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Response of nitrogen and silicon levels on growth, yield and nutrient uptake of rice (*Oryza sativa* L.)

K.K. Singh*, Kalyan Singh, Raghavendra Singh, Yogeshwar Singh and C.S. Singh

Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221 005, Uttar Pradesh, India

ABSTRACT

A pot experiment was carried out during the wet seasons of 2000 and 2001 to study the response of semi-tall rice cv. Swarna to varying levels of nitrogen and silicon in Alfisols. The results revealed that application of 180 kg N ha^{-1} recorded significantly higher growth, yield attributes, yield and nutrient uptake as compared to lower levels of nitrogen. However, 180 kg and 150 kg N ha^{-1} were statistically at par. Application of silicon at 150 kg ha^{-1} significantly improved the growth and yield attributes and ultimately resulted in higher grain yield and nutrient uptake as compared to lower levels of silicon.

Key words: *Alfisols, rice yield, nitrogen, silicon, nutrient uptake*

Nitrogen is the major component for protein synthesis, photosynthesis and is also involved in many biochemical and physiological activities of plants. Its deficiency or excess may adversely affect these processes and reduce crop yield. The recovery of applied nitrogen in field experiments has been found to vary from 28 to 34% for rice (Savant and De Datta, 1982). The nitrogen use efficiency can be significantly improved by application of other nutrients having synergistic effect with nitrogen uptake. Apparently applied Si seems to interact favourably with other applied fertilizer nutrients (N, P and K) and offers the potential to improve their physiological performance and efficiency in terms of yield response. Application of nitrogen with silicon has been found to raise the optimum nitrogen level from its existing level due to its synergistic effect (Ho *et al.*, 1980). Silicon has several potential benefits and its sufficient supply in soil is required for healthy growth and high productivity in rice crop. It improves the ability of crop to resist or tolerate the biotic stresses, such as attack of insect, pests and fungal disease (Datnoff *et al*., 1997) and abiotic stresses like toxicity of soil with Al, Fe, Mn (Sistani *et al.,* 1997) and excessive salts (Savant *et al*., 1999). Furthermore, its application reduces the cuticular transpiration and provides strength to crop against lodging caused by excessive N supply (Savant *et al.,* 1997). An attempt is made to obtain the optimum rate of nitrogen and silicon application on growth, yield and nutrient uptake of rice.

MATERIALS AND METHODS

Pot experiment was conducted during the wet seasons of 2000 and 2001 at the Institute Research Farm. The experimental soil was *Alfisols* having pH 6.3, organic carbon 0.51%, Ec 0.33 dsm^{-1} at 25^{0} C, in available phosphorus (9.10 kg ha^{-1}), available nitrogen (267.2 kg ha^{-1}) and available potassium (233.5 kg ha^{-1}) with high available silicon content (269.8 kg ha^{-1}). Medium sized pots (45 cm X 30 cm) were used for growing the plants and each pot was filled with 10 kg of air-dried and cleaned soil. The experiment was replicated thrice with 20 treatment combinations of five nitrogen levels (60, 90, 120, 150 and 180 kg N ha^{-1}) and four silicon levels (0, 50, 100 and 150 kg Si ha^{-1}). The nutrients were supplied through urea, single super phosphate and muriate of potash while requisite quantity of silicon was met through calcium silicate. The full doses of P_2O_5, K_2O at 60 kg ha^{-1} each, silicon and half dose of nitrogen was applied as basal while the remaining nitrogen was applied in two equal splits *i.e.* at tillering and panicle initiation stages. Thirty days old seedling of rice *cv.* Swarna was transplanted in puddled pot soil with two seedlings hill^{-1} and five hills were maintained in each pot. The soil in the pot was kept in a water-saturated state until seedling establishment and other agronomic management practices were followed. The leaf area index was worked out as per the method suggested by Gomez (1972). Nitrogen content in plant sample was determined by micro Kjeldahl's method (Jackson, 1973). The silicon content in plant sample was determined by autoclave induced digestion for colorimetric determination method (Elliot and Snyder, 1991). Nitrogen and silicon uptake by rice was determined by multiplying their respective chemical concentration with dry matter and yield.

RESULTS AND DISCUSSIONS

Growth characters. Nitrogen application induced significant variation in the crop growth attributes *viz.* plant height, tiller number and leaf area index and dry matter production (Table 1). Higher nitrogen level (180 kg ha^{-1}) manifested significant increase in tillers number. While, significant improvement in plant height and leaf area index was registered upto 150 kg N ha^{-1} and increment in nitrogen level beyond 150 kg N ha^{-1} did not show any significant improvement in neither plant height not leaf area index. Dry matter production in plant also increased significantly with each increment in nitrogen level (Fig.1 and 2) and the maximum dry matter assimilation was observed with 180 kg N ha^{-1}. The increase in dry matter production due to nitrogen application might be due to increased chlorophyll formation which ultimately improved photosynthesis (Dikshit and Paliwal, 1989).

Different silicon levels also showed significant improvement in all growth characters i.e. plant height, tiller number, LAI and dry matter production of rice (Table 1) and the maximum value of these growth characters was associated with the highest level of silicon application (150 kg Si ha^{-1}). The enhanced vegetative growth with higher silicon levels might be

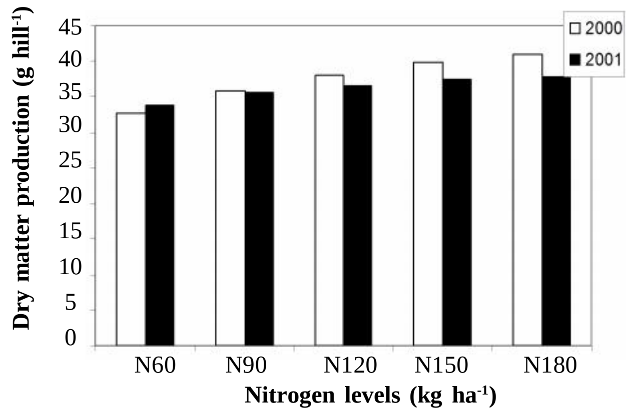

Fig.1. Effect of nitrogen on dry matter production of rice

Table 1. Performance of rice as influenced by nitrogen and silicon levels (pooled data)

Treatments	Growth attributes			Yield attributes			Yield	
	Plant height (cm)	Tiller hill^{-1} (No.)	Leaf area index	Productive tiller (hill^{-1})	Panicle weight (g)	Grains panicle^{-1}	Grain yield (g hill^{-1})	Strawyield (g hill^{-1})
Nitrogen levels (kg ha^{-1})								
N_{60}	72.90	10.38	2.82	9.96	1.89	104.1	15.4	22.1
N_{90}	75.90	11.75	3.62	11.00	1.94	108.9	17.5	23.2
N_{120}	77.45	12.25	3.76	11.76	1.97	117.7	19.1	24.1
N_{150}	78.67	12.90	4.48	12.38	2.01	119.2	20.4	24.9
N_{180}	79.30	13.24	4.54	12.91	2.03	123.9	20.6	25.3
SEm±	0.25	0.11	0.08	0.12	0.01	0.83	0.11	0.14
CD (P=0.05)	0.70	0.30	0.22	0.33	0.04	2.33	0.31	0.41
Silicon levels (kg ha^{-1})								
Si_{0}	73.48	10.40	3.22	10.13	1.84	105.5	16.8	22.5
Si_{50}	76.03	11.61	3.43	11.15	1.93	113.0	18.2	23.4
Si_{100}	78.01	12.71	4.05	12.15	2.02	117.3	19.2	24.4
Si_{150}	79.86	13.69	4.59	12.99	2.08	123.3	20.2	25.4
SEm±	0.15	0.06	0.05	0.07	0.01	0.50	0.07	0.09
CD (P=0.05)	0.42	0.18	0.13	0.20	0.02	1.40	0.18	0.24

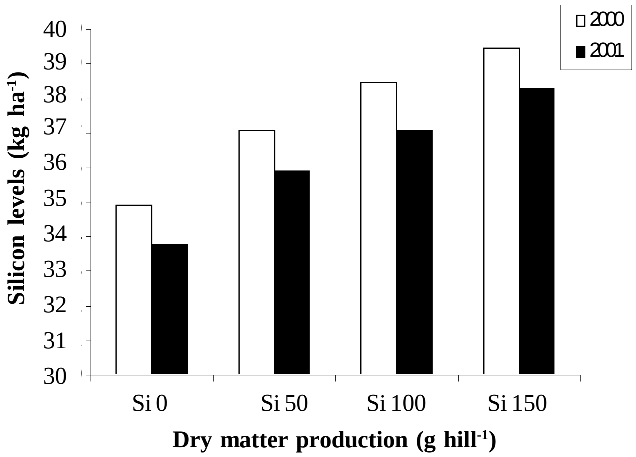

Fig.2. Effect of silicon on dry matter production of rice

the result of leaf erectness which facilitated better penetration of sunlight leading to increase in photosynthetic activity of plant and more formation of carbohydrate (Ma *et al.*, 1989) and better growth and development of plants. It was also reported that higher dry matter production with Si application may be due to higher photosynthesizing area resulting in enhanced photosynthetic activity (Rani *et al*., 1997).

Yield attributes and yield. Highly significant differences in yield attributing characters were observed due to nitrogen application. The yield attributes *i.e.* productive tillers number, grains panicle^{-1}and panicle weight markedly increased with increasing nitrogen levels up to 180 kg N ha^{-1} (Table 1). The nitrogen levels failed to show any significant effect on test weight. Supply of nitrogen enabled rice plant to assimilate sufficient photosyntheates resulting in increased dry matter production and these together produced more panicles and more number of filled grains (Jaiswal and Singh, 2001) leading to higher grain yield (Table 2). Significant response of nitrogen application was obtained in grain yield upto 150 kg N ha^{-1}. Similarly, straw yield also increased significantly with increasing nitrogen level up to 150 kg ha^{-1}. The higher straw yield was the result of better vegetative growth *viz*. leaf number, tiller number and final plant stand.

Silicon application significantly increased all the yield attributing characters of rice except the test weight. As the silicon level increased the productive tillers and grains panicle^{-1} were also increased correspondingly and the highest values of all these traits were found at 150 kg Si ha^{-1}. Similar findings were also corroborated by Zhu *et al.* (1999). Grain and straw yield of crop are resultant effect of yield attributing traits and similarly, the yield was also increased with increasing silicon level being highest at 150 kg Si ha^{-1}.

Table 2. **Yield of rice as influenced by nitrogen and silicon levels (pooled data)**

Treatments	Yields (g hill^{-1})		Nutrient uptake (mg hill^{-1})			
			Nitrogen		Silicon	
	Grain	Straw	Grain	Straw	Grain	Straw
Nitrogen levels (kg ha^{-1})						
N_{60}	15.44	22.09	20.83	11.74	18.22	57.03
N_{90}	17.50	23.24	23.96	12.56	20.66	64.72
N_{120}	19.05	24.11	26.11	13.09	22.58	67.65
N_{150}	20.42	24.89	28.12	13.62	24.21	70.26
N_{180}	20.58	25.32	28.42	13.86	24.79	71.28
SEm±	0.11	0.14	0.15	0.09	0.13	0.60
CD (P=0.05)	0.31	0.41	0.43	0.25	0.36	1.68
Silicon levels (kg ha^{-1})						
Si_{0}	16.80	22.52	22.28	11.75	19.71	58.35
Si_{50}	18.16	23.44	24.93	12.77	21.46	64.96
Si_{100}	19.21	24.39	26.62	13.37	22.89	69.07
Si_{150}	20.20	25.38	28.10	13.99	24.30	72.39
SEm±	0.07	0.09	0.09	0.05	0.08	0.36
CD (P=0.05)	0.18	0.24	0.26	0.15	0.22	1.01

The increase in yield was might be due more utilization of solar radiation, moisture and nutrients since silicon provides more erectness in rice plant for efficient utilization of solar radiation (Rani *et al*., 1997).

Uptake of N and Si in rice. Nitrogen uptake by grain and straw as well as total uptake by biological produce significantly increased with increasing nitrogen level up to 150 kg ha^{-1} (Table 2). However, 180 kg and 150 kg N ha^{-1} were statistically at par in respect of nitrogen uptake by grain and straw. Similar findings were also reported by Saravanam and Manickam (1994) in rice crop. Silicon uptake by grain and straw was also significantly influenced by nitrogen application and maximum uptake was associated with the application of highest nitrogen level i.e. 180 kg ha^{-1}.

Silicon levels also influenced the nitrogen uptake by grain and straw up to the highest level (150 kg Si ha^{-1}) which might be due to synergistic effect of silicon with other nutrients. Silicon uptake by grain and straw were also significantly increased with increasing silicon levels and maximum uptake was associated with 150 kg Si ha^{-1}.

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