes required for efficient photosynthesis (Mengel and Kirkby, 1996) ^[6]. Enhanced total chlorophyll content under optimum nitrogen nutrition might have improved light interception and photosynthetic efficiency, resulting in greater assimilate production and overall crop growth. These findings are in agreement with those reported by Pramanik and Bera (2013) ^[8].

Effect of pigmented paddy varieties

Total chlorophyll of pigmented rice varieties was significantly influenced. At 30 DAT, significantly higher total chlorophyll content was recorded by Krishna Vrihi (2.10 mg g⁻¹) which was on par with Kalabatti (2.07 mg g⁻¹) and Raktashali (2.00 mg g⁻¹). While, significantly lower total chlorophyll content was recorded by Navara (1.87 mg g⁻¹).

At 60 DAT, significantly higher total chlorophyll content was recorded by Krishna Vrihi (2.41 mg g⁻¹) which was on par with Kalabatti (2.38 mg g⁻¹) and Raktashali (2.29 mg g⁻¹). While, significantly lower total chlorophyll content was recorded by Navara (2.19 mg g⁻¹).

At 90 DAT, significantly total higher content was recorded by Kalabatti (2.50 mg g⁻¹) followed by Krishna Vrihi (2.18 mg g⁻¹) which was on par with Raktashali (2.09 mg g⁻¹). While, significantly lower total chlorophyll content was recorded by Navara (1.96 mg g⁻¹).

The significant variation in total chlorophyll content among the pigmented rice varieties might be attributed to inherent genetic differences regulating chlorophyll biosynthesis, chloroplast development, and photosynthetic efficiency. Genotypic variation in chlorophyll synthesis and retention may have influenced the photosynthetic capacity of the varieties, resulting in differences in total chlorophyll content. These findings are in accordance with the reports of Bele *et al.* (2021) ^[3] and Song *et al.* (2024) ^[9].

Interaction effect of variable fertilizer levels and pigmented paddy varieties

The interaction effect between variable fertilizer levels and pigmented paddy varieties was found to be non-significant for total chlorophyll content.

Table 1: Total Chlorophyll (mg g⁻¹) of pigmented paddy varieties as influenced by variable fertilizer levels at different intervals

Treatments	30 DAT	60 DAT	90 DAT
Main plots: Fertilizer Doses			
M1: Control (0-0-0 NPK kg ha ⁻¹)	1.48	1.78	1.65
M2: 50% RDF (60-30-20 NPK kg ha ⁻¹)	1.98	2.28	2.16
M3: 75% RDF (90-45-30 NPK kg ha ⁻¹)	2.18	2.49	2.36
M4: 100% RDF (120-60-40 NPK kg ha ⁻¹)	2.39	2.72	2.57
SE(m) ±	0.05	0.06	0.05
CD (P=0.05)	0.17	0.19	0.17
Sub plots: Pigmented Rice			
S1: Navara (Red)	1.87	2.19	1.96
S2: Rakta Shali (Red)	2.00	2.29	2.09
S3: Kalabatti (Black)	2.07	2.38	2.50
S4: Krishna Vrihi (Black)	2.10	2.41	2.18
SE(m) ±	0.04	0.05	0.05
CD (P=0.05)	0.12	0.15	0.15
Interaction			
M×S			
SE(m) ±	0.09	0.10	0.10
CD (P=0.05)	NS	NS	NS
S×M			
SE(m) ±	0.08	0.10	0.10
CD (P=0.05)	NS	NS	NS

Conclusion

Total chlorophyll content of pigmented rice was significantly influenced by fertilizer levels and varietal differences throughout the crop growth period. Application of 100% RDF consistently enhanced total chlorophyll content at 30, 60 and 90 DAT, indicating improved photosynthetic capacity under adequate nutrient supply. Among the varieties, Krishna Vrihi and Kalabatti recorded higher total chlorophyll content than Navara and Raktashali, reflecting their superior chlorophyll accumulation and retention. These findings suggest that balanced fertilizer application, particularly 100% RDF, is effective in maximizing chlorophyll content and photosynthetic efficiency in pigmented paddy.

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