DOI: https://doi.org/10.52756/ijerr.2024.v46.024 *Int. J. Exp. Res. Rev.*, Vol. 46: 305-312 (2024)

Original Article | Peer Reviewed | Open Access

International Journal of Experimental Research and Review (IJERR)
© Copyright by International Academic Publishing House (IAPH)
ISSN: 2455-4855 (Online)
www.iaph.in

Effect of Different Levels of Nitrogen and Silicon in Rice under Red and Laterite Soil

Sujay Kumar Paul[1,2]*, Ganesh Chandra Malik[1], Mahua Banerjee[1] and Sitabhra Majumder[2]

[1]Department of Agronomy, Palli Siksha Bhavana, Visva Bharati, Sriniketan, W.B-731236, India; [2]Department of Agronomy and Agroforestry, M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha-761211, India

E-mail/Orcid Id:

SKP, sujay.paul39@gmail.com, https://orcid.org/0000-0001-6197-4405; *GCM*, ganeshchandra.malik@visva-bharati.ac.in, https://orcid.org/0000-0002-1785-2360; *MB*, mahua.banerjee@visva-bharati.ac.in, https://orcid.org/0000-0002-3871-408X; *SM*, sitabhra.majumder@cutm.ac.in, https://orcid.org/0009-0004-3587-2818

Article History:

Received: 19th Jun., 2024
Accepted: 25th Dec., 2024
Published: 30th Dec., 2024

Keywords:
Agriculture, LCC, Nitrogen, Silicon

How to cite this Article:
Sujay Kumar Paul, Ganesh Chandra Malik, Mahua Banerjee and Sitabhra Majumder (2024). Effect of Different Levels of Nitrogen and Silicon in Rice under Red and Laterite Soil. *International Journal of Experimental Research and Review, 46,* 305-312.
DOI: https://doi.org/10.52756/ijerr.2024.v46.024

Abstract: A field experiment was conducted at Agriculture Farm, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal, during *kharif* season of 2021-22 and 2022-23 in order to assess the performance of rice under various levels of nitrogen and silicon in red and laterite soil of West Bengal. The experiment was laid out in split plot design with three levels of nitrogen in main plots and five levels of silicon in sub plots. In the pooled data of both the years, among the main plots, treatment N3 with nitrogen applied @ 20 kg/ha as basal + LCC-4 at 20 kg N/ha had the highest plant height (141.24 cm), dry matter accumulation (1411.97 g/sq. m) at harvest, LAI at 60 DAT (4.88), number of tillers per sq. m at harvest (273.94), panicle length (29.04 cm), panicle number (263.82), number of filled grains (102.51), test weight (25.2 g), rice grain yield (6.17 t/ha), straw yield (8.25 t/ha), protein content (7.22%) and protein yield (446.78 kg/ha). Among the sub-plots, treatment S5 with SiO_2 applied @ 400 kg/ha recorded the highest plant height (137.98 cm), dry matter accumulation (1337.48 g/sq. m) at harvest, LAI at 60 DAT (4.74), number of tillers per sq. m at harvest (272.91), panicle length (29.53 cm), panicle number (259.73), number of filled grains (105.37), test weight (25.3 g), rice grain yield (5.83 t/ha), straw yield (7.86 t/ha), protein content (7.65 %) and protein yield (445.81 kg/ha).

Introduction

Rice (*Oryza sativa* L.) is an important crop that covers a vast area under cultivation and is also substantially related to people's food security and livelihood across countries. Rice production in India has increased to 120 million tonnes in 2020-2021 from 53.6 million tonnes in 1980 (Malabadi et al., 2022). Rice, being an exhaustive feeder crop, judicious nutrient management plays a vital role in maintaining the fertility of the soil (Thind et al., 2012; Das et al., 2024; Mishra et al., 2024; Pal et al., 2024). Nitrogen (N), one of the primary and essential nutrients, is involved in the proper growth and development of plants. Nitrogen management is an important aspect that needs to be taken care of for better utilization and uptake. Following blanket application of nitrogen doses and indiscriminate application by farmers lead to losses and pollution. Site-specific applications and crop growth-specific nitrogen applications help us in this regard. The application of nitrogen at specific recommended crop growth stages and the use of a leaf colour chart (LCC) can help properly manage nitrogen applied to the field. LCC is a plastic strip of four shades of green, which decides the nitrogen requirement of the rice crop. It is monitored every 7–10 days, starting from 15 days after transplanting till initiation of flowering and the prescribed amount of fertilizer N is applied whenever the colour of rice leaves falls below the critical LCC score (Thind and Gupta, 2010; Sow and Ranjan, 2021). Farmers can use the LCC as a visual indicator of the rice crop nitrogen status of the crop. Then, they can easily manage the N fertilizer application.

Silicon (Si) is a functional and agronomically essential nutrient (Savant et al., 1997), which helps crops sustain the system's growth and productivity in different ways. It

*Corresponding Author: sujay.paul39@gmail.com

This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

has also been observed that sometimes silicon absorption in rice is even more than nitrogen and potassium (Savant et al., 1997). However, plants differ greatly in Si accumulation because of differences in the ability of their roots to take up Si; shoot Si concentrations range from 0.1% to 10.0% (dry weight) (Ma et al., 2006). Repeated mining of silicon for crop cultivation is causing a deficiency of this nutrient in wider agriculture landscapes. Countries like Japan and Cambodia are already applying slag (containing silicon) into their fields to cope with the deficiency and realise higher yields (Ma, 2009; Correa-Victoria et al., 2001). In unstressed rice, silicon promotes the remobilization of amino acids during grain development to meet the increasing demand for nitrogen (Detmann et al., 2012). Si generally improves the concentration of N in rice plant tissues (Singh et al., 2006). Any research related to nitrogen and silicon application in crops is very scarce in this region. In this context, a field experiment was conducted to study the effect of nitrogen and silicon on growth parameters, yield attributes, and rice yield in the laterite zone of West Bengal, India.

Materials and Methods

A field experiment was conducted during *kharif* seasons of 2021-22 and 2022-23 at Agricultural Farm of Palli Siksha Bhavana, Visva-Bharati, Sriniketan located at latitude 23°40′33″N and longitude 87°39′37″E and at an altitude of 58 m above mean sea level. The experiment was to study the effect of different levels of nitrogen and silicon under the red and laterite soil of West Bengal (India). The soil of the experimental site was sandy and loamy in texture. The physico-chemical properties were pH (1:2.5 soil & water) of 5.46, electrical conductivity (1:2.5 soil & water) 0.22 dS/m and organic matter was 0.36 % at the top 15 cm of soil. Chemical properties of soil were available N (200 kg/ha), P_2O_5 (26.5 kg ha^{-1}) and K_2O (229.46 kg ha^{-1}).

The experiment conducted in split plot design replicated thrice, consisted of three levels of N in main plots [N1: Control 0 kg/ha, N2: N @ 80 kg/ha (Basal $1/4^{th}$ N, ½ N at active tillering, $1/4^{th}$ at panicle initiation) and N3: N @ 20 Kg/ha in basal + LCC-4 @ 20 kg N/ha] and in sub plots silicon (S1: Control @ 0 kg/ha, S2: SiO_2 @ 100 kg/ha, S3: SiO_2 @ 200 kg/ha, S4: SiO_2 @ 300 kg/ha and S4: SiO_2 @ 400 kg/ha). Urea, single super phosphate, and a murate of potash and calcium silicate were used as a source of nitrogen, phosphorus, potassium and SiO_2, respectively. Recommended fertiliser dose was 40 kg/ha P_2O_5 and 40 kg/ha K_2O in all the plots as basal. All the fertilisers were broadcasted before transplanting into the plots as per treatments in plots of 5 m × 4 m. Transplanting of seedlings was done with a spacing of 20 cm × 15 cm on 20th July 2021 and 30th July 2022. The rice variety, Pratikshya (IET-15191), was sown with a seed rate of 50 kg/ha and the crop was harvested on 9th November 2021 and 20th November 2022. For taking LCC reading, the customized leaf colour chart developed by National Rice Research Institute, Cuttack, was used in the study.

The samples, readings and calculations of plant height, leaf area, dry matter accumulation, number of tillers, yield attributes and yield were carried out following standard procedures (Kunal et al., 2024). All yields were expressed in tons/ha. The leaf area index (LAI) was calculated using the formula of leaf area (m^2) divided by ground area (m^2) (Watson, 1952). Harvest index (%) was calculated by dividing economic yield by biological yield, converted to percentage (Kunal et al. 2024). The protein content of grain was calculated by multiplying grain nitrogen content (%) by 6.25 (Paul et al., 2023). Nitrogen content in percentage in the grain was estimated by Kjeldahl method (Kunal et al., 2024).

All the data collected from the field experiment in both years were pooled and analysed by analysis of variance (ANOVA). Significance of treatments was estimated at 5 % probability level following the principles of Gomez and Gomez (1984) using SPSS Software version 20.

Result and Discussion

Effect of different levels of nitrogen and silicon on growth parameters of rice

The pooled analysis of two years of data on growth attributes showed a significant effect of different levels of nitrogen and silicon on plant height, number of tillers per sq. m, dry matter accumulation at harvest and LAI at 60 DAT of rice under red and laterite soil (Table 1).

The observations of plant height at harvest showed that nitrogen dose N3 (141.24 cm) was significantly higher than all other treatments but was at par with N2 (137.75 cm). Plots where LCC managed nitrogen, N3 was 13.55% more plant height than N1 (122.1 cm). Geetha and Balasubramanian, 2016 also observed similar results of nitrogen management by LCC-4 and N application in splits; Lal, 2004. They noted that LCC nitrogen management increased the growth metrics in rice plants. Lone and Ganie (2017) also concluded in their research that plant height in plots of the recommended dose of fertilisers was smaller than LCC-4 treated plots. Among the different levels of silicon, the plant height of S5 (137.98 cm) was significantly higher than all other treatments, but it was at par with S3 (134.78 cm) and S4 (135.68 cm). The application of silicon increased plant height @ 9 % and 18.73 % in similar experiments of rice by Ullah et al. (2017); Hoseinian et al. (2020). Silicon deposition on the epidermal layers of the plant helped improve stature, shoot length, and plant height. Increased plant height in the silicon-applied plots can also be linked to better development and higher nutrient uptake (Vasudevan and Thiyagarajan, 2022).

The effect of nitrogen and silicon levels positively influenced the leaf area index of rice at 60 DAT. Among the different nitrogen levels, pooled data of N3 (4.88) plots were significantly highest among all other treatment levels. Nitrogen management through LCC helps increase nitrogen use efficiency and increase leaf chlorophyll content, thus enhancing the leaf area index (Reddy and Pattar, 2006). For the silicon levels, pooled data of S5 plots (4.74) were significantly highest among all other treatments but were at par with S4 (4.49). Silicon generally boosts the carotenoid levels, preserves the water balance, lowers water balance, reduces chlorophyll destruction, and improves chlorophyll a, b, and total chlorophyll (Maghsoudi et al., 2016; Othmani et al., 2021).

The number of tillers per sq. m of rice showed the effect of nitrogen and silicon treatment levels. N3 (273.94) Nitrogen treatment plots gave significantly the highest number of tillers but were at par with N2 (262.59) plots. Pooled value of two years showed the number of tillers per sq. m. N3 had 22.23 % more tillers than control plots. Split application of nitrogen enhanced nitrogen recovery and LCC nitrogen management improved the overall growth metrics by increasing tiller numbers (Kondo et al., 2000; Geetha and Balasubramanian, 2016; Maiti et al., 2004). Among the silicon levels, S5 (272.91) had significantly highest number of tillers per sq. m but was at par with S4 (263.61) plots. Hoseinian et al. (2020) also observed 66.6% increase in the number of tillers due to silicon fertilisation in rice.

Dry matter accumulation (g/sq. m/day) of rice in the pooled data of both the years showed significant effects of different levels of nitrogen and silicon. Among all the nitrogen-treated plots, N3 (1411.97 g/m^2) had significantly highest dry matter accumulation, which was significantly highest among all other treatments. Appropriate, timely application of nitrogen by LCC reduced nitrogen losses, improved uptake, increased nitrogen availability, chlorophyll formation and dry matter accumulation (Kumar et al., 2018). Silicon level S5 (1337.48 g/m^2) with 400 kg/ha SiO_2 showed highest dry matter accumulation among all other silicon levels but was at par with S3 (1269.62 g/m^2) and S4 (1308.69 g/m^2). Dry matter accumulation of S5 plots was 18.88% more than that of dry matter accumulation of S1 (1084.87 g/m2), i.e., control plots. Silicon application reduces chlorophyll destruction and increases leaf area, photosynthetic activity and dry matter accumulation (Gerami et al., 2012).

The interaction effect of different levels of nitrogen and silicon on rice was non-significant for the growth attributes of plant height, number of tillers per sq. m, dry matter accumulation at harvest and LAI at 60 DAT of rice.

Effect of different levels of nitrogen and silicon on yield attributes of rice

The two-year pooled data analysis showed that yield attributes significantly affected different levels of nitrogen and silicon (Table 2). Panicle length and number of panicles were significantly affected by different levels of nitrogen and silicon**.** Panicle length and number of panicles of nitrogen level, N3 (29.04 cm & 263.82), was significantly highest among all other treatments and it was at par with N2 (27.7 cm and 250.55) level**.** This is mainly due to the availability of nitrogen at specific growth stages and intervals, which minimised nitrogen losses and enhanced the demand and supply of nitrogen (Yogendra et al., 2017)**.** Among the silicon levels, S5 (29.53 cm & 259.73) was significantly highest and was at par with S3 (28.11 cm and 246.79) and S4 levels (28.32 cm, 249.58) in the case of panicle length and number of panicles. Similar results of an increase in panicle number and spikelet/panicle were also observed by Dorairaj et al. (2017).

Among all the nitrogen levels, the number of filled grains per panicle was significantly highest in N3 (102.51) and was maximum in pooled analysis. Timely fertiliser application increases percentage of the fertile tiller and filled spikelet percentage (Malav et al., 2017). The silicon dose, S5 (105.37) showed significantly the highest number of filled grains per panicle and was at par with the S4 (102.29) level. Adequate silicon levels increase the number of panicles, filled grains/panicles, percentage ripening and nutrient use efficiency in rice (Malav et al., 2017).

Test weight did not show any effect of different levels of nitrogen and silicon on rice in the two-year pooled analysis data. Gradual increases in test weight due to LCC management and higher silicon doses are mainly due to higher nitrogen use efficiency, higher nutrient availability, and uptake of N and Si (Singh et al., 2006).

DOI: https://doi.org/10.52756/ijerr.2024.v46.001

The interaction effect of yield attributes due to different levels of nitrogen and silicon on rice was non-significant.

Effect of different levels of nitrogen and silicon on the yield of rice

The pooled data of grain yield (t/ha), straw yield (t/ha) and biological yield (t/ha) were significantly influenced by different levels of nitrogen and silicon in rice. Among the nitrogen levels, grain yield (t/ha), straw yield (t/ha) and biological yield (t/ha) of treatment, N3 with N applied @ 20 kg/ha in basal + LCC-4 at 20 kg N/ha (6.17 t/ha, 8.25 t/ha and 14.41 t/ha) was significantly highest among all other treatments in the pooled data. Better yield in LCC-based N-managed plots was mainly due to its upper hand in vegetative growth, better photosynthesis and better translocation of photosynthates to the grains (Malav et al., 2017). Need-based nitrogen management using LCC enhanced all the yield attributes, which positively impacted the rice crop yield (Yogendra et al., 2017).

Among the silicon levels, grain yield (t/ha), straw yield (t/ha) and biological yield (t/ha) of treatment, S5 (SiO_2 @ 400 kg/ha) (5.83 t/ha, 7.86 t/ha and 13.69 t/ha) respectively was significantly highest among all other treatments but was at par with treatment, S4 with (SiO_2 @ 300 kg/ha) (5.54 t/ha, 7.55 t/ha and 13.09 t/ha) respectively. For straw yield, treatment S5 was also at par with treatment S3 (7.33 t/ha) (SiO_2 @ 300 kg/ha). Silicon levels enhanced silicon availability in soil and gradual uptake by plants, which enhanced water use, absorption and mobility of nitrogen and nitrogen use efficiency in return, increasing vegetative growth, reflected in the yield attributes and yield (Malav et al., 2017).

For all the yields, control plots N1 (N @ 0 kg/ha) (4.19 t/ha, 6.13t/ha & 10.31 t/ha) and S1 (SiO_2 @ 0 kg/ha) (4.65 t/ha, 6.55 t/ha & 11.2 t/ha) recorded minimum values among the nitrogen and silicon levels.

Correlation analysis of yield attributes and yield as affected by different levels of nitrogen and silicon on rice

The correlation analysis between yield attributes and grain yield showed significant relationships across several variables (Fig. 2). Grain yield demonstrated a strong positive correlation with panicle number ($r = 0.89$, $p < 0.001$) and straw yield ($r = 0.95$, $p < 0.001$), indicating that higher numbers of panicles and straw production are associated with increased grain yield. Moderate correlations were observed between grain yield and the number of filled grains ($r = 0.56$, $p < 0.05$), as well as grain yield and test weight ($r = 0.51$, $p < 0.05$). The strong relationship between straw yield and grain yield ($r = 0.95$, $p < 0.001$) suggests that both these traits may be influenced by common growth factors. These findings suggest that panicle number and straw yield are the most influential factors determining grain yield, while test weight and the number of filled grains have a moderate impact.

The strong positive correlation between grain yield and both panicle number ($r = 0.89$, $p < 0.001$) and straw yield ($r = 0.95$, $p < 0.001$) is particularly noteworthy. Higher panicle numbers and increased straw production appear to be associated with greater grain yield. This finding aligns with our understanding of plant physiology: more panicles mean more potential sites for grain development, while increased straw yield likely reflects overall plant health and vigor (Parida et al., 2022). These factors—panicle number and straw yield—could serve as key targets for crop improvement strategies to enhance grain yield. Additionally, the moderate correlations observed between grain yield and the number of filled grains ($r = 0.56$, $p<0.05$) and grain yield and test weight ($r = 0.51$, $p < 0.05$) provide valuable insights. Filled grains contribute directly to grain yield, and their relationship suggests that optimizing grain-filling processes could positively impact overall yield. Similarly, test weight—a grain density measure—may indirectly influence yield by affecting harvest efficiency and market value (Zhao et al., 2022). However, the moderate strength of these correlations implies that other factors also play a role in determining grain yield. The intriguing aspect lies in the strong relationship between straw yield and grain yield ($r = 0.95$, $p < 0.001$). This suggests that common growth factors influence both traits. For instance, robust plant architecture, efficient resource allocation, and effective photosynthesis likely contribute to both straw production and grain yield (Smith et al., 2018).

Effect of different levels of nitrogen and silicon on protein content (%) and protein yield

The pooled analysis of two years of data on the protein content (%) of rice grains showed a significant effect of different levels of nitrogen and silicon, which was statistically analysed and presented in Table 3. Among the nitrogen levels, the protein yield of grains was significantly maximum in N3 (446.78 kg/ha) with N applied @ 20 kg/ha in basal + LCC-4 at 20 kg N/ha. Protein content of N2 (7.4 %) was significantly highest amongst all others. The lowest protein content and yield values were recorded in N1 (6.71 % & 281.60 kg/ha) treatment (Control N @ 0 kg/ha). The better protein content in N3 and N2 was mainly due to better availability, better photosynthetic activity, and increased

DOI: https://doi.org/10.52756/ijerr.2024.v46.001

nitrogen uptake, which enhanced the protein content and protein yield (Kumar et al., 2018). Among the silicon levels, protein content (%) and protein yield were significantly highest in S5 (SiO_2 @ 400 kg/ha) (7.65 % and 445.81 kg/ha), which was at par with S4 (SiO_2 @ 300 kg/ha) (7.39% & 410.83 kg/ha). The lowest protein content and yield results were recorded in S1 plots (Control plot) (6.51% and 303.33 kg/ha). Similiar results of the positive impact of silicon application in rice were also found by Kheyri et al. (2019).

Table 1. Effect of different levels of nitrogen and silicon on growth parameters of rice at different growth stages.

Treatments	Pooled observations of growth parameters			
	Plant height (cm)	LAI at 60 DAT	Number of tillers (per sq. m)	Dry matter accumulation (g/sq. m)
Nitrogen levels				
N1	122.1	3.36	213.04	993.05
N2	137.75	4.32	262.59	1326.33
N3	141.24	4.88	273.94	1411.97
SEm±	1.9	0.08	3.98	15.06
CD(p≤0.05)	6.19	0.25	12.96	49.12
Silicon levels				
S1	128.32	3.55	225.52	1084.87
S2	131.71	3.94	233.51	1218.24
S3	134.78	4.21	253.76	1269.62
S4	135.68	4.49	263.61	1308.69
S5	137.98	4.74	272.91	1337.48
SEm±	1.79	0.06	3.83	25.06
CD(p≤0.05)	5.09	0.18	10.88	71.25
Nitrogen × Silicon interaction				
SEm±	2.73	0.1	5.78	31.32
CD(p≤0.05)	NS	NS	NS	NS

Table 2. Effect of different nitrogen and silicon levels on rice yield attributes at harvest.

Treatments	Pooled observations of yield attributes			
	Panicle length (cm)	Panicle Number	Number of filled grains	Test weight (g)
Nitrogen levels				
N1	26.03	206.25	90.67	24.42
N2	27.7	250.55	96.91	25.11
N3	29.04	263.82	102.51	25.2
SEm±	0.56	4.41	1.09	0.23
CD(p≤0.05)	1.82	14.36	3.55	0.75
Silicon levels				
S1	24.89	217.06	87.4	24.69
S2	27.1	227.89	91.51	24.76
S3	28.11	246.79	96.92	24.96
S4	28.32	249.58	102.29	24.83
S5	29.53	259.73	105.37	25.3
SEm±	0.77	4.68	1.66	0.4
CD(p≤0.05)	2.18	13.3	4.71	1.12
Nitrogen × Silicon interaction				
SEm±	1.01	6.76	2.12	0.49
CD(p≤0.05)	NS	NS	NS	NS

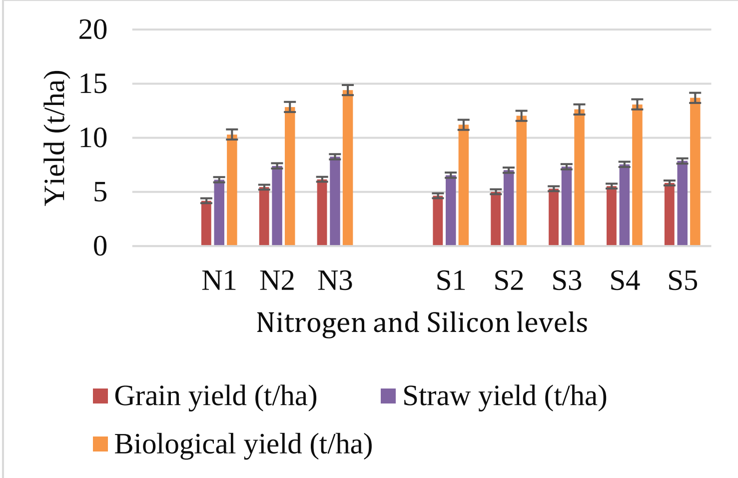

Figure 1. Effect of different levels of nitrogen and silicon on yield of rice at harvest.

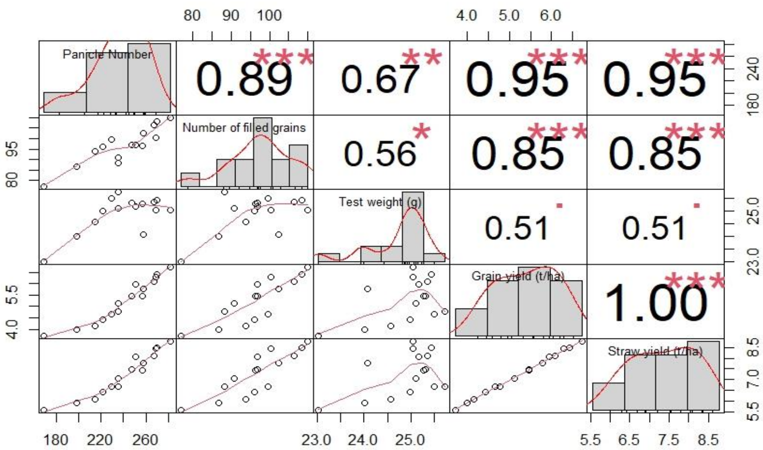

Figure 2. Correlation analysis of yield attributes and yield as affected by different levels of nitrogen and silicon on rice.

Table 3. Effect of different levels of nitrogen and silicon on panicle content (%) and protein yield (kg/ha) of rice at harvest.

Treatments	Protein content	Protein yield (kg/ha)
Nitrogen levels		
N1	6.71	281.60
N2	7.4	403.04
N3	7.22	446.78
SEm±	0.05	6.75
CD(p≤0.05)	0.17	22.01
Silicon levels		
S1	6.51	303.33
S2	6.94	349.81
S3	7.06	375.91

DOI: https://doi.org/10.52756/ijerr.2024.v46.001

S4	7.39	410.83
S5	7.65	445.81
SEm±	0.11	10.40
CD(p≤0.05)	0.31	29.57
Nitrogen × Silicon interaction		
SEm±	0.13	13.24
CD(p≤0.05)	NS	NS

Main Plots: N1: Control, **N2:** N @ 80 kg/ha (Basal 1/4th N, ½th N at active tillering, 1/4th N at Panicle Initiation), **N3:** N @ 20 kg/ha in basal + LCC-4 at 20 kg N/ha

Sub Plots: **S1:** Control (No Silicon)**, S2:** SiO_2 @ 100 kg/ha, **S3:** SiO_2 @ 200 kg/ha, **S4:** SiO_2 @ 300 kg/ha, **S5:** SiO_2 @ 400 kg/ha

Conclusion

From the present experiment, it can be concluded that the different levels of nitrogen and silicon in rice positively impacted growth, yield attributes, yield, protein content and protein uptake of rice. The pooled data of both the years were analysed and it was concluded that treatment, N3 with N applied @ 20 kg/ha in basal + LCC-4 at 20 kg N/ha and S5 (SiO_2 @ 400 kg/ha) was better in terms of plant height, LAI in 60 DAT, number of tillers (per sq. m), dry matter accumulation, panicle length, panicle number, number of filled grains, test weight (g), grain yield, straw yield and protein yield.

Future scope of research

Future work in this regard can include similar work being done in different seasons and on different crops grown in the region to observe the effect on them.

Acknowledgement

The authors acknowledge the Palli Siksha Bhavana (Institute of Agriculture), Visva Bharati, Sriniketan, India, for providing all the facilities necessary to carry out this study.

Conflict of Interest

The authors declare no conflict of interest.

References

Correa-Victoria, F. J., Datnoff, L. E., Okada, K., Friesen, D. K., Sanz, J. I., & Snyder, G. H. (2001). Effects of silicon fertilization on disease development and yields of rice in Colombia. In *Studies in plant science*, *8*, 313-322). Elsevier. https://doi.org/10.1016/S0928-3420(01)80023-9

Das, A., Sarkar, R., & Choudhury, B. (2024). Influence of Phosphate on Arsenic Uptake and Activities of Different Phosphatase Enzymes in Growing Rice (Oryza sativa L.) Seedlings. *International Journal of Experimental Research and Review*, *44*, 20–29. https://doi.org/10.52756/*IJERR*.2024.v44spl.003

Detmann, K. C., Araújo, W. L., Martins, S. C., Sanglard, L. M., Reis, J. V., Detmann, E., ... & DaMatta, F. M. (2012). Silicon nutrition increases grain yield, which, in turn, exerts a feed- forward stimulation of photosynthetic rates via enhanced mesophyll conductance and alters primary metabolism in rice. *New Phytologist*, *196*(3), 752-762. https://doi.org/10.1111/j.1469-8137.2012.04299.x

Dorairaj, D., Ismail, M. R., Sinniah, U. R., & Kar Ban, T. (2017). Influence of silicon on growth, yield, and lodging resistance of MR219, a lowland rice of Malaysia. *Journal of Plant Nutrition*, *40*(8), 1111–1124. https://doi.org/10.1080/01904167.2016.1264420

Geetha, P., & Balasubramanian, P. (2016). Effect of varieties and nitrogen application on growth and yield of aerobic rice. *ORYZA-An International Journal on Rice*, *53*(4), 458-463.

Gerami, M., Fallah, A., & Moghadam, M. K. (2012). Study of potassium and sodium silicate on the morphological and chlorophyll content on the rice plant in pot experiment (Oryza sativa L.). *International Journal of Agriculture and Crop Sciences*, *4*(10), 658-661.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research (2nd Ed.). An International Rice Research Institute Book. Wiley-Interscience Publication, John Wiley and Sons, New York. pp. 20-30.

Hoseinian, Y., Bahmanyar, M. A., Sadegh-Zade, F., Emadi, M., & Biparva, P. (2020). Effects of different sources of silicon and irrigation regime on rice yield components and silicon dynamics in the plant and soil. *Journal of Plant Nutrition*, *43*(15), 2322-2335. https://doi.org/10.1080/01904167.2020.1771577

Kheyri, N., Norouzi, H. A., Mobasser, H. R., & Torabi, B. (2019). Effects of silicon and zinc nanoparticles on growth, yield, and biochemical characteristics of rice. *Agronomy Journal*, *111*(6), 3084-3090. https://doi.org/10.2134/agronj2019.04.0304

Kondo, M., Singh, C. V., Agbisit, R., & Murty, M. V. R. (2005). Yield response to urea and controlled-release urea as affected by water supply in tropical upland rice. *Journal of plant nutrition*, *28*(2), 201-219. https://doi.org/10.1081/PLN-200047601

Kumar, P. P., Abraham, T., Pattanaik, S. S. C., Kumar, R., Kumar, U., & Kumar, A. (2018). Effect of customised leaf colour chart (CLCC) based real time N management on agronomic attributes and protein content of rice (*Oryza sativa* L.). *ORYZA-An International Journal on Rice*, *55*(1), 165-173. https://doi.org/10.5958/2249-5266.2018.00019.X

Kunal, B., Mishra, S. R., Singh, A. K., Mishra, A. N., Pandey, S., & Raj, J. (2024). Assessing the effect of the direction of transplanting and yield of rice (Oryza Sativa L.) Under different crop growing environments. *Plant Archives*, *24*(1), 1628-1634. https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.1.227

Lal, R. (2004). The potential of carbon sequestration in soils of South Asia. In: *Conserving soil and water for society: sharing solutions*, ISCO 2004 – *13th International soil conservation organisation conference* – Brisbane, July 2004, 134**,** pp. 1-6.

Lone, A.H., & Ganie, M.A. (2017). Nitrogen Management in Rice through Leaf Colour Chart under Kashmir Conditions. *International Journal of Engineering Research & Technology*, *6*(06), 50-54. https://doi.org/10.17577/IJERTV6IS060045

Ma, J. F. (2009, April). Silicon uptake and translocation in plants. In *Info: The Proceedings of the International Plant Nutrition Colloquium XVI, Department of Plant Sciences, UC Davis, UC Davis*.

Ma, J. F., & Yamaji, N. (2006). Silicon uptake and accumulation in higher plants. *Trends in Plant Science*, *11*(8), 392-397. https://doi.org/10.1016/j.tplants.2006.06.007

Maiti, D., Das, D. K., Karak, T., & Banerjee, M. (2004). Management of nitrogen through the use of leaf color chart (LCC) and soil plant analysis development (SPAD) or chlorophyll meter in rice under irrigated ecosystem. *The Scientific World Journal*, *4*, 838-846. https://doi.org/10.1100/tsw.2004.137

Malabadi, R. B., Kolkar, K. P., & Chalannavar, R. K. (2022). White, and brown rice-nutritional value and health benefits: Arsenic toxicity in rice plants. *International Journal of Innovation Scientific Research and Review*, *4*, 3065–3082.

Malav, J. K., Ramani, V. P., Sajid, M., & Kadam, G. L. (2017). Influence of Nitrogen and Silicon Fertilization on Yield and Nitrogen and Silicon uptake by Rice (Oryza Sativa L.) under Lowland Conditions. *Research Journal of Chemistry and Environment*, *21*(8), 45-49.

Mishra, A., Kalasare, R. S., Sarkar, S., Barik, B. R., Adhikary, R., & Gupta, V. K. (2024). Effect of Different Levels of Potash on Growth, Yield Attributes and Yields of Transplanted Kharif Rice (Oryza sativa L.) in Southern Odisha. *International Journal of Experimental Research and Review*, *44*, 257–265. https://doi.org/10.52756/IJERR.2024.v44spl.022

Othmani, A., Ayed, S., Bezzin, O., Farooq, M., Ayed-Slama, O., Slim-Amara, H., & Ben Younes, M. (2021). Effect of silicon supply methods on durum wheat (Triticum durum Desf.) response to drought stress. *Silicon*, *13*, 3047-3057. https://doi.org/10.1007/s12633-020-00639-3

Parida, A. K., Sekhar, S., Panda, B. B., Sahu, G., & Shaw, B. P. (2022). Effect of panicle morphology on grain filling and rice yield: genetic control and molecular regulation. *Frontiers in Genetics*, *13*. https://doi.org/10.3389/fgene.2022.876198

Paul, S. K., Malik, G. C., Banerjee, M., & Chowdhury, A. (2021). Effect of Carrier and Liquid based Biofertilisers on Summer Green Gram [*Vigna radiata* (L.) Wilczek] Grown in Red Laterite Soil. *Legume Research - an International Journal*, *Of*. https://doi.org/10.18805/lr-4680

Pal, S., Shankar, T., Majumder, S., Adhikary, R., & Pal, S. (2024). Impact of Agronomic Zinc Biofortification on Yield Attributes, Yield and Micronutrient Uptake of Rice (*Oryza sativa* L.) in Southern Odisha. *International Journal of Experimental Research and Review*, *40*(Spl Volume), 90-103. https://doi.org/10.52756/ijerr.2024.v40spl.007

Reddy, B. M., & Pattar, P. S. (2006). Leaf colour chart-a simple and inexpensive tool for nitrogen management in transplanted rice (*Oryza sativa*). *The Indian Journal of Agricultural Sciences*, *76*(5), 289-292

Savant, N. K., Datnoff, L. E., & Snyder, G. H. (1997). Depletion of plant- available silicon in soils: A possible cause of declining rice yields. *Communications in Soil Science and Plant Analysis*, *28*(13-14), 1245-1252. https://doi.org/10.1080/00103629709369870

Singh, K. K., Singh, K., Singh, R., Singh, Y., & Singh, C. S. (2006). Response of nitrogen and Si levels on growth, yield and nutrient uptake of rice (*Oryza sativa* L.). *Oryza 43*:220–223

Smith, M. R., Rao, I. M., & Merchant, A. (2018). Source-sink relationships in crop plants and their influence on yield development and nutritional quality. *Frontiers in plant science*, *9*, 1889.

Sow, S., & Ranjan, S. (2021). Precision Nutrient Management: As a tool to enhance Nutrient Use Efficiency.

Thind, H. S., & Gupta, R. K. (2010). Need based nitrogen management using the chlorophyll meter and leaf colour chart in rice and wheat in South Asia: a review. *Nutrient Cycling in Agroecosystems*, *88*(3), 361-380. https://doi.org/10.1007/s10705-010-9363-7

Thind, H. S., Sharma, S., Vashistha, M., & Singh, G. (2012). Land application of rice husk ash, bagasse ash and coal fly ash: Effects on crop productivity and nutrient uptake in rice–wheat system on an alkaline loamy sand. *Field Crops Research*, *135*, 137-144. https://doi.org/10.1016/j.fcr.2012.07.012

Ullah, H., Luc, P. D., Gautam, A., & Datta, A. (2018). Growth, yield and silicon uptake of rice (Oryza sativa) as influenced by dose and timing of silicon application under water-deficit stress. *Archives of Agronomy and Soil Science*, *64*(3), 318-330. https://doi.org/10.1080/03650340.2017.1350782

Vasudevan, V., & Thiyagarajan, C. (2022). Screening Maize Hybrids for Silicon Efficiency to Improve the Growth and Yield on Silicon Deficient Soils. *Silicon*, *14*(15), 9711-9720. https://doi.org/10.1007/s12633-022-01700-z

Watson, D. J. (1952). The physiological basis of variation in yield. *Advances in Agronomy*, *4*, 101-145. https://doi.org/10.1016/S0065-2113(08)60307-7

Yogendra, N. D., Kumara, B. H., Chandrashekar, N., Prakash, N. B., Anantha, M. S., & Shashidhar, H. E. (2017). Real-time nitrogen management in aerobic rice by adopting leaf color chart (LCC) as influenced by silicon. *Journal of Plant Nutrition*, *40*(9), 1277-1286. https://doi.org/10.1080/01904167.2016.1263333

Zhao, C., Liu, G., Chen, Y., Jiang, Y., Shi, Y., Zhao, L., Liao, P., Wang, W., Xu, K., Dai, Q., & Huo, Z. (2022). Excessive nitrogen application leads to lower rice yield and grain quality by inhibiting the grain filling of inferior grains. *Agriculture*, *12*(7), 962. https://doi.org/10.1080/01904167.2016.1263333

How to cite this Article:

Sujay Kumar Paul, Ganesh Chandra Malik, Mahua Banerjee and Sitabhra Majumder (2024). Effect of Different Levels of Nitrogen and Silicon in Rice under Red and Laterite Soil. *International Journal of Experimental Research and Review*, *46*, 305-312.

DOI : https://doi.org/10.52756/ijerr.2024.v46.024

This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.