Nutri-Facts

IPNI

Agronomic fact sheets on crop nutrients

Silicon

NO. 14

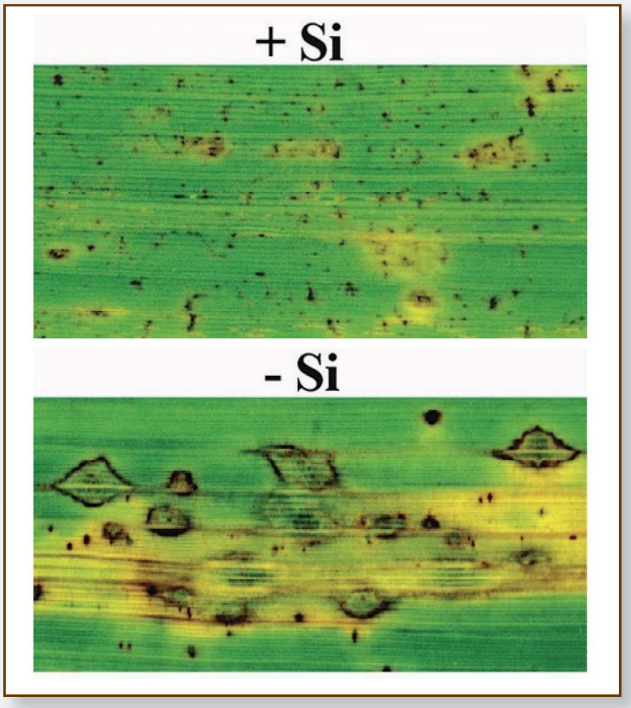
NORTH AMERICAN EDITION

Silicon (Si) is generally not considered an essential element for plant growth. However, due to its important role in plant nutrition, particularly under stressful conditions, it is now recognized as a "beneficial substance" or "quasi-essential."

Silicon in Plants

Silicon refers to the chemical element, while silica or silicon dioxide (SiO_2) are solid, glass-like compounds containing both Si and oxygen. Plants roots take up soluble Si from the soil in the form of silicic acid [$Si(OH)_4$]. It is translocated through the plant until it is deposited and precipitated in the intercellular spaces of the plant[1].

When Si forms solid structures in the plant tissue (called phytoliths), it provides important strength to cell walls, without a direct role in plant metabolism. Many plants, especially grasses, accumulate large amounts of Si, which contributes to stalk strength and helps keep them upright. Accumulation of silica in sugarcane leaves provides protection from over-exposure to ultraviolet light, preventing leaf freckling. These small solid particles of silica located in leaves and stems also help protect some plants from a variety of environmental stresses, insect attacks, and disease[2].



WWW.APSNET.ORG

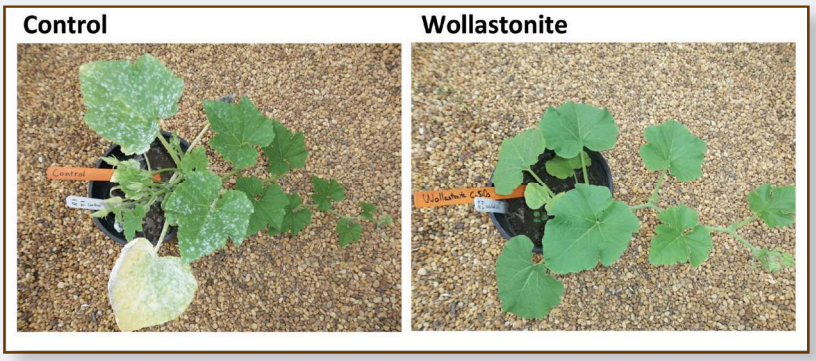
Development of leaf blast symptoms in rice with (top) or without (bottom) additional silicon.

Silicon deposition between cells also provides benefits beyond mechanical strength, although less is known about these contributions to plant growth. For example, Si is beneficial in stimulating natural plant defenses against fungal pathogens by activating various organic compounds and enzymes.

The quantity of Si taken up and accumulated by plants varies according to the species, but it can be significant. Higher plants are divided into three main groups according to their ability to accumulate Si. The highest concentrations of Si (up to 10%) are found in sedges (such as horsetail) and some wetland grasses. Dryland grasses, such as sugarcane, most cereals, and a few dicots will typically contain 1 to 3% Si. The lowest Si concentrations (<0.5%) are found in most dicots, especially legumes. Plants with Si concentrations >1% are classified as "accumulators", <0.5% are "excluders", and plants with Si concentrations between these levels are known as "intermediates".

IPNI INTERNATIONAL PLANT NUTRITION INSTITUTE

3500 PARKWAY LANE, SUITE 550
PEACHTREE CORNERS, GEORGIA 30092-2844 USA
PHONE (770) 447-0335 | WWW. IPNI.NET



J. HECKMAN

Figure 1. Powdery mildew disease suppression in pumpkin plants following calcium silicate (Wollastonite) application[2].

M.K. SCHON

Figure 2. Leaf freckling is a symptom of low Si in sugarcane receiving direct sunlight. Silicon is thought to act as a filter for harmful UV radiation.

Table 1. Silicon concentration in the shoots of various crops[3].

Crop	% dry weight
Rice	4.2
Wheat	2.5
Barley	1.8
Sugarcane	1.5
Soybean	1.4
Corn	0.8
Cassava	0.5
Potato	0.4

Examples of Si concentrations of several crops are reported in **Table 1**.

Silicon in Soils

Silicon is second only to oxygen in the amount present in the earth's crust. Soils commonly contain as much as 30% Si, almost all of which is found in minerals and rocks. A lack of Si in soil is not common, but the concentration of soluble silicic acid can be too low to meet plant needs. Soluble Si concentrations typically range between 3.5 and 40 mg Si/L, averaging about 14 to 20 mg/L across most agricultural soils.

Soil texture has been considered one of the most important factors affecting Si concentration in the soil solution. Although sand is mostly composed of SiO_2, it is not very soluble. The low water-holding capacity of sandy soils also prevents Si accumulation. Highly weathered tropical soils tend to have a lower Si content, as do soils containing very high organic matter, such as peats and muck soils.

Fertilizing with Silicon

Since the requirement for Si in plants is not clearly determined, it is difficult to predict Si fertilizer needs. When needed, the typical approach is to apply Si in combination with other essential nutrients. The most commonly applied Si fertilizer source is calcium silicate ($CaSiO_3$). Calcium silicate is abundant in steel mill slag by-products and also occurs naturally as the mineral wollastonite. Calcium silicate can be used as a liming agent in low pH soils. Other Si fertilizer sources include potassium silicate (K_2SiO_3) and sodium silicate (Na_2SiO_3), which can be applied to high-value horticultural crops through drip irrigation systems.

Table 2. Response of rice grain yield to Si fertilization[4].

Application rate, kg Na_2SiO_3/ha	t/ha
0	7.0
75	7.9
105	8.2
135	8.2

Silicon Deficiency Symptoms

Visual symptoms of Si deficiency in plants are generally not directly observed. Because of its natural abundance in soil and water (even highly purified water contains trace concentrations of Si), leaves of accumulator plants in a "no silicon" experiment may contain 1 to 4 mg SiO_2/g leaf dry weight, which contributes to the difficulty in determining the essentiality of Si for plant growth.

More commonly observed symptoms of Si deficiency are secondary effects such as an increase in disease or pest damage in plants not receiving adequate Si **(Figure 1)**, a lack of stem strength, or abiotic stress symptoms like leaf freckling in sugarcane **(Figure 2)**.

Table 3. Response of sugarcane yield to Si fertilization[5].

Location	Si source	Rate, t/ha	Cane yield, t/ha
Mauritius	Electric furnace slag	0	267
		6.2	314
Hawaii	TVA slag	0	253
		4.5	327
Hawaii	Calcium silicate	0	131
		1.7	166
Florida	Calcium silicate slag	0	126
		6.7	156

Crop Response to Silicon

Several crops including corn, wheat, oats, pumpkin, cucumber, and various species of ornamentals have been shown to respond favorably to additions of Si under certain conditions. The most frequently observed positive results have been reported in rice **(Table 2)** and sugarcane **(Table 3)**.

Without adequate soil tests or tissue testing guidelines, there are no routine recommendations to predict when responses to additional Si will be beneficial. There are a growing number of examples of positive responses to Si fertilization, but there is still much to learn about this potentially beneficial nutrient.

References

1. Epstein, E. 2009. Ann. App. Bio. 155:155-160.
2. Heckman, J. 2013. Better Crops 97(4) 14-16.
3. Hodson M.J. et al. 2005. Ann. Bot. 96:1027-1046.
4. Ma, J.F. and E. Takahashi. 2002. Soil, fertilizer, and plant silicon research in Japan. Elsevier, Amsterdam.
5. Matichenkov, V.V. and D.V. Calvert 2002. J. Am. Soc. Sugarcane Tech. 22:21-30.