

Effect of Silicon and Nitrogen Levels on Yield and Economics of Transplanted Rice (*Oryza Sativa L.*) var. CSR 76.

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ABSTRACT

Efficient nutrient management is essential for improving rice productivity and profitability under changing agro-ecological conditions. A field experiment was conducted to evaluate the effect of different levels of silicon and nitrogen on yield and economic profitability of transplanted rice. The experiment was laid out in a randomized block design with three replications, comprising twelve treatments consisting of different levels of silicon (50, 75 and 100 kg ha⁻¹) and nitrogen (50 and 100 kg ha⁻¹), respectively. Results indicated that combined application of silicon and nitrogen significantly enhanced grain yield and economic returns compared with individual nutrient applications. The highest grain yield of 6.88 t ha⁻¹ was obtained with the treatment comprising 100 kg ha⁻¹ silicon and 100 kg ha⁻¹ nitrogen, which also resulted in the highest gross return of ₹162,927 ha⁻¹, net return of ₹126,448 ha⁻¹ and benefit-cost ratio of 3.47. The lowest yield and economic returns were recorded in the control treatment. Correlation analysis revealed a strong positive relationship between grain yield and economic parameters, with yield showing high correlation with net return ($r = 0.87$) and gross return ($r = 0.86$), indicating that higher productivity directly contributed to increased economic profitability. The increase in productivity and profitability due to combined silicon and nitrogen application may be attributed to improved nutrient uptake, enhanced photosynthetic efficiency and better plant growth. The study suggests that the combined application of silicon and nitrogen can be an effective strategy for improving yield and economic returns of rice cultivation.

Keywords: Rice, Silicon, Nitrogen, Yield, Economics, Nutrient management.

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1. INTRODUCTION

Rice (*Oryza sativa L.*) is a major cereal crop and is the primary food source for over half of the world's population (Dhokne *et al.*, 2025). Increasing rice productivity is essential to meet the food demand of the rapidly increasing population. However, nutrient management remains a major challenge in sustainable rice production. Nitrogen is the most essential nutrient influencing rice growth and yield, as it plays a vital role in chlorophyll formation, protein synthesis and vegetative growth. Adequate nitrogen supply significantly improves yield-related traits including the number of panicles, grain filling capacity and biomass production. However, inefficient nitrogen use may lead to nutrient losses and environmental problems (Sudharshan *et al.*, 2024).

Silicon has recently gained attention as a beneficial element for rice cultivation. Rice is considered a silicon-accumulating crop, and silicon plays an essential role in improving plant tolerance to various stresses, strengthening plant tissues and enhancing photosynthesis.

Silicon application has been shown to enhance plant growth, boost grain yield, and improve resistance to pests and diseases (Cuong *et al.*, 2017). The combined application of nitrogen and silicon has shown synergistic effects in rice cultivation. Silicon improves nutrient uptake efficiency and enhances nitrogen utilization, leading to improved growth and productivity. Studies have reported significant increases in grain yield and economic returns when nitrogen and silicon are applied together compared to individual applications (Jan *et al.*, 2018). Improved nutrient management practices have been shown to generate higher economic returns in various crops by increasing both yield and profitability. Hence, this study was undertaken to evaluate the effects of varying levels of silicon and nitrogen on grain yield and economic returns in transplanted rice.

Although nitrogen and silicon have been widely recognized for their roles in enhancing rice growth and yield, information on their interaction under saline soil conditions, particularly in relation to productivity and

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economic returns, remains limited (Arambam et al., 2025). In the Indo-Gangetic plains, where soil salinity poses a major constraint, the optimal combination of these nutrients has not been sufficiently explored (Singh et al., 2020). The combined application of silicon and nitrogen has been reported to improve nutrient uptake, promote plant growth and enhance yield under stress conditions. Therefore, the present study was undertaken to evaluate the effect of varying levels of silicon and nitrogen on yield and economic performance of transplanted rice and to identify the most suitable nutrient combination for improving productivity and profitability under saline soil conditions.

2. MATERIALS AND METHODS

Experimental Site

The field experiment was carried out during the Kharif season of 2024 at the experimental farm of the School of Agriculture, Galgotias University, Greater Noida, Gautam Buddha Nagar, Uttar Pradesh, India (28.36° N, 77.54° E; approximately 200 m above mean sea level). The region falls under the semi-arid subtropical climatic zone of the Indo-Gangetic plains with hot summers and moderate rainfall during the monsoon season.

Treatment Details

Treatment	Description
T ₁	Control
T ₂	Silicon @ 50 kg ha ⁻¹
T ₃	Silicon @ 75 kg ha ⁻¹
T ₄	Silicon @ 100 kg ha ⁻¹
T ₅	Nitrogen @ 50 kg ha ⁻¹
T ₆	Nitrogen @ 100 kg ha ⁻¹
T ₇	Silicon @ 50 kg ha ⁻¹ + Nitrogen @ 50 kg ha ⁻¹
T ₈	Silicon @ 50 kg ha ⁻¹ + Nitrogen @ 100 kg ha ⁻¹
T ₉	Silicon @ 75 kg ha ⁻¹ + Nitrogen @ 50 kg ha ⁻¹
T ₁₀	Silicon @ 75 kg ha ⁻¹ + Nitrogen @ 100 kg ha ⁻¹
T ₁₁	Silicon @ 100 kg ha ⁻¹ + Nitrogen @ 50 kg ha ⁻¹
T ₁₂	Silicon @ 100 kg ha ⁻¹ + Nitrogen @ 100 kg ha ⁻¹

Rice seedlings were transplanted in the experimental plots following recommended agronomic practices. Silicon and nitrogen fertilizers were applied according to treatment combinations.

Parameters

Grain yield and economic returns of rice were evaluated under different silicon and nitrogen treatments to determine the most productive and economically viable nutrient management practice. Economic analysis of the treatments were imposed by calculating cost of cultivation, gross return, net return and benefit-cost ratio following the procedure described by Mishra et al. (2015).

Grain Yield

At maturity, rice crop from each experimental plot was harvested and threshed separately. The grains obtained were cleaned, weighed, and yield was calculated in tonnes per hectare (t ha⁻¹) for comparison among treatments. Grain yield is considered one of the most important parameters for evaluating the performance of nutrient management practices in rice cultivation. Yield obtained

The experimental field soil was sandy loam in texture and slightly saline. Prior to the start of the experiment, composite soil samples were collected from a depth of 0-15 cm and analyzed using standard soil analysis procedures.

The experimental soil was slightly alkaline with a pH of 7.27 and an electrical conductivity of 4.28 dS m⁻¹, indicating saline conditions. It contained 0.37 per cent organic carbon. The available nitrogen, phosphorus, and potassium were 157.4, 10.6, and 138.4 kg ha⁻¹, respectively.

Experimental Design

The experiment was laid out in a Randomized Block Design (RBD), consisted of 12 treatments replicated three times, resulting in a total of 36 experimental plots. Each plot measured 5 m × 2.5 m (12.5 m²). Each plot was separated by irrigation channels of 1 m, to ensure uniform water distribution and prevent lateral movement of nutrients between plots. Treatments were randomly allocated within each replication.

from each treatment was used for further economic analysis (Yoshida, 1981).

Cost of Cultivation

The cost of cultivation for each treatment was calculated by considering all inputs used during the crop season. These included the cost of fertilizers (silicon and nitrogen sources), labour charges for land preparation, transplanting, fertilizer application, irrigation and harvesting operations. The cost varied among treatments depending on the level of fertilizers applied (Mishra et al., 2015).

Gross Return

Gross return represents the total monetary value obtained from the grain yield of rice. It was calculated by multiplying the grain yield obtained under each treatment with the prevailing market price of rice grain during the experimental period.

Gross return (₹ ha⁻¹) = Grain yield (t ha⁻¹) × Market price of grain

In agronomic experiments, gross benefit is generally estimated by multiplying yield with the market price of the produce (Bezabeh et al., 2021).

Net return

Net return indicates the actual profit obtained from rice cultivation after deducting the total cost of cultivation from the gross return (Mishra et al., 2015).

Net return (₹ ha^{-1}) = Gross return - Cost of cultivation

Benefit-cost ratio (B:C ratio)

The benefit-cost ratio was calculated to determine the economic efficiency of different treatments. It represents the ratio between the total income obtained and the total cost incurred during cultivation. Higher B:C ratio values

indicate greater profitability of the treatment (Mishra et al., 2015).

Benefit-cost ratio (B:C) = Net return / Cost of cultivation

Economic analysis of agronomic experiments commonly involves calculating yield, gross benefits and net returns to compare the profitability of different treatments (Mishra et al., 2015).

Correlation Analysis

In addition to economic analysis, correlation analysis was performed to determine the relationship between grain yield and economic parameters such as gross return, net return and benefit-cost ratio. Pearson’s correlation coefficient was calculated using R software to assess the strength and direction of association between variables.

3. RESULTS AND DISCUSSION

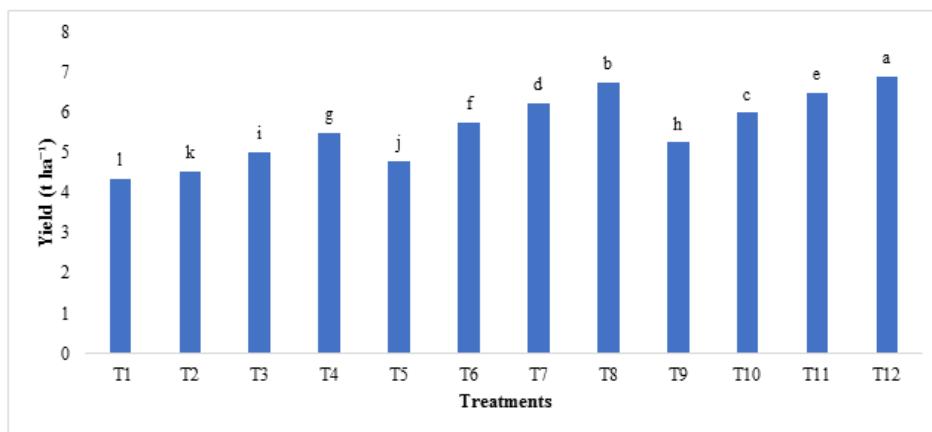


Fig 1. Yield (t ha^{-1}) of rice cultivation as influenced by different silicon and nitrogen levels.

(Means followed by different letters differ significantly at $p \leq 0.05$ according to Duncan’s Multiple Range Test)

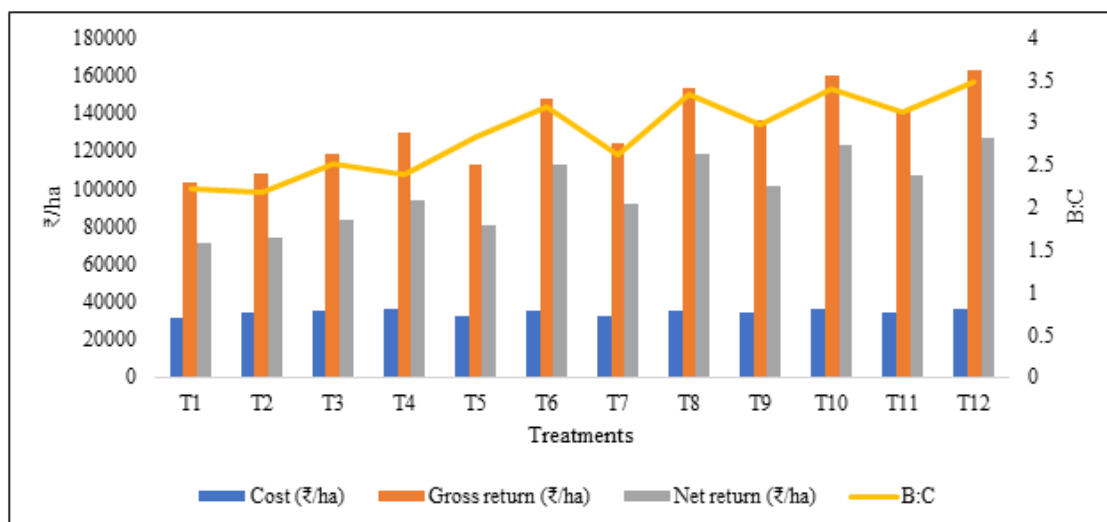


Fig 2. Economic analysis of rice as influenced by silicon and nitrogen

Table 1. Correlation between grain yield and economic parameters.

Parameter	Correlation with Yield (r)
Net Return	0.87
Gross Return	0.86
B:C Ratio	0.78

The grain yield of rice was significantly influenced by different levels of silicon and nitrogen, as presented in Fig. 1. A clear increasing trend in yield was observed with the progressive increase in nutrient levels. Among the treatments, T₁₂ (silicon 100 kg ha⁻¹ + nitrogen 100 kg ha⁻¹) recorded the highest grain yield of 6.88 t ha⁻¹, which was significantly superior to all other treatments. This treatment was closely followed by T₁₁ and T₈, which also exhibited higher yields but remained statistically inferior to T₁₂, indicating the advantage of combined higher levels of silicon and nitrogen.

At intermediate levels, treatments such as T₆, T₇ and T₁₀ showed moderate yield performance, forming a distinct statistical group. These treatments indicate that partial optimization of either silicon or nitrogen improves yield; however, maximum productivity is achieved only when both nutrients are applied at optimum amounts. In contrast, lower treatments including Control, T₂ and T₅ recorded significantly lower yields, with control showing the minimum yield of 4.34 t ha⁻¹. The gradual increase in yield from control to T₁₂ reflects a consistent and positive response of rice to incremental nutrient supply, without any irregular variation, thereby strengthening the reliability of the observed trend.

The improvement in yield under higher nutrient combinations can be attributed to the complementary roles of silicon and nitrogen in plant growth and development. Silicon enhances structural integrity by deposition in plant tissues, thereby improving resistance to lodging and abiotic stresses, while also maintaining better water balance and physiological efficiency. On the other hand, nitrogen plays a crucial role in chlorophyll synthesis, protein formation and vegetative growth, leading to increased tillering and biomass production. The combined application of these nutrients therefore results in improved photosynthetic efficiency and assimilate partitioning towards grain formation. Similar synergistic effects of silicon and nitrogen on rice yield have also been reported by Cuong et al. (2017), Berahim et al. (2021) and Jan et al. (2018).

The economic analysis (Fig. 2) further reinforced the yield findings, showing a parallel trend across treatments. Higher nutrient levels resulted in increased gross and net returns, primarily due to enhanced yield. Treatment T₁₂ (silicon 100 kg ha⁻¹ + nitrogen 100 kg ha⁻¹) recorded the highest gross return of ₹162,927 ha⁻¹, net return of ₹126,448 ha⁻¹ and benefit-cost ratio of 3.47, indicating maximum economic efficiency. Treatments T₁₀ and T₈ also demonstrated relatively higher economic returns, forming the next best group after T₁₂. In contrast, treatments with lower nutrient inputs, particularly control and T₂, showed reduced profitability.

A notable observation is that although the cost of cultivation increased slightly with higher nutrient application, the corresponding increase in yield and returns was proportionately higher, resulting in improved

benefit-cost ratio. This indicates that the investment in higher levels of silicon and nitrogen is economically justified under the given conditions. The consistency between yield and economic parameters suggests that productivity gains directly translated into profitability, without any disproportionate increase in input cost. Similar findings have been reported by Sudharshan et al. (2024), who observed enhanced economic returns with balanced nutrient management in rice.

Correlation analysis revealed a strong positive association between grain yield and economic parameters (Table 1). Grain yield exhibited a high positive correlation with net return ($r = 0.87$, $p < 0.01$) and gross return ($r = 0.86$), indicating that an increase in yield directly resulted in higher economic returns. Similarly, yield also showed a positive correlation with benefit-cost ratio ($r = 0.78$), suggesting improved economic efficiency with increased productivity.

The strong positive correlation between yield and economic returns indicates that productivity is the key determinant of profitability in rice cultivation. The results suggest that higher nutrient application levels not only enhanced yield but also translated into better economic gains. The increase in cost of cultivation was proportionately lower than the increase in returns, thereby improving overall economic efficiency. This finding confirms that yield improvement directly contributes to enhanced farm profitability.

Overall, the results clearly demonstrate that the combined application of silicon and nitrogen at higher levels not only maximizes yield but also ensures better economic returns, highlighting the importance of integrated nutrient management for sustainable rice production under such conditions.

4. CONCLUSION

The findings of the present study indicated that the application of silicon and nitrogen significantly influenced the grain yield and economic returns of transplanted rice. The results clearly indicated that the combined application of silicon and nitrogen performed better than their individual application. The treatment comprising silicon at 100 kg ha⁻¹ in combination with nitrogen at 100 kg ha⁻¹ recorded the highest grain yield, gross return, net return, and benefit-cost ratio among all treatments. The observed improvement in productivity may be explained by the beneficial effects of silicon in enhancing nutrient uptake, strengthening plant tissues, and improving physiological efficiency, while nitrogen facilitated vegetative growth and yield development. The combined application of these nutrients therefore enhanced both crop productivity and profitability. From a practical perspective, the adoption of this nutrient combination can provide a viable option for farmers to achieve higher yields and improved profitability, particularly under saline soil conditions where crop performance is often constrained. The use of silicon along with nitrogen may help in better stress tolerance and efficient utilization of applied nutrients,

thereby reducing the risk of yield losses and ensuring more stable returns. Therefore, the integrated application of silicon and nitrogen can be recommended as an effective nutrient management strategy for transplanted rice in the Indo-Gangetic plains. However, further multi-season and multi-location studies are required to validate the consistency of these findings under diverse agro-ecological conditions.

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