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YIELD AND UPTAKE OF NUTRIENTS IN RICE AS AFFECTED BY SILICON AND BORON NUTRITION

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ABSTRACT

A field experiment was conducted at College of Agriculture, Padannakkad, Kasaragod, Kerala, during the kharif season of 2013 to study the yield and uptake of nutrients in rice as affected by silicon and boron nutritionin on laterite soils. The experiment was laid out in randomised block design replicated thrice with nine treatments using Aishwarya as the test variety. The results revealed that the three folia sprays of potassium silicate @ 0.5% and borax 0.5% were more effective in improving the content and uptake of nutrients compared to soil application of silicon and boron. The Fe content in straw (136 mg kg^{-1}) and grain (137 mg kg^{-1}) decreased with application of silicon while Fe uptake in plant alone was significantly increased. Application of three sprays of silicon and boron proved significantly superior with respect to plant height (90 cm), number of productive tillers plant^{-1} (17.33), thousand grain weight (30.70g), grain (6.54 t ha^{-1}) and straw (4.95 t ha^{-1}) yield of rice. Application of Si and B significantly improved the uptake of nutrients by crop, grain and straw yield of rice over control. Available B and Si in post harvest soil increased with their application over control.

Key words: Silicon, boron, rice, nutrient uptake, iron, yield

INTRODUCTION

Rice (*Oryzasativa*L.) is the most important food grain in India contributing 41.5% to the total food grain production. Rice yields are decelerating / stagnating / declining in post green revolution era mainly due to imbalance in fertilizer use, soil degradation, lack of suitable rice genotypes for low moisture adaptability and disease resistance. Crop production in laterite soils has been found to be low due to several constraints. However, there is considerable scope for improving the productivity of these acid soils through proper land management.The prevailing form of silicon in soil solution is monosilicic acid (H_4SiO_4). Iron and aluminum oxides of soil have the capacity to adsorb a considerable amount of silicon (Si) on their surfaces.Aluminum oxides are more effective in binding silicon through adsorption mechanism than iron oxides. Silicon (Si) is the second most abundant element in soil. Si is assimilated by plant roots as monosilicic acid (H_4SiO_4) (Epstein, 1999). Rice is a high silicon accumulating plant. Silicon is a beneficial element for plant growth and is agronomically essential for improving and sustaining rice productivity. Besides rice yield increase, Si has many fold advantages of increasing nutrient availability (N, P, K, Ca and Zn) and minimizing biotic and abiotic stress in plants. Hence the application of Si to soil or plant is practically useful in laterite derived paddy soils. Ahmad *et al.* (2013) reported that application of Si fertilizers enhanced the growth parameters, increased yield, yield attributes and quality of rice crop.The boron requirement is much higher for reproductive growth than for vegetative growth in most plant species. Boron uptake correlated well with the concentration of H_3BO_3 in soil solution. Boron is immobile in plant, deficiency symptoms of B in rice begin with a whitish discoloration and twisting of new leaves. Barman *et al.* (2014) observed that application of boron significantly increased N, P, K, Ca, Mg, S and Zn content in soil due to application of boron. The application of boron through different sources either through soil or foliar spray was found to be beneficial in stimulating plant growth and in increasing yield of rice (Rao *et al.,* 2013). With this background, the present study on the yield and uptake of nutrients in rice as affected by silicon and boron nutritionin laterite soilswas carried out.

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MATERIALS AND METHODS

The field experiment was laid out in farmer's field at Padannakkad. It is geographically located at12.2°N latitude, 75.1°E longitude and at an altitude of 16 m above mean sea level, having a humid tropical climate. The experimental soil was sandy loam belonging to the taxonomical order Inceptisol, having pH 4.7, EC 0.12 dSm-1, CEC 7.25 c mol (p+) kg-1, organic carbon 3.3 g kg^{-1}, available nitrogen 220.8 kg ha-1, available P2O5 61.6 kg ha-1, available K_2O 58.5 kg ha^{-1}, available Ca 261.7 mg kg^{-1}, available Fe 144.2 mg kg^{-1}, available Cu 1.26 mg kg^{-1}, available Zn 2.65 mg kg^{-1}, available B 0.16 mg kg^{-1} and available Si 20.5 mg kg^{-1}. The experiment was laid out in randomized block design replicated thrice with the test crop of rice variety Aishwarya. There were 9 treatments *viz.,*T_1- control, T_2 - 100 kg calcium silicate ha^{-1},T_3 - potassium silicate @ 0.5% spray,T_4 - 10 kg borax ha^{-1}, T_5 - borax 0.5 % 3 foliar sprays,T_6 - 100 kg calcium silicate ha^{-1} + 10 kg borax ha^{-1}, T_7 - 100 kg calcium silicate ha^{-1} + borax 0.5% sprays , T_8 - Potassium silicate @ 0.5% sprays + borax 0.5% sprays, T_9 - potassium silicate @ 0.5% sprays + 10 kg borax ha^{-1}.Nitrogen, P and K fertilizers were applied as per package of practices recommendations.. Straw and grain samples were analysed for N by Kjeldahl method. (Jackson, 1973).Phosphorus was analysed in di acid digest by vanadomolybdate yellow colour method, K by flame photometer, and Ca (Issac and Kerber, 1971) Fe, Cu and Zn on atomic absorptions spectrophotometer. Boron was analysed by azomethine-H colorimetric method (Bingam, 1982) and Si by blue silicomolybdous acid method (Ma *et al.,* 2002). Biometric observations *viz.,* plant height, number of productive tillers $plant^{-1}$, thousand grains weight, grain and straw yields were recorded at maturity. The results obtained were statistically analysed using statistical analysis software (SAS).

RESULTS AND DISCUSSION

Growth and Yield

The three sprayings of 0.5 % silicon + 0.5 % boron (T_8) recorded maximum plant height (90 cm) and number of productive tillers $plant^{-1}$ (17.33). The test weight of 30.70 g and grain yield of 4.94 t ha^{-1} were obtained in the treatment receiving three sprayings of 0.5 % silicon + 0.5 % boron (Table 1). In case of straw yield (6.57 t ha^{-1}), the treatment receiving 100 kg calcium silicate ha^{-1} + 10 kg borax ha^{-1} was superior to other treatments. The tune of increase in grain yield due to T_8 treatment was 1.90 t ha^{-1}(Table 1). This can be attributed to the significant increase in available nutrients and positive influence on the availability and uptake of nutrients as reported by Gholami and Falah (2013); Ahmad *et al.* (2013); Nagula *et al.* (2015).

Table 1: Effect of silicon and boron on yield and yield attributes of rice

Treatment	Plant height (cm)	Productive tillers $plant^{-1}$	Thousand grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	74.66	12.00	20.96	3.05	4.75
T_2	84.66	15.33	30.20	4.61	6.17
T_3	80.66	14.66	29.30	4.25	6.20
T_4	85.73	14.00	29.90	3.50	6.00
T_5	83.33	14.66	29.53	3.52	6.04
T_6	87.00	16.00	30.30	4.76	6.57
T_7	82.33	14.33	29.63	3.54	6.33
T_8	90.00	17.33	30.70	4.95	6.54
T_9	85.33	15.00	29.86	4.00	6.22
CD (P=0.05)	2.71	2.34	1.57	0.09	0.41

Available nutrients

Application of 100 kg calcium silicate ha^{-1} + 10 kg borax ha^{-1} (T_6) increased available Si content (27.08 mg kg^{-1}) in soil at harvest stage (Table 2) over control. Application of calcium silicate prevailed in soil as monosilicic acid (H_4SiO_4) and enhanced soil silicon availability (Singh *et al.,* 2006). Available boron (0.30mgkg^{-1})

in soil at harvest stage, increased with soil application of 10 kg borax ha^{-1}(T_4) over control (Table 2). Therefore after meeting the requirement of the crop, the added boron might have helped to increase the boron status of the soil from the deficiency to sufficiency level. These finding are in line with those reported by Nagula *et al.* (2015). The lowest amounts of available Si and B were recorded under control.

Table 2: Silicon and boron content in soil at harvest stage of rice

Treatment	Silicon (mg kg^{-1})	Boron (mg kg^{-1})
T_1	16.66	0.19
T_2	24.00	0.24
T_3	23.91	0.22
T_4	19.58	0.30
T_5	18.33	0.25
T_6	27.08	0.28
T_7	25.00	0.22
T_8	23.00	0.24
T_9	21.16	0.25
CD (P=0.05)	5.09	0.02

Uptake of nutrients

Total uptake (180.2 kg ha^{-1}) of N was maximum with, 100 kg calcium silicate ha^{-1} + 10kg borax ha^{-1}(T_6) (Table 3). This might have naturally resulted in enhanced absorption of N by the crop ultimately leading to higher N uptake. Similar results have also been reported by Singh *et al.* (2006) and Barman *et al.* (2014). The sprayings of potassium silicate @ 0.5 % + borax 0.5 % (T_8) resulted in significantly higher total uptake of P (37.1 kg ha^{-1}). The higher uptake of P under this treatment may be due to better absorption of P by plant and higher yield of rice grain and straw. Similar results were reported by Ma and Takahashi (1990). The sprayings of Si and B increased total uptake (258.7 kg ha^{-1}) of K over control. The sprays of potassium silicate @ 0.5 % + borax 0.5 % (T_8) was superior in terms of total uptake of Ca (18.7 kg ha^{-1}) This increase may be ascribed in enhanced absorption of calcium along with yields (Cachorro *et al.* 1994).The treatment receiving 100 kg calcium silicate ha^{-1}(T_3) produced significantly higher total uptake of iron (3.25 kg ha^{-1}) compared to the other treatments (Table 2). Similar results were reported by Qiang *et al.,* (2012).The results revealed a significant increase in and total uptake of Zn and Cu in crop (Table 2) with potassium silicate @ 0.5 % spray + borax 0.5 % spray.

Table 3.Effect of silicon and boron on total nutrient uptake by rice crop (kg ha^{-1})

Treatments	N	P	K	Ca	Fe	Zn	Cu	Si	B
T_1	69.4	10.6	138.1	11.6	2.76	0.19	0.37	125.6	0.018
T_2	146.9	21.5	229.9	15.8	3.25	0.43	0.41	377.4	0.032
T_3	147.0	21.1	211.3	16.7	3.16	0.30	0.45	448.4	0.032
T_4	123.9	18.0	193.2	15.6	3.24	0.27	0.38	253.5	0.044
T_5	120.8	18.5	186.5	16.0	3.24	0.28	0.38	259.9	0.042
T_6	180.2	23.5	248.1	16.5	2.96	0.38	0.46	352.5	0.044
T_7	153.3	20.7	216.0	15.3	2.74	0.33	0.41	310.1	0.039
T_8	175.8	37.1	258.7	18.7	2.94	0.45	0.49	362.5	0.047
T_9	151.9	22.1	228.0	16.9	2.80	0.42	0.44	298.0	0.041
CD (P=0.05)	6.8	5.5	13.0	1.0	0.19	NS	NS	44.1	0.005

This increase may be associated with the above treatments which contributed to the higher uptake of Zn and Cu in the crop. These results also corroborate with the findings of Bhutto *et al.* 2013).The silicon nutrition of rice evaluated in terms of uptake was influenced by silicon fertilization as calcium silicate (soil application) and potassium silicate (foliar spray). Application of potassium silicate @ 0.5 % spray was superior to soil application of calcium silicate in respect of silicon uptake by the crop. Hence it can be presumed that the foliar application of potassium silicate (0.5%) resulted in better absorption and translocation of silicon compared to soil application of calcium silicate. These finding are in line with those reported by Singh *et al.* (2006).Soil application of boron (10 kg borax ha^{-1}) and foliar sprays (borax 0.5 % spray) showed significant increase in boron uptake in straw and grain over control. Application of potassium silicate @ 0.5 % spray + borax 0.5 % spray (T_8) was superior in terms of B uptake

(0.047 kg ha^{-1}) over other treatments. This is because the available boron content of soil also was increased from sub optimal level to the sufficiency level for the addition of borax as soil and foliar spray. Similar results were reported by Rakshit *et al.* (2002).

It may be concluded that spray application of potassium silicate @ 0.5 % spray + borax 0.5 % at 15 days interval significantly improved uptake of nutrients, grain and straw yield of rice in laterite soils.

REFERENCES

Ahmad, A., Afzal, M., Ahmad, A.U.H. and Tahir, M. (2013) Effect of foliar application of silicon on yield and quality of rice (*Oryzasativa* L.). *CeecetariAgronomice* **10**(3): 21-28.

Barman, M., Shukla, L.M., Datta, S.P. and Rattan, R.K. (2014) Effect of applied lime and boron on the availability of nutrients in an acid soil. *Journal of Plant Nutrition***37**: 357-373.

Bhutto, M.A., Maqsood, Z.T., Arif, S., Riazuddin, Iqbal, S., Mahmood, Q., Akhlaq, A., Bhutto, R., Moheyuddin, K., Mari, A.H., Panhwar, R.N. and Salahuddin, J. (2013) Effect of zinc and boron fertilizer application on uptake of some micronutrients into grain of rice varieties.*American-Eurasian Journal of Agricultural Environmental Sciences* **13**(8): 1034-1042.

Bingham, F.T. (1982) Boron. In: Page, A.L. (ed.), *Methods of soil analysis*. American Society of Agronomy, Madison, USA, 438p.

Cachorro, P., Ortiz, A. and Cerda, A. (1994) Implications of calcium nutrition on the response of *Phaseolus vulgaris* L. to salinity. *Plant and Soil* **159**: 205-212.

Epstein, E. (1999) Silicon. *Annual Review of Plant Physiology and Plant Molecular Biology* **50**: 641-644.

Gholami, Y. and Falah, A. (2013) Effect of different sources of silicon on dry matter production, yield and yield components of rice*. International Journal of Agriculture and Crop Science* **5** (3): 227-231.

Issac, R.A. and Kerber, J.D. (1971) Atomic absorption and flame photometry techniques and uses in soil, plant and water analysis. *In:*Walsh, L.M. (ed.), Instrumental methods for analysis of soil and plant tissue. *Soil Science Society America, Madison, USA,* pp. 17-37.

Jackson, M.L. (1973) *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi.

Lindsay, W. L. and Norvell, W. A. (1978) Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal* **42**: 421-448.

Ma, J. **F.**and Takahashi, E. (1990) The effect of silicic acid on rice in a P deficient soil. *Plant Soil* 126: 121-125.

Ma, J.F., Tamai, M., Ichii, M. and Wu, K. (2002) A rice mutant defective in active silicon uptake. *Journal of Plant Physiology* **130**: 2111-2117.

Nagula, S., Joseph, B. and Gladis, R. (2015) Effect of silicon and boron on nutrient status and yield of rice in laterite soils. *Annals of Plant and Soil Research* **17**(3): 299-302.

Qiang, F.Y., Hong, S., Ming, W.D. and Zheng, C.K. (2012) Silicon-mediated amelioration of Fe^{2+}toxicity in rice (*Oryzasativa*L.) roots. *Pedosphere* **22**(6): 795-802.

Rakshit, A.,Bhadoria, P. B. S.and Ghosh, D. (2002) Influence of boron on NPK uptake of rice (*Oryzasativa* L.) in acid alluvial soils of Coochbehar, West Bengal. *Environment and Ecology* **20**(1): 188-190.

Rao, P.R., Subrhamanyam, D., Sailaja, B., Singh, R.P., Ravichandran, V., Rao, G.V.S., Swain, P., Sharma, S.G., Saha, S., Nadaradjan, S., Reddy, P.J.R., Shukla, A., Dey, P.C., Patel, D.P., Ravichandran, S. and Voleti, S.R. (2013) Influence of boron on spikelet fertility under varied soil conditions in rice genotypes. *Journal of Plant Nutrition* **36**: 390-400.

Singh, K., Singh, R., Singh, J.P., Singh, Y. and Singh, K.K. (2006) Effect of level and time of silicon application on growth, yield and its uptake by rice. *Indian Journal of Agricultural sciences* **76**(7): 410-413.