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Role of Silicon as Beneficial Nutrient for Rice Crop

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Owing to several potential benefits in rice, sufficient supply of Si to rice crop can ensure healthy growth and better yield. Its beneficial effects on growth and yield, enhancing grain quality, alleviating the effects of abiotic stresses, etc have been reported. This article discusses in short about important role of silicon in rice crop.

Introduction

Silicon (Si) is the second most abundant element found in earth crust next to oxygen and in soil it exists mostly in the form of SiO_2 whose content ranges from 1 to 45% by dry weight. Generally sandy soils have more Si content (450 to 480 g Si kg^{-1}) compared to clay (200 to 350 g Si kg^{-1}) soils. Though the amount of silicon in soil is huge, only a small fraction is soluble and available for plant uptake. In many soils the available silicon content is enough to grow a "satisfactory crop" without external addition of silicon. However our farmers are not aware of the role of silicon for better crops with increased stress and disease resistance. Silicon will help healthier crops and higher yield which will indirectly reduce the use of plant protection chemicals. Without this awareness farmers are using more chemicals for controlling pest and diseases.

Silicon in Rice

Though all the plants contains Si in their tissues it is considered as plant nutrient "anomaly" because there is no evidence showing that Si is involved in the metabolism of plants, and not been recognized as an essential element. But many scientists proved the beneficial effect of Si on pest and disease control of plants, especially Si accumulators like Rice and Sugarcane. Silicon has several potential benefits and sufficient supply of Si to rice crop can ensure healthy growth and better yield. Moreover Si seems to interact favourably with other fertilizer nutrients like N, P and K and enhances their efficiency. Hence the scientists of Japan recognized Si as an "agronomically essential element" for rice, a typical Si-accumulating plant, as high accumulation of Si is required for optimal growth and sustainable production of rice. Silicic acid or ortho silicic acid ($Si(OH)_4$, or H_4SiO_4) are the soluble, plant available form of silicon in soils. Rice plant absorbs Si by the roots in the form of ortho silicic acid (H_4SiO_4) along with water and translocated to the shoots. In the shoot, with the loss of water through transpiration, silicic acid is concentrated and polymerized to silica (SiO_2) and finally deposited on the different tissues (Yoshida 1975).

Beneficial effects of silica in rice plants

- Silicon is considered as a beneficial element for plant growth. It helps the plants to overcome multiple stresses including biotic and abiotic stresses (Mitani and Ma, 2005)
- The cuticle-Si double layer can obstruct the penetration of disease causing organisms and acting as a modulator of host resistance. Datnoff *et al.,* 1997 reported the increased resistance for blast disease in rice crop due to Si content.
- The deposition of silica on epidermal layers offers a physical barrier to pests. Panda *et al*. (1977) found that the infestations of rice stem borer were markedly reduced by Si application.
- Silicon plays an effective role in preventing lodging of rice crop by increasing the thickness of the culm wall and the size of the vascular bundles thereby enhancing the strength of the stems
- It helps to enhance the grain quality in rice by reducing the number of blank spikelets per panicles (Mauad *et al.*,2003)
- Silica can reduces the transpiration loss through leaves and enhances the water-use efficiency of the crop and improves the tolerance of rice plants to water stress.
- Rice plants containing sufficient amount of Si will have stronger stems and improved leaf angle making the leaves more erect, thus enabling capture of more sunlight and subsequent increased rates of photosynthesis.
- Si reduces the availability of toxic elements such as manganese, iron and aluminum to roots of rice crop.
- Silicon also alleviates the effects of other abiotic stresses including salt stress, drought stress, radiation damage, nutrient imbalance, high temperature and freezing (Ma, 2004).

Source of Si

Si can be applied to soil as potassium, magnesium and calcium silicate both soil and foliar application. Calcium silicate products are the most commonly applied silicon fertilizers for field application. Steel mill slags are a rich source of calcium silicate. However, silicate slags are considered to be expensive Si sources so there is a need to find or develop cheaper and more efficient sources of Si. In general, silicon fertilizers should be applied to the soil or added to nutrient solutions. Foliar application of silicon fertilizers on plants is less effective when compared to soil application. Recycling of rice hulls and/or straw may be one possible alternative option in integrated nutrient management system. As rice leaf and stem generally contain 5-6% some times 2-10% Si depends on the Si status of the soil, and rice husk contains 10%, thus returning the crop residues back to the soil will help to replenish Si in the soil. These organic sources have residual activity that persists over long time which helps in reduced number of application. Increased soil biological activity associated with organic matter may improve to solubility of silicon from soils. Scientists isolated some Silica solubilizing *Bacillus spp* ie Silicate Solubilizing Bacteria (SSB) which can be used as biofertilizer for Si. The bacteria produces organic acids like citric acid, oxalic acid, keto acids and hydroxy carbolic

acids as part of its metabolism which form complexes with cations and make the silica available to the plant. Application of this SSB with organic manures will also enhance the availability of Si to the rice crop. Flyash is also considered to be a rich source of Si application of fly ash particularly in Si-deficient soils will improve the growth and yield of rice crop.

Conclusion

Role of Si in Rice plants are highly discernible when the plants are under stress conditions, whereas under favourable conditions its role is often minimal or even nonexistent. Hence it cannot be counted as essential nutrient. Rather, seeing the defensive roles of Si in the plants against all manner of adversities it may be considered as an inorganic secondary nutrient. Intensive cultivation tends to create Si deficiency in soils. The application of Si in soil amendments is needed for both optimized soil fertility and improved plant nutrition. Consequently there is a definite need to consider Si as an agronomically essential element for increasing and/or sustaining rice production. Sources of Si and their management practices should be developed and standardized for rice crop under different soil conditions.

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