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Effect of nitrogen sources and soil amendments on growth and yield of rice

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Abstract
The field experiment was undertaken to study the impact of different nitrogen as well as mitigation sources application of growth and yield of rice. The experiment was laid out in factorial randomized block design with two factors viz. nitrogen and mitigation sources. The nitrogen sources comprised of Control, 100 kg N ha^{-1} through Urea, 100 kg N ha^{-1} through Ammonium Sulphate, 100 kg N ha^{-1} through Calcium Nitrate, 100 kg N ha^{-1} through 16:16:16 (50 % Ammonical and 50 % Nitrate N), 100 kg N ha^{-1} through Vermicompost and RDN through Konkan Annapurna Briquettes. Whereas, another factor comprised of soil amendments consisting Control, Orthosilicic Acid 0.08% @ 15 kg ha^{-1}, Rice Husk Biochar @ 5 t ha^{-1} and Neem Cake @ 1 t ha^{-1}. The results indicated that, plant height, number of tillers, number of panicle, number of grains per panicle and length of panicle of rice as well grain and straw yield of rice significantly enhanced by application of 100 kg N ha^{-1} through urea. The number of tillers of rice significantly increased by application of orthosilicic acid 0.08% @ 15 kg ha^{-1}. Therefore it is concluded that, the application of 100 kg N ha^{-1} through urea along with Orthosilicic Acid 0.08% @ 15 kg ha^{-1} is beneficial for improving growth and yield of rice crop.

Keywords: Rice, nitrogen, silicon, yield, amendment

Introduction
The Rice crops is essential to global food security, providing a major source of nourishment and income for millions of people worldwide. However, the widespread reliance on chemical fertilizers and pesticides in crop production and pest control has led to growing concerns about environmental damage and potential risks to human health as well as soil quality. Consequently, there is a rising interest in sustainable and environmentally friendly practices that can maintain high crop productivity and soil health. In this context, soil amendments and its related products have gained attention as effective alternatives, offering significant advantages for improving crop yields and managing soil fertility.

An adequate and well-balanced nutrient supply is essential for achieving optimal yields and maintaining the nutritional quality of grain crops. To overcome nutrient limitations and reduce soil degradation resulting from intensive farming practices, the integrated use of chemical and organic fertilizers, such as vermicompost, has been widely recommended. The inclusion of vermicompost, along with crop residues and cover crop biomass, helps enhance soil fertility, improve nutrient accessibility, and support sustainable, long-term productivity in grain crop systems (Singh and Misal 2022) [12].

The nitrogen is a key nutrient essential for rice cultivation, yet a significant portion of applied nitrogen is often lost through processes such as denitrification, ammonia volatilization, runoff, and immobilization, resulting in low nitrogen recovery by the crop. Compared with conventionally applied prilled urea, deep placement of fertilizer briquettes has been shown to be more efficient (Savant and Stangel, 1995) [10]. Furthermore, continuous cultivation of high-yielding rice varieties with repeated application of fertilizers supplying only primary nutrients may increase the need for micronutrient supplementation to ensure long-term and sustainable crop productivity (Subbaiah and Mitra, 1997) [14].

Silicon is recognized as a beneficial element for plant development and plays an agronomically important role in enhancing and maintaining rice productivity. Plants can absorb silicon only in the form of monosilicic acid (H_4SiO_4), but the natural conversion of SiO_2 into this available form occurs very slowly (Ma and Yamaji, 2008) [5]. Rice is known as a silicon-accumulating crop, with silicon levels reaching up to 10% of its dry matter. Silicon plays a crucial role in helping plants tolerate both biotic and abiotic stresses, including salinity and heavy metal toxicity, and also enhances the efficiency of NPK fertilizer use (Guntzer *et al*. 2012) [2].

Biochar has gained considerable interest in recent years because of its beneficial characteristics, making it a promising amendment for enhancing soil organic matter content (Plaza *et al*. 2016) [8]. Research has shown that biochar application can support plant growth, improve crop productivity, and increase overall yields. In addition, biochar has been reported to help reduce greenhouse gas emissions (Wang *et al*. 2017) [16]. As a result, numerous studies have concentrated on evaluating the impact of biochar incorporation on greenhouse gas emissions, particularly in rice-based agroecosystems such as paddy fields.

Neem cake, a by-product obtained after oil extraction, contains approximately 5% nitrogen. The use of neem-coated urea has been reported to enhance nitrogen use efficiency, leading to improved rice yields (Reddy *et al*. 2019) [9]. Nitrification inhibitors such as neem cake, when applied in combination with urea, help minimize nitrogen losses and thereby increase nitrogen use efficiency in crops. Moreover, integrating organic neem cake with inorganic nitrogen fertilizers can further improve overall nutrient utilization efficiency (Khandey *et al.* 2017) [4].

Materials and Methods

The field experiment was undertaken for 2 successive seasons to study the impact of different nitrogen sources as well as various soil amendments on growth and yield of rice during *kharif* season 2022 and *kharif* 2023. The experiment was conducted at experimental farm Department of Soil Science and Agricultural Chemistry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.

The rice variety Karjat - 3 developed by Regional Rice Research Station Karjat used as test crop. The seeds were sown on seedbed and raised for seedlings. The 30 days old rice seedlings transplanted in puddled plot with 12 sq. m size with 20 x 15 cm spacing.

The experiment was laid down in factorial randomized block design with two replications. Total 28 treatment combinations consisted with two factors viz. nitrogen sources and soil amendments. The nitrogen sources comprised of forms of plant available of nitrogen along with control; treatments consisting of N_0 - Control, N_1-100 kg N ha^{-1} through Urea, N_2 - 100 kg N ha^{-1} through Ammonium Sulphate, N_3 - 100 kg N ha^{-1} through Calcium Nitrate, N_4 - 100 kg N ha^{-1} through 16:16:16 (50 % Ammonical and 50 % Nitrate N), N_5 - 100 kg N ha^{-1} through Vermicompost and N_6 - RDN through Konkan Annapurna Briquettes. Whereas, another factor comprised of soil amendments along with control; treatments consisting M_0 - Control, M_1 - Orthosilicic Acid 0.08% @ 15 kg ha^{-1}, M_2 - Rice Husk Biochar @ 5 t ha^{-1} and M_3 -Neem Cake @ 1 t ha^{-1}.

Amongst the whole dose of nitrogen 40 % was applied at the time of transplanting; 40 % during tillering stage and remaining 20 % during panicle initiation stage of rice as per treatments. The phosphorous @ 50 kg ha^{-1} through SSP and potassium @ 50 kg ha^{-1} through MOP applied as basal dose as well as vermicompost @ 4 ton ha^{-1} was applied during preparatory tillage. The application of orthosilicic acid, rice husk biochar and neem cake was done at the time of transplanting.

The observations of growth attributes viz. number of tillers and plant height were recorded at 30 days after transplanting, 60 days after transplanting and at harvest of rice; however the yield and yield attributes were recorded at harvest of rice crop.

The experimental data was analyzed statistically by the technique of Analysis of Variance as applicable to Factorial Randomized block design. The significance of treatment difference was tested by 'F' (Variance ratio) test. Critical difference (CD) at 5 per cent level of probability was worked out for comparison and statistical interpretation of the treatment means (Panse and Sukhatme).

Results and Discussion

Effect on plant height

The result presented in table 1 showed that, the significantly highest plant height (58.10 and 66.18 cm in the year 2022 and 2023, respectively) was noticed by treatment N_1 receiving application of 100 kg N ha^{-1} through urea. At 60 days after transplanting, the application of 100 kg N ha^{-1} through urea (N_1) recorded the highest plant height (84.99 cm) during the year 2022, whereas, in the year 2023 the N_1 treatment found superior over all nitrogen sources except N_4 treatment. At harvest of the rice, the similar effect was noticed, application of 100 kg N ha^{-1} through urea (N_1) observed highest plant height; 89.10 and 89.69 cm during 2022 and 2023, respectively. The lowest plant height was noticed due to control at all stages of rice growth during both the years.

The application of various mitigation sources did not influence the plant height during 30 days after transplanting, 60 days after transplanting and at harvest of rice during the year 2022 and 2023 whereas, during the year 2023, at 30 days after transplanting plant height was significantly influenced by application of orthosilicic acid 0.08% @ 15 kg ha^{-1} (M_1) which recorded the highest height (63.53 cm). The interaction effect between nitrogen and mitigation sources was not influenced significant during both the years of experimentation

The glance look at the data indicated that, the highest plant height was achieved by application of nitrogen through urea amended plots compared to other treatments. The urea is readily soluble in the water, insure rapid conversion into the plant available form. The rapid availability of nitrogen at early growth stages promoted the vegetative growth of rice. As compared to urea other sources such as briquettes and vermicompost released nitrogen at slow rate, which was limited the nitrogen availability to rice. Singh *et al.* (2006) [11] noticed the similar observations regarding plant height; reported maximum plant height with split application of nitrogen at transplanting, tillering and panicle initiation stages of rice. The results are confirmed by Walekar *et al.* (2022) [15] recorded maximum plant height with RDF compared to other nitrogen sources.

Effect on number of tillers of rice

The plant height of rice influenced by nitrogen source application (Table 2). At 30 days after transplanting, the N_1 treatment consisting application of 100 kg N ha^{-1} through urea was found to be higher in relation to number of tillers (8.78 and 9.74) during both the years of experimentation. Similarly, during 60 days after transplanting, the N_1 treatment receiving 100 kg N ha^{-1} through urea application recorded the highest number of tillers (17.85 and 17.63) during both the years of experimentation. The application of N_1 treatment was achieved significantly higher number of tillers (16.34 and 16.51 during 2022 and 2023 respectively) at harvest stage of rice. However, the lowest number of tillers during the year 2022 and 2023, respectively was recorded with control at all growth stages of rice.

During the year 2022, significantly highest number of tillers was found due to the application of orthosilicic acid 0.08% @ 15 kg ha^{-1} (M_1) However, the highest number of tillers (9.15) was observed with the application of M_1 treatments in the year 2023. At 60 days after transplanting of rice, the number of tillers showed significant effect due to orthosilicic acid 0.08% @ 15 kg ha^{-1}. The highest number of tillers (16.38 during 2022 and 16.85 during 2023) was found to be significantly highest with the application of M_1 treatment. Numerically the highest number of tillers (14.98 and 15.12) was observed with the application of orthosilicic acid 0.08% @ 15 kg ha^{-1} (M_1) as compared to other mitigation sources at harvest during the year 2022 and 2023 respectively. The interaction between nitrogen and mitigation sources did not reach to the level of significance during both the years of experimentation.

The Rice plants exhibit a strong demand for nitrogen during their early vegetative growth, specifically to promote vigorous tillering and the formation of lateral shoots. Urea effectively meets this need because when it's applied to the soil, it rapidly hydrolyzes into plant-available ammonium (NH^{4+}) and then can be nitrified into nitrate (NO^{3-}). This quick transformation provides a rapid "N flush" that is crucial for triggering these essential development at tillering stage of rice. The urea was applied in three splits, at transplanting, tillering and at panicle initiation of rice which might be responsible for increasing tillering in the respective treatment. The similar results were noted by Walekar *et al.* (2022) [15] and Singh *et al.* (2006) [11]. The rice is silicon accumulator plant therefore, the application of the silicon showed strongly positive effect on the growth of rice crop. Silicon application increases the availability of the nutrients and uptake in the paddy (Pati *et al.*, 2018) [7]. The application Si kept rice plant erect and increase the photosynthesis activity. Increased dry matter production by the application of the silicon might be responsible for the increment number of tillers of rice.

Effect on yield attributes of rice.

Effect on number of panicle per hill

The application of different nitrogen sources resulted significant (Table 3) for number of panicles per hill the highest number of panicles (13.27 and 13.01) was recorded due to the application of M_1 treatment receiving 100 kg N ha^{-1} through urea during the year 2022 and 2023 respectively. However, the lowest number of panicles per hill was noticed by control treatment.

The number of panicles of rice as influenced by different mitigation sources ranged from 10.86 to 11.94 and 11.01 to 12.52 in year 2022 and 2023, respectively. However, application of mitigation sources as well as interaction effects was found to be non-significant during both the years of experimentation.

Sistani *et al.* (1998) [13] reported that the highest yield attributes were observed by highest nitrogen application and which was independent to method of N application. Walekar *et al.* (2022) [15] found similar results; recorded highest number of panicle per hill by urea application as compare to Konkan Annapurna Briquettes and Vermicompost.

Effect on Number of grains per panicle

The application of nitrogen sources significantly influenced the number of grains per panicle (Table 3). The significantly highest number of grains (115.63 and 117.85) per panicle of rice was recorded due to application of N_1 treatment consisting of 100 kg N ha^{-1} through urea compared to other treatments during the year 2022 and 2023 respectively. The effects of nitrogen sources was recorded significantly superior in the year 2023. The number of grains per panicle was numerically varied due to application of different mitigation sources and it ranged from 100.21 to 110.21 and 102.32 to 109.75 during the year 2022 and 2023, respectively but the effect of mitigation sources application did not observe to be significant during both the year. Similarly the interaction effect was noticed non-significant.

Sistani *et al.* (1998) [13] reported that the high nitrogen rates produced highest number of grains were achieved by highest nitrogen application regardless of the method of application. The results were tune with findings obtained by Singh *et al.* (2006) [11].

Effect on average length of panicle

The data presented in table 3 revealed that, the panicle length of rice increased significantly due to various nitrogen sources from 19.18 to 23.72 and 18.66 to 23.96 cm during the year 2022 and 2023, respectively. Among the different nitrogen sources, the application of N_1 treatment comprising 100 kg N ha^{-1} through urea recorded significantly highest (23.72 and 23.86 cm) panicle length of rice during the year 2022 and 2023, respectively**.** The data pertaining impact of mitigation sources and interaction effect of different nitrogen and mitigation sources was found to be non-significant on panicle length during both the years of experimentation.

Effect of nitrogen and mitigation sources on yield of rice.

Effect on grain and straw yield of rice (q ha^{-1})

From the results presented in table 4, it was observed that the application of nitrogen sources significantly influenced the grain yield of rice during the year 2022 and 2023, respectively. The significantly highest grain yield (46.16 and 45.33 q ha^{-1}) of rice was noticed due to the application of N_1 treatment receiving 100 kg N ha^{-1} through urea during the year 2022 and 2023 respectively. The grain yield of rice as influenced by different mitigation sources varied from 38.22 to 40.37 and 38.12 to 39.95 q ha^{-1} during the year 2022 and 2023, respectively. The highest straw yield of rice was recorded due to the application of M_1 treatment application but results did not reach the level of significance. The interaction effect of nitrogen sources and mitigation sources did not observed significantly.

Similar to the grain yield the highest straw yield (58.29 and 54.40 q ha^{-1}) of rice was observed due to N_1 treatment application comprising 100 kg N through urea application. It was noticed significantly superior over remaining treatments during the year 2022 however recorded at par with N_4 and N_6 treatments during 2023. Influence of different mitigation sources on straw yield of rice varied from 46.02 to 48.75 and 45.98 to 47.83 q ha^{-1} during the year 2022 and 2023, respectively but did not rich the level of significance. The interaction between nitrogen and mitigation sources was also found non significance.

Broadcasted urea delivers a rapid surge of nitrogen during early vegetative stage, which stimulates tiller development. A sufficient and timely nitrogen supply is crucial, ensuring a higher proportion of these tillers mature into productive, grain-bearing panicles. This enhanced tillering and leaf growth collectively lead to increased biomass accumulation throughout the plant's lifecycle forming the essential base for subsequent grain filling (Islam *et al.*, 2011) [3]. In case of other nitrogen sources without adequate early nitrogen, many tillers may not develop fully or could abort. Similarly, the application of treatment N_1 adequately supplied phosphorous to soil that may contribute to growth and yield of rice. Mohapaira and Jee, 1993

[6] opined that, increasing levels of phosphorous application significantly enhanced the grain yield of rice. The similar findings were obtained by Walekar *et al*. (2022) [15] and Singh *et al*. (2006) [11] recorded highest yield by urea application.

Table 1: Effect of different nitrogen and mitigation sources on plant height (cm) at various growth stages of rice.

2022															
Treatments	**30 DAT Stage**					**60 DAT Stage**					**At Harvest Stage**				
	M_0	**M_1**	**M_2**	**M_3**	**Mean**	**M_0**	**M_1**	**M_2**	**M_3**	**Mean**	**M_0**	**M_1**	**M_2**	**M_3**	**Mean**
N_0	47.50	53.03	51.60	51.15	50.82	61.10	67.83	65.50	65.73	65.04	67.30	75.76	73.93	74.49	72.87
N_1	56.05	59.63	59.20	57.53	58.10	81.43	90.49	85.00	83.03	84.99	84.84	92.69	88.59	90.30	89.10
N_2	51.33	56.43	53.30	54.03	53.77	70.40	75.83	70.23	71.03	71.87	74.19	77.03	76.10	76.70	76.00
N_3	56.06	57.78	55.86	57.32	56.76	77.83	82.85	81.58	79.31	80.39	81.27	85.65	85.03	83.45	83.85
N_4	55.20	56.38	55.36	55.45	55.60	82.73	85.80	83.80	83.30	83.91	85.03	87.89	85.80	87.60	86.58
N_5	50.50	51.88	51.30	51.50	51.29	67.83	72.73	70.10	71.90	70.64	75.23	77.80	77.30	76.45	76.69
N_6	55.88	59.73	55.90	57.68	57.30	80.40	83.63	81.35	82.19	81.89	83.48	86.30	84.20	84.20	84.54
Mean	53.22	56.41	54.65	54.95	54.80	74.53	79.88	76.79	76.64	76.96	78.76	83.30	81.56	81.88	81.38
	N		**M**		**N x M**	**N**		**M**		**N x M**	**N**		**M**		**N x M**
S.E.±	1.31		0.99		2.62	2.12		1.60		4.23	1.55		1.17		3.10
C.D.@ 5%	3.80		NS		NS	6.14		NS		NS	4.50		NS		NS
2023															
Treatments	**30 DAT Stage**					**60 DAT Stage**					**At Harvest Stage**				
	M_0	**M_1**	**M_2**	**M_3**	**Mean**	**M_0**	**M_1**	**M_2**	**M_3**	**Mean**	**M_0**	**M_1**	**M_2**	**M_3**	**Mean**
N_0	46.41	50.57	48.80	49.04	48.70	67.42	69.73	68.16	68.56	68.47	76.35	80.26	77.15	78.92	78.17
N_1	62.42	69.74	65.93	66.62	66.18	85.32	89.57	86.27	86.77	86.98	88.42	90.93	89.01	90.42	89.69
N_2	47.53	54.81	50.88	52.30	51.38	71.49	75.09	73.54	74.99	73.78	79.65	85.03	80.03	80.92	81.40
N_3	54.31	63.95	59.28	62.63	60.04	75.39	84.11	79.45	80.03	79.74	83.70	86.81	84.92	85.50	85.23
N_4	58.84	64.55	63.19	65.37	62.99	79.04	83.11	81.54	81.86	81.39	85.87	88.41	85.91	87.87	87.01
N_5	49.10	54.07	49.26	48.85	50.32	67.19	75.46	70.49	71.86	71.25	75.86	82.15	77.86	80.37	79.06
N_6	60.41	66.04	63.75	64.97	63.79	78.27	81.43	79.04	80.88	79.91	84.89	89.89	85.99	87.74	87.12
Mean	54.14	60.53	57.30	58.54	57.63	74.87	79.79	76.93	77.85	77.36	82.10	86.21	82.98	84.53	83.96
	N		**M**		**N x M**	**N**		**M**		**N x M**	**N**		**M**		**N x M**
S.E.±	1.98		1.50		3.97	2.24		1.69		4.48	1.76		1.33		3.53
C.D.@ 5%	5.75		4.35		NS	6.50		NS		NS	5.12		NS		NS

Table 2: Effect of different nitrogen and mitigation sources on number of tillers hill^{-1} at various growth stages of rice.

2022															
Treatments	**30 DAT Stage**					**60 DAT Stage**					**At Harvest Stage**				
	M_0	**M_1**	**M_2**	**M_3**	**Mean**	**M_0**	**M_1**	**M_2**	**M_3**	**Mean**	**M_0**	**M_1**	**M_2**	**M_3**	**Mean**
N_0	5.70	6.72	5.83	6.60	6.21	13.80	14.00	14.10	13.70	13.90	10.98	13.73	11.80	12.63	12.28
N_1	8.18	9.49	8.53	8.83	8.76	16.80	19.40	16.60	18.60	17.85	15.80	16.88	15.70	16.99	16.34
N_2	6.50	7.63	6.91	6.67	6.93	13.43	15.92	13.30	14.28	14.23	11.73	14.28	12.10	12.13	12.56
N_3	7.95	8.62	7.60	8.10	8.07	14.36	16.04	14.50	14.70	14.90	12.03	14.08	12.60	13.68	13.10
N_4	8.20	9.00	8.54	8.10	8.46	14.77	16.40	15.60	16.06	15.71	13.59	15.70	13.80	14.60	14.42
N_5	6.15	8.01	7.00	7.77	7.23	13.29	15.50	14.61	14.80	14.55	12.00	13.32	13.30	13.30	12.98
N_6	6.60	9.59	7.63	7.74	7.89	16.00	17.40	16.78	16.90	16.77	15.47	16.88	15.49	15.60	15.86
Mean	7.04	8.43	7.43	7.69	7.65	14.64	16.38	15.07	15.58	15.42	13.08	14.98	13.54	14.13	13.93
	N		**M**		**N x M**	**N**		**M**		**N x M**	**N**		**M**		**N x M**
S.E.±	0.36		0.28		0.73	0.51		0.39		1.02	0.62		0.47		1.24
C.D.@ 5%	1.06		0.80		NS	1.48		1.12		2.96	1.79		1.36		NS
2023															
Treatments	**30 DAT Stage**					**60 DAT Stage**					**At Harvest Stage**				
	M_0	**M_1**	**M_2**	**M_3**	**Mean**	**M_0**	**M_1**	**M_2**	**M_3**	**Mean**	**M_0**	**M_1**	**M_2**	**M_3**	**Mean**
N_0	6.20	7.11	6.36	6.97	6.66	12.92	14.35	13.92	13.97	13.79	11.23	12.85	11.39	12.02	11.87
N_1	8.86	11.37	9.29	9.46	9.74	16.92	18.54	17.36	17.71	17.63	15.46	17.30	16.49	16.78	16.51
N_2	6.70	7.76	6.99	7.71	7.29	13.87	16.21	14.24	14.80	14.78	11.30	13.24	12.28	12.91	12.43
N_3	7.94	9.76	8.91	9.14	8.93	14.65	17.60	16.10	17.50	16.46	13.49	15.97	14.03	14.58	14.52
N_4	8.52	10.17	9.23	10.24	9.54	15.51	17.16	15.96	16.92	16.39	13.63	16.01	14.33	15.02	14.74
N_5	6.36	8.64	6.92	8.02	7.48	13.83	16.33	14.25	14.51	14.73	12.21	13.93	12.46	13.27	12.97
N_6	7.26	9.26	8.81	9.05	8.59	15.53	17.75	17.23	17.63	17.03	14.42	16.57	15.74	16.29	15.75
Mean	7.40	9.15	8.07	8.65	8.32	14.74	16.85	15.58	16.15	15.83	13.10	15.12	13.82	14.41	14.11
	N		**M**		**N x M**	**N**		**M**		**N x M**	**N**		**M**		**N x M**
S.E.±	0.51		0.39		1.03	0.65		0.49		1.30	0.60		0.46		1.20
C.D.@ 5%	1.49		1.13		NS	1.88		1.42		NS	1.75		1.32		NS

Table 3: Effect of different nitrogen and mitigation sources on number of panicles hill^{-1}, number of grains per panicle and average length of panicle (cm) of rice.

Treatments	Number of Panicles per Hill					Number of Grains per Panicle					Av. Length of Panicle (cm)				
2022															
	M0	**M1**	**M2**	**M3**	**Mean**	**M0**	**M1**	**M2**	**M3**	**Mean**	**M0**	**M1**	**M2**	**M3**	**Mean**
N0	9.30	9.60	9.40	10.00	9.58	86.50	93.50	86.50	91.50	89.50	18.70	19.55	19.00	19.45	19.18
N1	12.45	13.50	13.23	13.90	13.27	110.50	122.00	110.50	119.50	115.63	23.70	23.81	24.55	22.80	23.72
N2	9.59	11.14	9.45	10.63	10.20	91.00	96.00	90.00	91.50	92.13	18.90	20.49	19.95	20.05	19.85
N3	11.30	11.78	11.20	11.13	11.35	97.50	112.50	111.50	110.00	107.88	19.83	21.25	20.13	20.90	20.53
N4	11.90	13.41	12.98	12.68	12.74	106.50	120.50	119.50	105.50	113.00	19.47	21.00	19.85	20.38	20.17
N5	10.10	11.43	10.30	10.20	10.51	105.00	114.50	107.50	101.00	107.00	20.20	18.90	19.62	18.35	19.27
N6	11.40	12.70	12.10	12.60	12.20	104.50	112.50	110.00	111.50	109.63	23.45	22.10	23.05	22.75	22.84
Mean	10.86	11.94	11.24	11.59	11.41	100.21	110.21	105.07	104.36	104.96	20.61	21.01	20.88	20.67	20.79
	N		**M**		**N x M**	**N**		**M**		**N x M**	**N**		**M**		**N x M**
S.E.±	0.61		0.46		1.22	3.62		2.74		7.24	0.49		0.37		0.99
C.D.@ 5%	1.77		NS		NS	10.51		NS		NS	1.43		NS		NS
2023															
Treatments	**Number of Panicles per Hill**					**Number of Grains per Panicle**					**Av. Length of Panicle (cm)**				
	M0	**M1**	**M2**	**M3**	**Mean**	**M0**	**M1**	**M2**	**M3**	**Mean**	**M0**	**M1**	**M2**	**M3**	**Mean**
N0	8.55	10.56	9.46	10.24	9.70	87.26	95.52	94.91	94.26	92.99	18.55	19.33	18.45	18.32	18.66
N1	13.19	14.17	12.08	12.60	13.01	114.76	120.11	118.76	117.76	117.85	23.07	24.72	23.44	24.59	23.96
N2	9.80	11.35	9.33	10.22	10.17	97.26	103.44	101.94	100.76	100.85	19.38	20.10	19.53	19.57	19.64
N3	11.81	13.10	12.08	12.33	12.33	106.25	112.60	110.75	111.25	110.21	21.36	22.91	21.89	22.26	22.10
N4	12.06	13.68	13.03	13.19	12.99	103.02	117.52	115.69	107.02	110.81	21.89	23.36	22.46	22.66	22.59
N5	9.56	11.18	10.17	10.11	10.25	93.76	102.15	94.26	97.76	96.98	18.47	20.48	20.38	19.49	19.70
N6	12.12	13.65	11.67	13.12	12.64	113.94	116.93	112.26	111.26	113.60	22.23	23.60	22.75	23.70	23.07
Mean	11.01	12.52	11.11	11.68	11.58	102.32	109.75	106.94	105.72	106.18	20.71	22.07	21.27	21.51	21.39
	N		**M**		**N x M**	**N**		**M**		**N x M**	**N**		**M**		**N x M**
S.E.±	0.62		0.47		1.24	4.28		3.24		8.57	0.73		0.55		1.46
C.D.@ 5%	1.80		NS		NS	12.43		NS		NS	2.12		NS		NS

Table 4: Effect of different nitrogen and mitigation sources on the yield (q ha^{-1}) of rice.

Treatments	2022					2023				
Grain Yield										
	M0	**M1**	**M2**	**M3**	**Mean**	**M0**	**M1**	**M2**	**M3**	**Mean**
N0	31.35	32.71	31.93	32.00	32.00	30.36	32.80	31.55	32.45	31.79
N1	45.29	47.48	45.64	46.22	46.16	44.47	46.06	45.86	44.92	45.33
N2	32.24	34.06	32.94	33.97	33.30	30.96	33.35	32.33	32.41	32.26
N3	40.70	43.90	42.76	42.92	42.57	42.36	43.08	43.71	41.42	42.64
N4	42.17	44.78	43.50	44.14	43.65	43.41	44.92	43.97	44.41	44.17
N5	32.95	34.18	33.42	33.29	33.46	32.91	34.52	33.43	33.91	33.69
N6	42.82	45.48	42.00	42.82	43.28	42.40	44.97	42.91	44.20	43.62
Mean	38.22	40.37	38.88	39.34	39.20	38.12	39.95	39.11	39.10	39.07
	N		**M**		**N x M**	**N**		**M**		**N x M**
S.E.±	1.19		0.90		2.37	0.69		0.52		1.38
C.D.@ 5%	3.44		NS		NS	2.01		NS		NS
Straw Yield										
Treatments	**2022**					**2023**				
	M0	**M1**	**M2**	**M3**	**Mean**	**M0**	**M1**	**M2**	**M3**	**Mean**
N0	37.26	39.54	38.77	38.40	38.49	37.42	39.42	37.39	38.39	38.15
N1	57.06	59.63	58.68	57.80	58.29	53.73	55.35	53.56	54.96	54.40
N2	36.91	39.31	38.08	39.43	38.43	38.26	39.86	39.13	39.21	39.11
N3	50.02	54.17	51.34	52.21	51.93	50.38	52.80	50.81	51.65	51.41
N4	51.81	54.19	52.76	53.85	53.15	52.29	54.08	53.28	53.65	53.33
N5	37.98	38.97	38.88	39.91	38.94	38.05	39.92	38.67	39.52	39.04
N6	51.08	55.46	51.50	52.02	52.52	51.73	53.40	52.64	53.26	52.76
Mean	46.02	48.75	47.15	47.66	47.39	45.98	47.83	46.50	47.23	46.89
	N		**M**		**N x M**	**N**		**M**		**N x M**
S.E.±	1.27		0.96		2.55	1.02		0.77		2.03
C.D.@ 5%	3.70		NS		NS	2.95		NS		NS

Conclusion

It is concluded from the experimental findings that, plant height, number of tillers, number of panicle, number of grains per panicle and length of panicle of rice as well grain and straw yield of rice significantly enhanced by application of 100 kg N ha^{-1} through urea. The number of tillers of rice significantly increased by application of orthosilicic acid 0.08% @ 15 kg ha^{-1}.

References

1. Detmann KC, Araujo WL, Martins SC, Sanglard LM, Reis

JV, Detmann E, Rodrigues FA, Nunes-Nesi A, Fernie AR, Damatta FM. Silicon nutrition increases grain yield and stimulates photosynthesis via enhanced mesophyll conductance in rice. Sci World J. 2012;2012:752462.
2. Guntzer F, Keller C, Meunier JD. Benefits of plant silicon for crops: a review. Agron Sustain Dev. 2012;32:201-213.
3. Islam MSh, Rahman F, Hossain ATMS. Effects of NPK briquette on rice (*Oryza sativa* L.) in tidal flooded ecosystem. Agriculturists. 2011;9(1):37-43.
4. Khandey N, Singh RS, Anurag S, Sengar S, Kumar R. Response of applied neem-coated urea on yield and yield attributing parameters of rice (*Oryza sativa* L.) in Vertisol. Int J Chem Stud. 2017;5(4):1671-1675.
5. Ma JF, Yamaji N. Functions and transport of silicon in plants. Cell Mol Life Sci. 2008;65:3049-3057.
6. Mohapatra AK, Jee RC. Response of lowland rice (*Oryza sativa*) to green manuring, levels and sources of phosphatic fertilizer in coastal Orissa. Indian J Agron. 1993;38(3):374-377.
7. Pati S, Saha S, Pal B, Saha B, Hazra GC. Soil application of silicon: effects on economic yield and nutrition of phosphorus, zinc and iron in rice (*Oryza sativa* L.). J Indian Soc Soil Sci. 2018;66(3):329-335.
8. Plaza C, Giannetta B, Fernández JM, López-de-Sá EG, Polo A, Gascó G, Méndez A, Zaccone C. Response of different soil organic matter pools to biochar and organic fertilizers. Agric Ecosyst Environ. 2016;225:150-159.
9. Reddy NCHP, Rao BB, Surekha K, Hussain SA. Transplanted rice as influenced by different enriched nitrogen sources: an economic appraisal. Int J Curr Microbiol Appl Sci. 2019;8(6):3229-3231.
10. Savant NK, Stangel PJ. Recent developments in urea briquette use for transplanted rice. Fert News. 1995;40:27-33.
11. Singh K, Singh R, Singh JP, Singh Y, Singh KK. Effect of levels and time of silicon application on growth, yield and uptake by rice (*Oryza sativa* L.). Indian J Agric Sci. 2006;76(7):410-413.
12. Singh S, Misal NB. Effect of different levels of organic and inorganic fertilizers on maize (*Zea mays* L.). Indian J Agric Res. 2022;56:562-566.
13. Sistani KR, Reddy KC, Kanyika W, Savant NK. Integration of rice crop residue into sustainable rice production system. J Plant Nutr. 1998;21(9):1855-1866.
14. Subbaiah S, Mitra BN. Effect of foliar spray of micronutrients on growth and yield of rice. Oryza. 1997;34:148-151.
15. Walekar AA, More SS, Kasture MC, Jadhav SC, Hole B, Rajemahadik VA, Bedase TJ. Effect of nutrient and beneficial sources on yield, nutrient content and uptake of rice. Pharma Innov J. 2022;11(1):1153-1160.
16. Wang SJ, Xia GM, Li YF, Wang WZ, Chi DC. Effects of biochar-based fertilizer and water stress on physiological characteristics and yield of peanut. Chin J Oil Crop Sci. 2017;39(6):827-833.