International Journal of Chemical Studies 2017; 5(6): 1359-1361

International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(6): 1359-1361

Received: 15-09-2017
Accepted: 17-10-2017

Guntamukkala Babu Rao
PhD. Scholar. Department of Agronomy. Assam Agricultural University, Assam, India

Pusarla Susmitha
PhD. Scholar. Department of Seed Science and Technology. Anand Agricultural University, Gujarat, India

Correspondence
Guntamukkala Babu Rao
PhD. Scholar. Department of Agronomy. Assam Agricultural University, Assam, India

Silicon management in Rice

Guntamukkala Babu Rao and Pusarla Susmitha

Abstract
Silicon (Si) is considered as a beneficial element for crop growth, especially for crops under Poaceae family. Rice is a typical silicon accumulating plant and it benefits from silicon nutrition. Silicon is deposited beneath the cuticle as cuticle-silicon double layer in the form of silicic acid. Highly weathered soils are low in available silicon mainly due to leaching loss. Its supply is essential for healthy growth and economic yield of the rice crop. Silicon interacts favourably with other applied nutrients and improves their agronomic performance and efficiency in terms of yield response. Also it improves the tolerance of rice plants to abiotic and biotic stresses. Hence, silicon management is essential for increasing and sustaining rice productivity.

Keywords: Silicon, Rice, Biotic stress, Abiotic stress, Yield, Productivity

Introduction
Silicon (Si) is the second most abundant element in the earth's crust. It is a principal soil component lost during weathering and the conversions of Si to secondary minerals are most important mechanisms of soil formation. The amount of Si present in soils varies with the type of soils, climatic conditions, nature of rocks and minerals forming soils etc. In soil solutions, the prevailing form is mono silicic acid Si $(OH)_4$, which is in equilibrium with quartz (SiO_2) and the concentrations in the soil solution are usually ranging from 14 to 20 mg l^{-1} Si (Devanur, 2015) [3]. However, the Si concentration of plant shoots varies greatly among plant species, ranging from 0.1 to 10% Si on a dry weight basis. Si is not considered as an essential element, but is a beneficial element for crop growth, especially for Poaceae crops. Silica strengthens the plant, protects the plants against insect pests, increases crop production and quality, increases plant nutrition and neutralizes heavy metal toxicity in acid soils. Plants vary widely in their capacity to take up silicon. Due to continuous mono-cropping and/or intensive cultivation of cereal crops like rice, the soil Si concentration is depleted which can be the main reason for declined rice yields (Mali *et al.*, 2008) [7]. Chemical fertilizers, organic sources of Si can be used for silicon fertilization. Therefore, a continued supply of this element would be required particularly for the healthy and productive development of plant during all growth stages.

Silicon in Soils
In the soil solution, Si is present as Monosilicic acid and Polysilicic acid as well as complexes with organic and inorganic compounds such as aluminium oxides and hydroxides. While it is the PAS (plant available silicon) that is taken up by the plants and has a direct influence on crop growth. The solubility of Si in the soil is affected by a number of dynamic processes occurring in the soil including the particle size of the Si fertilizer, the soil acidity (pH), organic complexes, presence of aluminium, iron and phosphate ions, temperature and exchangeable/dissolution reactions. Si can be added via irrigation water and fertilization (Berthelsen *et al*., 2003) [1]. Si improves physical, chemical and biological properties of soil.

Role of Silicon in Rice
Rice is a high silicon accumulating plant and the plant is benefited from Si nutrition. Rice crop can uptake Silicon in the range of 230-470 kg ha^{-1}. Si 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, Mg, S, Zn), decreases nutrient toxicity (Fe, Mn, P, Al) and minimizing biotic and abiotic stress in plants (Ma *et al.*, 2008) [6].

Hence, the application of Si to soil or plant is practically useful in laterite derived paddy soils, not only to increase yield but also to alleviate the iron toxicity problems. Si increases the mechanical strength of the culm, thus reducing crop lodging (Savant *et al*., 1997) [11].

Silicon Deficiency

Si deficiency affects the development of strong leaves, stems, and roots and makes the rice plants susceptible to pests and diseases. Si deficiency is common in areas with poor soil fertility, and in old and degraded soils. Its deficiency also seen in organic soils with less Si reserves and also occurs in highly weathered soils in rainfed lowland and upland areas. The critical level of Si in soil is 40 mg kg^{-1} and the critical level of Si in rice (leaf and straw) is 5%.

Silicon deficiency leads to:

1. Soft and droopy leaves which cause lodging and mutual shading.
2. Reduced photosynthetic activity.
3. Reduced grain yields.
4. Increased occurrence of diseases such as blast.
5. Reduced number of panicles and filled spikelets per panicle (IRRI, 2016) [16].

Silicon Fertilizers

Rice is a known silicon accumulator and the plant is benefited from silicon nutrition. In 1955, silicon was first recognized as a fertilizer in Japan and since then 1.5-2.0 t ha^{-1} of silicate fertilizer have been applied to silicate deficient paddy soils. As a result, a 5-15% increase in rice yield has been reported by Savant *et al*. (1999) [12]. Silicon is absorbed as PAS (monosilicic acid) by rice plants in far larger quantities than the macronutrients, for example, silicon uptake is 108% greater than Nitrogen (N) uptake. A rice crop producing a yield of 5000 $kg.ha^{-1}$ removes 230-470 kg Si ha^{-1}. In continuous cropping with high silicon accumulator species such as sugarcane, the removal of PAS can be greater than the supply via natural processes releasing it into the soil unless fertilized with silicon (Savant *et al*, 1997; McGinnity, 2015) [11, 8].

1. Chemical fertilizers

Inorganic materials such as quartz, clays, micas, and feldspars, although rich in silicon, are poor silicon-fertilizer sources because of the low solubility of the silicon (Meharg *et al*., 2015) [9]. Calcium silicate, generally obtained as a by-product of an industrial procedure is one of the most widely used silicon fertilizers. Potassium silicate, though expensive, is highly soluble and can be used in hydroponic culture and also applied through foliage.

Table 1: Silicon containing fertilizers or materials

Name	Content
Calcium silicate	14-19% Si, 20.2%Ca
Potassium silicate	45%Si, 17%K
Sodium meta-silicate	23%Si
Fine silica	99%
Fused magnesium phosphate	20% Si, 20%P, 12% Mg

Table 2: Silicon Fertilizer recommendation for rice

Fertilizer	Recommended dose
Fine silica	100 kg ha^{-1}
Sodium silicate	250 kg ha^{-1} (foliar application: 4 ml/L)
Potassium silicate	40-60 kg ha^{-1} (foliar application: 5 ml/L)
Calcium silicate	120-200 kg ha^{-1}

2. Organic sources of Silicon

Silicon management agenda includes silicon fertilization and recycling of silicon in rice crop residues. Rice husk, rice husk ash and straw are organic sources of silicon (Sahebi *et al.*, 2015; Liang *et al.*, 2007) [13, 5]. Rice straw hauled away from rice fields and used for various purposes, such as animal feed/bedding, biogas production, or mushroom cultivation, may retain its nutrient value as a source of Si; thus the end products of these uses should be recycled. Composting of rice straw offers a potential way of recycling plant Si, because it reduces the bulk of straw to be handled. Silicon content in rice straw and rice husk ranges from 4-20% and 9-26% respectively.

3. Biofertilizer

Silicon solubilising bacteria (SSB) is a biological fertilizer based on a selected strain of naturally-occurring beneficial bacteria of the Bacillus genus isolated from a granite quarry. It is used as an effective soil inoculant. It solubilizes silica and provides the plant with strength to tolerate biotic and abiotic stresses and improves its resistance to pest and disease attack. SSB contains spores of the *Bacillus mucilaginosus*. With the changes occurring in the global environment, the role of Silica will become more and more important for better and sustainable production of the crop. In soil system also the application of silicates released more of phosphorus (Chinnasami *et al.*, 1978) [2]. SSB effectively mobilizes unavailable silica ions present as insoluble silicate complexes and make it assimilable by plants (Muralikannan, 1996) [10].

Conclusion

Rice is a Silicon accumulator; therefore, adequate attention should be given to the beneficial role that silicon nutrition and its management can play in a balanced integrated nutrient management system for increasing and sustaining rice yields. In general, highly weathered soils of the tropics and subtropics are low in available silicon mainly due to leaching process. Its sufficient supply in soil is required for healthy growth and productive development of the rice crop. Silicon application improves the availability of applied fertilizer nutrients (namely N**,** P, and K**)** and offers the potential to improve their agronomic performance and efficiency in terms of yield response. Si-amended rice plants possess varying degrees of ability to resist or to tolerate biotic stresses, such as attack of insect pests and fungal diseases, and abiotic stresses due to toxicity of soil Al, Fe, and Mn and excessive salts. Silicon management is essential for increasing and/or sustaining rice productivity in temperate, tropical, and subtropical soils. Silicon management is essential for increasing and/or sustaining rice productivity in temperate, tropical, and subtropical soils.

References

1. Berthelsen S, Noble AD, Kingston G, Hurney A, Rudd A, Garside A. Final Report, Sugar Research and Development Corporation Project CLW009. 2003, 138. Available: http://elibrary.sugarresearch.com.au/bitstream.pdf [23 Dec. 2016].
2. Chinnasami KN, Chandrasekaran S. Silica status in certain soils of Tamil Nadu. Madras Agric. J 1978; 65:743-746.
3. Devanur V. SILICON-Solution for tomorrow, Concept note, 2015. Available:

http://www.privilifesciences.com/download/silicon-supplement.pdf. [25 Dec. 2016].
4. IRRI (International Rice Research Institute). 2016. [On-line]. Silicon deficiency. Available: http://www.irri.com [25 DEC.2016].
5. Liang YC, Sun WC, Zhu YG, Christie P. Mechanisms of silicon-mediated alleviation of abiotic stresses in higher plants: a review. Environ. Pollut. 2007; 147:422-8.
6. Ma JF, Yamaji N. Functions and transport of silicon in plants. A review. Cell Mol. Life Sci. 2008; 65:3049-57.
7. Mali M, Aery NC. Silicon effects on nodule growth, dry-matter production, and mineral nutrition of cowpea (*Vigna unguiculata*). J Plant Nutr. Soil Sci. 2008; 171:835-40.
8. McGinnity P. Silicon and its Role in Crop Production. 2015, 16. Available: http://www.planttuff.com/pdf [25. DEC.2016].
9. Meharg C, Meharg AA. Silicon, the silver bullet for mitigating biotic and abiotic stress, and improving grain quality in rice? Environ. Exp. Bot. 2015; 120:8-17.
10. Muralikannan N. Biodissolution of silicate, phosphate and potassium by silicate solubilizing bacteria in rice ecosystem. M.Sc. (Ag) thesis submitted to Tamil Nadu Agricultural University, Coimbatore. 1996, 125.
11. Savant NK, Snyder GH, Datnoff LE. Silicon management and sustainable rice production. *Adv. Agron*. 1997; 58:1245-1252.
12. Savant NK, Korndorfer GH, Datnoff LE, Snyder GH. Silicon Nutrition and Sugarcane Production. A review. J Plant Nutr. 1999; 25:1853-1903.
13. Sahebi M, Hanafi MM, Akmar ASN, Rafii MY, Azizi P, Tengoua FF *et al*. Importance of Silicon and Mechanisms of Biosilica Formation in Plants. Bio. Med. Res. Int. 2015, 16.
14. Savant NK, Korndorfer GH, Datnoff LE, Snyder GH. Silicon Nutrition and Sugarcane Production. A review. J. Plant Nutr. 1999; 25:1853-1903.