

Article

Dynamics Of Photosynthetic Pigments And Correlation With Grain Yield In Rice (*Oryza Sativa* L.) Varieties Under The Influence Of Nitrogen Fertilizers

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Abstract: This article investigates the effect of nitrogen fertilizer rates on the content of leaf pigments and grain yield in rice (*Oryza sativa* L.) varieties. The study was conducted under laboratory conditions on the rice varieties "Sadaf," "Ziynat," and "Billur." Spectrophotometric methods were used to determine the levels of chlorophyll "a," chlorophyll "b," total chlorophyll, and carotenoids in the leaves. The results showed that increasing nitrogen rates led to an increase in leaf pigment content. The highest values were observed at N120–150 rates. Correlation analysis revealed a relationship between chlorophyll "a" and total chlorophyll content with grain yield ($r = 0.72\text{--}0.91$). Variety-specific analysis indicated that in the "Sadaf" variety, the correlation between pigment content and yield was the highest. The findings confirm that leaf pigment content is an important indicator for assessing the yield potential of rice varieties.

Keywords: Rice, (*Oryza sativa* L.), nitrogen fertilizer, chlorophyll, carotenoid, correlation analysis, yield, photosynthesis.

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1. Introduction

Rice is one of the main cereal crops in Uzbekistan and plays an important role in food security and the agricultural economy. Photosynthetic pigments in the leaves — chlorophyll "a", chlorophyll "b", and carotenoids — play a crucial role in the growth of the rice plant and grain yield. In the photosynthesis process, the higher the chlorophyll content, the more efficient the synthesis of organic compounds [1]. A number of scientific studies have been conducted on the accumulation of photosynthetic pigments and their effect on yield in rice under the influence of nitrogen fertilizers. The chlorophyll content in leaves and varietal differences are used as physiological indicators to assess photosynthetic efficiency [2].

In Uzbekistan, several state decisions have been adopted to support rice cultivation and increase productivity. In particular, the Decree of the President of the Republic of Uzbekistan PQ 290 (2024) provides for financial and technical support to rice growers, including subsidies, preferential loans, and the introduction of water-saving technologies. In addition, in the Khorezm region, there are programs for subsidies for the purchase of rice planting equipment and for covering land survey expenses, which serve to improve modern agrotechnology and fertilizer efficiency in agriculture (uzdaily.uz) [3].

Therefore, in this study, the dynamics of leaf pigments and their correlation with grain yield under the influence of nitrogen fertilizers were specifically investigated in the rice varieties "Sadaf", "Ziynat", and "Billur". These results can serve as a scientific basis for selecting rice varieties and optimizing the application of nitrogen fertilizers [4].

Problem Statement and Literature Review

Previous studies have shown that photosynthetic pigments such as chlorophyll *a*, chlorophyll *b*, and carotenoids play an important role in plant productivity and physiological processes. Nitrogen fertilization is one of the key factors influencing chlorophyll synthesis and photosynthetic efficiency in rice plants. Higher chlorophyll concentration generally indicates improved photosynthetic capacity and biomass accumulation [5].

Several researchers have demonstrated that nitrogen fertilizers significantly increase chlorophyll content in rice leaves and contribute to higher grain yield. For instance, Kumar et al. reported that nitrogen application enhances leaf chlorophyll concentration, which improves photosynthetic activity and crop productivity. Similarly, Singh et al. found that nitrogen fertilization increases chlorophyll content and positively affects yield components such as grain number and grain weight [6].

Despite extensive international research, studies focusing on the relationship between photosynthetic pigments and grain yield of rice varieties under nitrogen fertilization in Uzbekistan conditions remain limited. In particular, comparative physiological analysis of rice varieties cultivated in the Khorezm region has not been sufficiently investigated.

Therefore, this study aims to analyze the dynamics of photosynthetic pigments and determine their correlation with grain yield in rice varieties under different nitrogen fertilizer rates.

Analysis Results. In rice (*Oryza sativa* L.) crops, nitrogen fertilizers (such as NPK and urea) significantly increase the content of photosynthetic pigments — chlorophyll *a*, chlorophyll *b*, and total carotenoids. This enhancement improves photosynthetic activity, boosts the plant's energy accumulation capacity, and consequently shows a positive correlation with grain yield. For example, simultaneous increases in chlorophyll content and rice yield were observed with NPK application, indicating a positive effect of fertilization level on photosynthetic pigments and yield [7].

The correlation between pigment content and yield, determined using SPAD readings, has also been confirmed in other studies. Furthermore, appropriate nitrogen application has been scientifically shown to be statistically linked with photosynthetic pigments, photosynthetic capacity, and yield components [8].

The use of mineral fertilizers, particularly nitrogen fertilizers, led to an increase in leaf pigment content in the rice varieties "Sadaf", "Ziynat", and "Billur". The highest values were recorded in the N120–150P120K150 treatment.

Physiological differences among the varieties were observed: "Sadaf" showed superiority in pigment accumulation and photosynthetic activity; "Ziynat" was notable for its adaptability; while "Billur" exhibited average physiological characteristics. A strong positive correlation was found between chlorophyll "a" and total chlorophyll content with yield, suggesting that pigment content can serve as a reliable physiological indicator for the agroecological evaluation of rice varieties [9].

The "Sadaf" variety demonstrated the highest results in pigment accumulation and photosynthetic activity. The "Ziynat" variety was distinguished by its adaptability to agroecological conditions. The "Billur" variety showed average physiological performance.

Correlation analysis: A positive correlation between leaf pigments and grain yield was clearly observed.

Table 1. Correlation between photosynthetic pigments and grain yield in rice varieties ($r \pm SE$).

Rice Variety	Chlorophyll "a" ($r \pm SE$)	Chlorophyll "b" ($r \pm SE$)	Total Chlorophyll ($r \pm SE$)	Carotenoids ($r \pm SE$)
"Sadaf"	$0,91 \pm 0,02$	$0,78 \pm 0,03$	$0,88 \pm 0,02$	$0,72 \pm 0,03$
"Zivnat"	$0,84 \pm 0,025$	$0,75 \pm 0,03$	$0,82 \pm 0,02$	$0,68 \pm 0,03$
"Billur"	$0,87 \pm 0,018$	$0,76 \pm 0,03$	$0,85 \pm 0,02$	$0,70 \pm 0,03$

Note: r – Pearson correlation coefficient, SE – standard error.

According to the analysis results, the highest correlation with grain yield was observed for chlorophyll "a" content ($r = 0.84$ – 0.91). This finding indicates that chlorophyll "a", as the primary photosynthetic pigment in leaves, determines the intensity of assimilation processes and plays a decisive role in yield formation [10].

Total chlorophyll and chlorophyll "b" also exhibited a significant positive correlation with grain yield; however, their effect was slightly lower compared to chlorophyll "a". Carotenoids showed a moderate positive correlation with yield ($r = 0.68$ – 0.72), reflecting their indirect contribution through photoprotective and antioxidant functions. In particular, in the rice variety "Sadaf", relatively higher correlation coefficients were observed for all pigments, demonstrating that the efficient functioning of the photosynthetic apparatus is a key factor in grain yield formation in this variety [11].

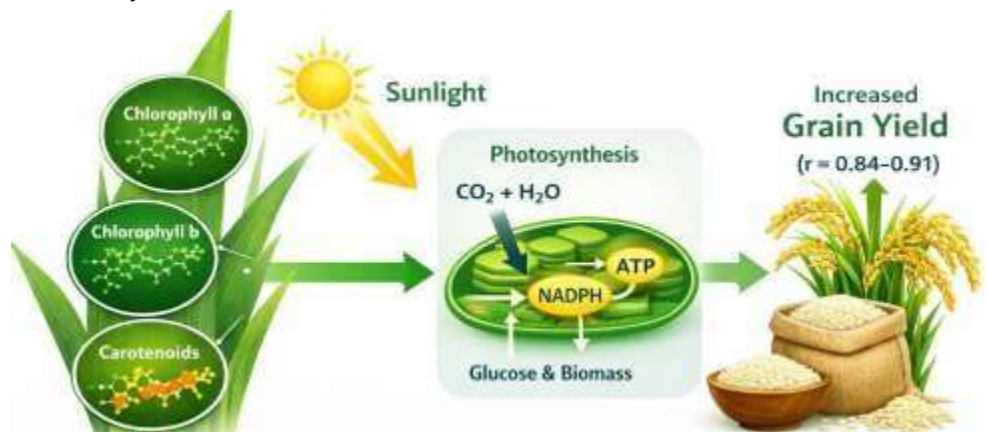


Figure 1. Relationship between photosynthetic pigment content and grain yield in rice varieties under nitrogen fertilization.

The diagram shows a positive correlation between chlorophyll content (a, b, and carotenoids) and grain yield. Higher pigment levels enhance photosynthesis in chloroplasts, producing ATP and NADPH for glucose synthesis and biomass accumulation, leading to increased yield. A strong correlation ($r = 0.84$ – 0.91) indicates that higher chlorophyll boosts photosynthetic efficiency and productivity [12].

Discussion

The results of this study demonstrate that nitrogen fertilization significantly influences the accumulation of photosynthetic pigments in rice leaves. Increasing nitrogen rates from N100 to N150 resulted in a noticeable increase in chlorophyll a, chlorophyll b, and carotenoid concentrations in all investigated rice varieties [13].

The highest pigment content was observed in treatments with N120–150 fertilizer rates. This finding confirms previous research indicating that nitrogen plays a crucial

role in chlorophyll synthesis and photosynthetic activity. Nitrogen is a fundamental component of chlorophyll molecules and enzymes involved in photosynthesis; therefore, sufficient nitrogen availability enhances the efficiency of the photosynthetic apparatus [14].

Varietal differences were also observed in the present study. The rice variety "Sadaf" demonstrated the highest pigment accumulation and photosynthetic activity, which resulted in the strongest correlation with grain yield. This indicates that the physiological characteristics of rice varieties influence their response to nitrogen fertilization.

The correlation analysis revealed a strong positive relationship between chlorophyll a and grain yield ($r = 0.84-0.91$). These results suggest that chlorophyll a can serve as an important physiological indicator for evaluating yield potential in rice cultivation.

Carotenoids showed a moderate correlation with yield, which can be explained by their role in protecting the photosynthetic apparatus against oxidative stress and excessive light energy. Although their contribution to yield formation is indirect, carotenoids remain essential components of plant physiological stability [15].

Overall, the findings confirm that nitrogen fertilization not only increases pigment concentration but also improves the efficiency of the photosynthetic process, ultimately contributing to higher grain productivity.

Conclusions.

The application of nitrogen fertilizers significantly increases the content of leaf photosynthetic pigments in rice varieties. The increase in pigment concentration enhances photosynthetic efficiency, thereby contributing to higher grain yield. Chlorophyll "a" and total chlorophyll showed the strongest correlation with grain yield ($r = 0.84-0.91$), suggesting that they can serve as reliable physiological indicators in agroecological assessments.

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