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Silicon Nutrition in Rice

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Abstract

Silicon is the second most abundant element with a concentration of 27.6% both on earth crust and in the soil. Even though it is not categorized as essential element it plays a good role in stimulating the growth and development of many plant species. Beneficial role of Si is able to mitigate both biotic and abiotic stresses. It is well known that silicon (Si) is present in primary silicate minerals, secondary alumino silicates and various forms of SiO_2. Si is not found in Free State. It is a tetravalent (Si^{4+}) element. It occurs as the oxide silica, SiO_2 in various forms like quartz, agate and flint. Monosilicic acid $Si(OH)_4$, is the prevailing form in soil solution and it's concentrations in the soil solution are usually ranging from 14 to 20 mg/l of Si. Silicon reduces leaching of phosphorous (P), potassium (K) and it improves soil physical, chemical and biological properties, improved water holding capacity, improved soil texture and increased cationic exchange capacity.

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Introduction

Silicon has not considered as essential element, but is a beneficial element for crop growth, especially for poaceae crops. Silicon deficiency is seen in soils of long period of intensive crop cultivation and also in intensively cultivated rice fields after removal of rice straw from the field. Silicon in plants develops resistance against diseases, lodging, herbivores, metal toxicity, salinity stress, drought stress, temperature stress and it also enhances photosynthesis, growth and yield. It protect the plant from biotic stresses, stimulate active immune system in plants and it also neutralizes aluminium toxicity in acid soils. Therefore, a continued supply of this element would be required particularly for healthy and productive development of plant during all growth stages.

Role of Silicon in Rice

Rice is a high silicon accumulating plant. It helps for improving and sustaining rice productivity. Besides this yield increase, it increases the availability of nutrients (like Nitrogen, Phosphorous, Potassium, Calcium, and Magnesium), decreasing nutrient toxicity (Iron, Aluminium, and Manganese) and minimizing biotic and abiotic stress in plants. In wetland rice lacking Si, the vegetative growth and yield are drastically reduced and it shows the deficiency symptoms like wilting of plants, necrosis of older leaves, soft and droopy leaves and culms, increased occurrence of disease, reduction in the number of panicle and filled spikelet's per panicle, smaller grain yield, and lodging.

Monosilicic acid is the form of silicon translocated in rice xylem sap. The form of silicon in xylem sap was identified by Si-Nuclear Magnetic Resonance Spectroscopy (NMR). Song *et al.* (2009) reported that silicon could alleviate the toxicity of metals in metal-contaminated soils, such as aluminium, manganese, cadmium and zinc. Excessive iron uptake can indirectly prevented by silicon application because it enhances the oxidative power of rice roots, resulting in enhanced oxidation of Fe from ferrous iron to insoluble ferric iron (Qiang *et al*., 2012). Increase in level of applied silicon may enhance the number of productive tillers and total number of tillers m^{-2}. Gholami and Falah (2013) reported that application of Si fertilizers enhanced the plant height, number of tillers per plant and number of productive tillers in rice crop. Calcium silicate recommendation for rice is 120-200 kg/ha, potassium silicate recommendation for rice is 40-60 kg/ha, sodium silicate recommendation for rice is 100 kg/ha. In vegetative stage the silicon requirement is less compared to reproductive stages. The fruit or grain yields, malformation of newly formed leaves, wilting, and early senescence improved pollen viability are effected due to lack of Si supply. The sources of silicon as fertilizers or materials are listed in Tab.

Table 1: Silicon Containing Fertilizers or Materials

Name	Chemical formula	Content
Calcium silicate	$CaSi0_3$	14-19% Si, 20.2% Ca
Potassium silicate	K_2SiO_3	45% Si, 17% K
Sodium metasilicate	$NaSi0_3$	23% Si
Calcium silicate slag		
(By product of electric furnaces)	$CaSi0_3$	14-19% Si, 25-32% Ca
Fused magnesium phosphate	$MgSi0_3$	9% Si, 9% P,7-9% Mg
Rice husk	-	Variable (4.6-7.0)
Rice straw	-	Variable

Most of the effects of Si were expressed through Si deposition on the leaves, stems, and hulls. If more Si accumulated in the shoots, the larger will be the effect. Rice is typical silicon accumulating plant. It has the superior capacity to uptake silicon compared to other plants.

Conclusion

Silicon is not considered as an essential element it is categorized under beneficial element. It improves yield and enhances the strength and rigidity of cell walls therefore it provides resistance against both biotic and abiotic stresses. And thus increases the resistance of plants to various stresses. Future research on Si nutrition of plants in our crop production system should focus on quantitative improvement in resistance against several pest and diseases and salinity and water stresses.

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