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Effect of various silicon sources on growth attributes of rice at various growth stages in iron toxic laterite soils of Kerala

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Abstract
An experiment was carried out at the farmer's field in Kerala during *Kharif*, 2016 to evaluate different silicon sources on growth attributes of rice at various growth stages. Field was laid out in randomised block design with seven treatments and replicated three times. Different silicon sources viz., potassium silicate, fine silica, rock dust, rice husk ash were involved in the treatments and fertilizer application was done according to the recommended dose of fertilizers as per Kerala Agricultural University, Package of Practice. Silicon nutrition have shown significant influence on number of tillers plant^{-1} at all the growth stages and also on the plant height except at the maximum tillering stage. Among the treatments, fine silica @ 50 kg ha^{-1} + rice husk ash @ 250 kg ha^{-1}, has shown the better results with respect to number of tillers plant^{-1} & plant height.

Keywords: silicon, iron**,** aluminium, plant height, tillers, soil acidity

Introduction
Rice is the most vital staple food of Kerala, but the rice sector of the state is facing a drastic decrease in area and production because of several soil related constraints like Iron and Aluminium toxicity and high acidity of the soils of the state (Maneesh *et al.*, 2016) [5]. Majority of Kerala soils are lateritic in nature which need separate management package as these soils are low in Organic carbon, N and K, very low in Ca and Mg. The low nutrient status of the soil coupled with the iron and aluminium toxicities were main reasons behind the low productivity of rice in laterite soils of kerala mainly in lowland situations (GOK, 2016) [4]. Silicon (Si) is one of the abundant element in the earth's crust and it is also known to have several beneficial effects crop growth, especially for Poaceae crops like Rice (Devanur, 2015) [2]. Silicon nutrition in rice helps in improving plant growth and yield, imparts resistance several abiotic and biotic stresses (Epstein, 2001) [3]. Silicon is known to reduce the concentration of toxic elements like Fe, Al, other heavy metals in laterite derived paddy soils and also improve soil physical properties viz. pH, OC, EC and soil texture (Devanur, 2015) [2]. In high rainfall regions due to heavy weathering less resistant silicates release silica which will be rapidly leached out to nearby streams. Although Si is present in soil in large amounts, it‟s availability to plants is limited. Due to the desilication process, subtropical and tropical soils are generally low in plant available silicon would benefit from silicon fertilization (Korndorfer and Lepsch. Silicon does not form a constituent of any cellular components but primarily deposited on the walls of epidermis and vascular tissues conferring strength, rigidity and resistance to pests and diseases. Silicon nutrition also manages many abiotic stresses including physical stresses like lodging, drought, radiation, high temperature, freezing and chemical stresses like salt, metal toxicity and nutrient imbalance. Si management erect leaves can easily account for a 10 per cent increase in the photosynthesis of the canopy and consequently increase in yield. In continuous monocropping with high silicon accumulator species such as rice, the removal of Plant Available Silicon (PAS) can be superior than the supply via natural practises releasing it into the soil unless fertilized with silicon. Therefore, a continued supply of Silicon would be required predominantly for the healthy and productive development of plant during all growth stages (Savant *et al.*, 1997; Epstein, 2001) [3, 9]. With this background the present investigation was undertaken with an objective to assess see the affect of silicon nutrition in rice on soil physicochemical properties of laterite soils of Kerala.

Materials and Methods

The field study was carried out at farmer's field in Kerala, during *Kharif* 2016. The soil of the experimental site was sandy clay loam, acidic in nature (pH 4.50), high in OC (1.01%) and safe EC (0.10 dS m^{-1}). Several silicon sources viz., fine silica, rock dust, rice husk ash and potassium silicate are used along with recommended fertilizers. All treatments were supplied with similar recommended dose of fertilizers i.e. Lime @ 150 kg ha^{-1} + farm yard manure @ 5 t ha^{-1} + NPK @ 90:45:120 kg ha^{-1}. The treatments are, T_1: Fine silica @ 100 kg ha^{-1}; T_2: Fine silica @ 75 kg ha^{-1}+ rock dust @ 25 kg ha^{-1}; T_3 : Fine silica @ 75 kg ha^{-1}+ foliar application of K_2SiO_3 at maximum tillering stage @ 0.5%; T_4 : Fine silica @ 50 kg ha^{-1}+ rock dust @ 25 kg ha^{-1}+ foliar application of K_2SiO_3 at maximum tillering stage @ 0.5%; T_5: Fine silica @ 75 kg ha^{-1} + rice husk ash @ 125 kg ha^{-1}; T_6: Fine silica @ 50 kg ha^{-1} + rice husk ash @ 250kg $ha^{-1;}$ T_7: Fine silica @ 50 kg ha^{-1} + rice husk ash @ 125kg ha^{-1} + foliar application of potassium silicate at maximum tillering stage @ 0.5%**.** The experiment was laid out in randomized block design with seven treatments and three replications with each plot size of 5 m x 4 m using Rice variety Uma, which was transplanted during first week of July with a spacing of 20 x 15 cm. Silicon sources such as fine silica, rock dust, rice husk ash were applied basally as per treatments at transplanting, and foliar application of potassium silicate @ 0.5 % at maximum tillering stage. Soil samples were analysed for pH at every fortnight until the harvest. The initial soil and soil collected after the harvest were analysed for soil OC, EC and Soil texture. The data obtained were subjected to statistical analysis and were tested at five per cent level of significance to interpret the treatment differences.

Results and Discussion

1. Plant Height

The data with respect to plant height at maximum tillering, panicle initiation (PI) and at harvest are shown in Table 1. Effect of silicon nutrition on plant height was found significant at panicle initiation (PI) stage and at harvest. At both these stages, plant height was found to be the highest in T_6 (fine silica @ 50 kg ha^{-1} + rice husk ash @ 250 kg ha^{-1}), which might be due to gradual and steady supply of sufficient quantity of silicon from the two silicon sources *viz.* rice husk ash and fine silica. However this treatment was statistically on a par with all the other treatments, except $T_{2,}$ in which fine silica @ 75 kg ha^{-1} and rock dust @ 25 kg ha^{-1} were applied. Similar results have been reported by Gholami and Falah (2013), Sunilkumar (2000), Bhaskaran (2014) and Ahmad *et al.* (2013) in rice.

Table 1: Effect of silicon nutrition on plant height at maximum tillering, panicle initiation and harvest stage

Treatments	Plant height (cm)		
	Maximum tillering	Panicle initiation	Harvest
T_1	45.30	75.47	110.99
T_2	44.70	75.36	110.73
T_3	45.12	75.50	108.13
T_4	45.88	74.50	111.23
T_5	44.68	76.68	112.60
T_6	46.94	76.78	113.90
T_7	46.00	76.70	112.75
S E m±	1.920	0.842	1.349
CD (0.05)	NS	1.836	2.940

2. Number of tillers m^{-2}

The results of the statistical analysis of the data on number of tiller m^{-2} are given in Table 2. There was significant increase in the number of tillers m^{-2} with silicon application in rice at all growth stages. At tillering stage application, treatments receiving a combination of different sources of silicon *viz.* T_7 (fine silica @ 50 kg ha^{-1} + rice husk ash @ 125kg ha^{-1} + foliar application of potassium silicate at maximum tillering stage @ 0.5%), T_6 (fine silica @ 50 kg ha^{-1} + rice husk ash @ 250 kg ha^{-1}) and T_5 (fine silica @ 75 kg ha^{-1} + rice husk ash @ 125 kg ha^{-1}) were found to be as effective as silicon supplied as single source as fine silica (T_1) in increasing tiller number. However as the crop reached PI and harvest stage, only the treatments wherein different sources of silicon were combined {T_6, T_7, T_5 and T_4 (fine silica @ 50 kg ha^{-1}+ rock dust @ 25 kg ha^{-1}+ foliar application of potassium silicate at maximum tillering stage @ 0.5%)} were found to be effective in enhancing tiller number. The higher number of tillers at later stages of crop growth might be due to the higher silicon availability to plants through the various sources of silicon. This is in confirmative with the findings of Savant *et al.* (1997a) [9] and Singh and Singh (2005). Silicon fertilization increased the number of tillers, when applied at transplanting stage (IRRI, 1965; Burbey *et al.,* 1988). Pawar and Hegde (1978) also observed that foliar spray of 100-400 ppm silicon applied twice per week to rice up to the booting stage increased tillering, vegetative growth and photosynthetic efficiency.

Table 2: Effect of silicon nutrition on number of tillers at maximum tillering, panicle initiation and harvest stage

Treatments	Number of tillers m^{-2}		
	Maximum tillering	Panicle initiation	Harvest
T_1	273	594	464
T_2	252	569	439
T_3	263	589	461
T_4	265	609	473
T_5	275	651	479
T_6	285	657	488
T_7	281	654	484
S E m±	8.5	24.8	7.97
CD (0.05)	18.638	54.104	17.372

Conclusion

The toxicities of iron and aluminium, high soil acidity together with de-silication are common in laterite soils of Kerala, which is one of the main reason behind the poor productivity of rice. The results of this study emphasized that, in view of the growth attributes of rice at various growth stages, application of fine silica @ 50 kg ha^{-1} + rice husk ash @ 250 kg ha^{-1} was found to be effective package for increasing plant height and number of tillers per plant in iron toxic laterite soils, along with the present KAU Package of Practices recommendation of lime @ 150 kg ha^{-1} + farm yard manure @ 5 t ha^{-1} + NPK @ 90:45:120 kg ha^{-1}.

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