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# Effect of silicon on soil physicochemical properties in laterite derived paddy soils of Kerala

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**Abstract**
A field experiment was conducted during *Kharif*, 2016 at the farmer's field in Kerala, to evaluate various sources of silicon on soil pH, Organic carbon (OC), Electrical conductivity (EC) and Soil texture. Experiment was laid out in randomised block design replicated thrice with seven treatments using Uma as the test variety. The initial soil pH, OC, EC and soil texture of the field were of 4.5, 1.01%, 0.10 dS $m^{-1}$ and sandy clay loam. The treatments comprised of silicon sources viz., fine silica, rock dust, rice husk ash and potassium silicate, along with the recommended dose of fertilizers as per Kerala Agricultural University, Package of Practice. Silicon nutrition increased soil pH and OC content in soil after the experiment but have not shown significant influence on EC and soil texture. Among the treatments, recommended dose of NPK kg $ha^{-1}$ + fine silica @ 50 kg $ha^{-1}$ + rice husk ash @ 250 kg $ha^{-1}$, has shown the better results with respect to soil pH and OC.

**Keywords:** Silicon, iron**,** aluminium, laterite soils, rice, soil acidity, organic carbon, texture

## Introduction
Rice is the most vital staple food of Kerala. For the past few years, there was a drastic decrease in area and production of rice due to multitude of problems. The main problem so far to be addressed in detail is soil associated constraints (Maneesh *et al.*, 2016) [5] About 65 per cent of Kerala soils are lateritic in nature which require distinct management package as these soils are low to medium in Organic carbon (OC), N and K, very low in Ca and Mg. In addition to low fertile soils, high acidity, Iron and Aluminimum toxicities are other important soil linked constraints in laterite soils of Kerala, which were responsible for the poor crop productivity in iron toxic laterite soils, especially in lowland situation. (GOK, 2016) [4].
Silicon (Si) is the second most copious element in the earth's crust and it also acts as a beneficial element for crop growth, specifically for Poaceae crops like Rice (Devanur, 2015) [2]. Silicon nutrition in rice helps in enhancement of growth and yield, imparts resistance against lodging, abiotic and biotic stress (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 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) [9, 3]. 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

Soil Analysis after the Experiment

### Soil Reaction (pH)

The data on the soil reaction (pH) are presented in Table 1. Soil pH after the harvest of the crop increased compared to the initial status (4.50). However the soil pH at fortnightly intervals was not influenced significantly, except at 3rd fortnight and at harvest.

At 3rd fortnight, the highest soil pH of 5.84 was recorded by $T_6$ *i.e*, fine silica @ 50 kg $ha^{-1}$ + rice husk ash @ 250 kg $ha^{-1}$ and it was significantly superior to all other treatments. The lowest soil pH value of 5.35 was observed in $T_2$ *i.e*, fine silica @ 75 kg $ha^{-1}$+ rock dust @ 25 kg $ha^{-1}$, which was on a par with $T_7$ (fine silica @ 50 kg $ha^{-1}$ + rice husk ash @ 125 kg $ha^{-1}$ + foliar application of potassium silicate at maximum tillering stage @ 0.5%) and $T_1$ (fine silica @ 100 kg $ha^{-1}$). After the harvest, the highest soil pH was recorded in $T_7$ (5.71) and it was on a par with $T_6$ (5.68), $T_1$ (5.67), $T_5$ (fine silica @ 75 kg $ha^{-1}$ + rice husk ash @ 125 kg $ha^{-1}$) (5.66) and $T_3$ (fine silica @ 75 kg $ha^{-1}$+ foliar application of potassium silicate at maximum tillering stage @ 0.5%) (5.66). The lowest soil reaction value of 5.59 was observed in $T_2$, which was on a par with $T_4$ (fine silica @ 50 kg $ha^{-1}$+ rock dust @ 25 kg $ha^{-1}$+ foliar application of potassium silicate at maximum tillering stage @ 0.5%).

Soil reaction increased in all the treatments after the harvest compared to the initial value (4.50). This increase in soil reaction could be attributed to the fact that silicate materials can increase soil reaction and also help in correcting soil acidity by neutralizing exchangeable Fe, Al and Mn and other toxic elements (Yadav *et al.*, 2017; Sandhya, 2013) [7, 10]. These results were also in line with that reported by Wallace (1993) [11] and Qiang *et al.* (2012) [8].

**Table 1:** Effect of silicon nutrition on soil reaction (pH) at fortnightly intervals

| Treatments | Soil reaction (pH) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st FT* | 2nd FT* | 3rd FT* | 4th FT* | 5th FT * | 6th FT* | 7th FT* | Harvest |
| $T_1$ | 6.58 | 6.50 | 5.55 | 5.70 | 5.43 | 5.41 | 5.47 | 5.67 |
| $T_2$ | 6.58 | 6.44 | 5.35 | 5.53 | 5.35 | 5.31 | 5.30 | 5.59 |
| $T_3$ | 6.63 | 6.25 | 5.63 | 5.66 | 5.39 | 5.39 | 5.56 | 5.66 |
| $T_4$ | 6.55 | 6.55 | 5.62 | 5.62 | 5.36 | 5.34 | 5.74 | 5.62 |
| $T_5$ | 6.55 | 6.39 | 5.57 | 5.65 | 5.32 | 5.37 | 5.49 | 5.66 |
| $T_6$ | 6.53 | 6.42 | 5.84 | 5.85 | 5.30 | 5.37 | 5.68 | 5.68 |
| $T_7$ | 6.60 | 6.57 | 5.45 | 5.80 | 5.41 | 5.34 | 5.78 | 5.71 |
| S E m± | 0.044 | 0.150 | 0.089 | 0.109 | 0.044 | 0.063 | 0.141 | 0.025 |
| CD (0.05) | NS | NS | 0.195 | NS | NS | NS | NS | 0.066 |

*Fortnight

### Organic Carbon (OC)

The data on organic carbon (OC) content of soil are presented in Table 2. The soil OC was found to vary significantly by silicon nutrition. The highest soil OC of 1.39 was recorded in the treatment $T_6$ *i.e*, fine silica @ 50 kg $ha^{-1}$ + rice husk ash @ 250 kg $ha^{-1}$ and it was on a par with $T_5$ (fine silica @ 75 kg $ha^{-1}$ + rice husk ash @ 125 kg $ha^{-1}$) and $T_7$ (fine silica @ 50 kg $ha^{-1}$ + rice husk ash @ 125kg $ha^{-1}$ + foliar application of potassium silicate at maximum tillering stage @ 0.5%) and significantly higher than all other treatments. The lowest value of 1.14 was observed in $T_4$ *i.e.* (fine silica @ 50 kg $ha^{-1}$+ rock dust @ 25 kg $ha^{-1}$+ foliar application of potassium silicate at maximum tillering stage @ 0.5%), and it was on a par with $T_1$ (fine silica @ 100 kg $ha^{-1}$), $T_2$ (fine silica @ 75 kg $ha^{-1}$+ rock dust @ 25 kg $ha^{-1}$) and $T_3$ (fine silica @ 75 kg $ha^{-1}$+ foliar application of foliar application at maximum tillering stage @ 0.5%). Treatments with rice husk ash ($T_5$, $T_6$, $T_7$) resulted in significant increase in organic carbon content in soil compared to the other treatments. The increase in soil organic carbon was due to the reason that organic materials like rice husk ash has direct impact on mineralization rate and increases soil carbon directly. This is in agreement with the findings of Njoku *et al.* (2011) [6] who observed the highest organic carbon content in the unburnt rice husk amended plots compared to the burnt rice husk ash.

### Electrical Conductivity

The data on electrical conductivity (EC) of soil after the harvest are given in Table 2. Silicon application in soil has not shown significant effect on soil electrical conductivity (EC), but there has been a slight increase in soil EC after the experiment. This might be attributed to submergence, increase in solubility of salts present in the soil and also due to the dissolution of silicon fertilizers as reported by Sandhya (2013) [10].

**Table 2:** Effect of silicon nutrition on Organic Carbon and Electrical conductivity in soil

| Treatments | Organic Carbon (%) | Electrical Conductivity (dS $m^{-1}$) |
|---|---|---|
| $T_1$ | 1.18 | 0.14 |
| $T_2$ | 1.18 | 0.14 |
| $T_3$ | 1.17 | 0.16 |
| $T_4$ | 1.14 | 0.13 |
| $T_5$ | 1.32 | 0.16 |
| $T_6$ | 1.39 | 0.14 |
| $T_7$ | 1.31 | 0.14 |
| S E m± | 0.051 | 0.000 |
| CD (0.05) | 0.113 | NS |

**Soil Texture**

The data on mechanical composition of soil are given in Table 3. There was no significant variation among treatments regarding mechanical composition of the soil, after the experiment. Initial soil texture and soil texture after the experiment are same i.e. Sandy clam loam. Silicon in soil increases soil reaction, slightly increases electrical conductance, improves physicochemical soil properties and maintains nutrients in plant available form but will not change soil texture (Devanur, 2015) [2]. Similar results have been reported by Berthelsen *et al.* (2003) [1].

**Table 3:** Effect of silicon nutrition on mechanical composition of soil

| Treatments | Sand (%) | Silt (%) | Clay (%) | Soil texture |
|---|---|---|---|---|
| $T_1$ | 51.50 | 5.70 | 43.20 | Sandy clay loam |
| $T_2$ | 53.93 | 5.16 | 41.13 | " |
| $T_3$ | 52.83 | 5.33 | 41.83 | " |
| $T_4$ | 52.33 | 5.33 | 42.33 | " |
| $T_5$ | 52.96 | 5.36 | 41.66 | " |
| $T_6$ | 53.83 | 5.06 | 41.10 | " |
| $T_7$ | 52.70 | 5.63 | 41.66 | " |
| S E m± | 0.876 | 0.346 | 0.687 | - |
| CD (0.05) | NS | NS | NS | NS |

**Conclusion**

The toxic build-up of Fe, Al, and high acidity together with silicon depletion are more common in tropical soils of Kerala leading to poor productivity of rice. The results of this experiment highlighted that, in view of the soil pH and OC, application of fine silica @ 50 kg $ha^{-1}$ + rice husk ash @ 250 kg $ha^{-1}$ was found to be effective package for correcting soil pH and improving soil OC 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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