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Silicon: Beyond a Beneficial Nutrient

by Wendy Zellner, Ph.D.

Many of us are unaware of the vital role silicon plays in crop health and nutrient balance. Silicon clearly demonstrates improvements to plants, especially under suboptimal growing conditions, yet is classified as a beneficial nutrient as its exact role in plant nutrition is vague. Above all, silicon protects yield potential and improves crop quality. Silicon achieves this through enhancing water, and nutrient use efficiencies, while boosting defense mechanisms that protect against environmental, and biological stress.

Beneficial nutrients are found at low concentrations in leaves; however, silicon content far exceeds concentrations of micronutrients in most plants **(Figure 1)**. In the literature, plants are described as either 'high' or 'low' silicon accumulators. If we put these categories into the context of other plant nutrients, we would replace 'high' and 'low' with 'primary' and 'secondary', respectively. This means most plants, including our agriculture crops, have silicon requirements at or above the levels of nitrogen in our 'high' accumulators, and that of calcium, magnesium, and sulfur in our 'low' accumulators. While we replace other nutrients each season, we've neglected to replenish the silicon deficit in our soils. This can be a contributing factor to yield decline, requiring an increase in other nutrients or chemical inputs to mask silicon deficiency symptoms.

Nutrient Concentration in Dry Tissue (ppm)

Macronutrients	Carbon	C	450,000	'High'
	Nitrogen	N	15,000	
	Potassium	K	10,000	
	Calcium	Ca	5,000	'Low'
	Magnesium	Mg	2,000	
	Phosphorus	P	2,000	
	Sulfur	S	1,000	
	Silicon	Si	1,000	
Micronutrients	Iron	Fe	100	
	Manganese	Mn	50	
	Boron	B	20	
	Zinc	Zn	20	
	Sodium	Na	10	
	Copper	Cu	6	
	Molybdenum	Mo	0.10	
	Nickel	Ni	0.05	

Silicon Concentration (ppm) in Plant Leaves

Rice	100,000	Sunflower	5,180	Almonds	1,800		
Wheat	40,000	Apples	4,600	Summer Gra	1,600		
Mustard	30,000	Pumpkin	4,591	Walnuts	1,300		
Verbena	20,352	Maple	4,580	Osteospermu	1,296		
Cannabis indica	20,000	Grape	3,700	Lavender	1,260		
Lantana	19,108	Barley	3,600	African Marig	1,256		
Zinnia	12,682	Summer Squash	3,497	Pansy	1,107		
Garden mum	10,430	Rudbeckia	3,469	Bacopa	1,016		
Cucumber	10,164	Apples	3,200	Bractentha	1,000		
Corn	10,000	Strawberry	3,000	Lysimachia	1,000		
Impatiens	8,490	Clementine	2,500				
Hops	8,200	Spinach	2,500	Basil	678		
Sugarcane	7,300	Asparagus	2,400	Rasperry	500		
Lettuce	7,000	Okra	2,041	Onion	500		
Soybean	6,500	Winter Squash	2,031	Tobacco	290		
Watermelon	6,340	Peanut	2,000	Swiss Chard	152		
		Tomato	2,000	Spinach	152		

Figure 1: Silicon accumulation in a selection of plants showing concentration above micronutrients. Highlighted colors for the plant species (right) correlate to nutrient concentrations in leaves (left). The black bar represents concentrations for 'high' and the gray bar for 'low' silicon accumulators.

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Silicon deficiency symptoms are unlike other nutrients. Nitrogen and phosphorous deficiencies produce distinct color changes in leaves, while calcium deficiency appears during fruit development. Less noticeably, silicon deficient plants grow with less vigor and reduced quality or yield, making it hard to visually spot symptoms early in the season when silicon fertilization is vital to performance. In addition, silicon-deficient plants are more susceptible to environmental stress, making them an easier target for pathogens and pests. This is especially true during seasons with sub-optimal weather conditions.

If we list all the positive responses silicon fertilization has on plants, it seems too good to be true. Silicon enhances water and nutrient efficiency and protects plants from an extensive list of environmental stress, like frost, heat, drought, flooding, salinity, heavy metals, and other nutrient toxicities or deficiencies. In addition, silicon-sufficient plants are more tolerant to biotic stress in a broad sense, which includes infections from bacterial, fungal, or viral pathogens, as well as other pests like aphids, borers, mites, and nematodes. This is not due to pesticidal mechanisms but is a result of a robust immune response by silicon-fed plants. Does this make silicon the super nutrient of the fertilizer world? Absolutely not. Think about what would happen if you reduced nitrogen, calcium, or even water. Any deficiencies in a plant nutrient results in poor water and nutrient use as well as susceptibility to environmental and biotic stress. Silicon isn't a miracle compound, it is simply a plant nutrient responsible for health, productivity, and quality of our crops.

While beneficial nutrients are typically advantageous to only a few plant species, silicon benefits all plants evaluated under silicon-limiting conditions. Silicon responses are observed in plants whether they accumulate at 10% or 0.01% Si. For example, in cotton, silicon promotes growth and fiber development while limiting stress from deficiencies, toxicities, drought, salt, and low temperature. Silicon also reduces pathogens in cotton including insects and infections by fungi and bacteria. Tobacco also benefits from silicon fertilization, resulting in stress tolerance to toxicities, salinity, and drought. Positive responses with silicon fertilization are documented in many agronomically important crops like alfalfa, almond, citrus, corn, cucumber, peanut, potato, rice, rye, soybean, strawberry, tomato, and wheat, just to name a few **(Table 1)**. It is increasingly evident that silicon functions as an essential nutrient, protecting plants from stress at a general level. That is, silicon is essential to help protect your crops' yield and quality with the largest return on investment produced during seasons of marked stress from either environmental or biological factors.

Silicon fertilization was believed to be only important for grains and a few specialty crops with the thought that large amounts of silicon in our mineral soils was sufficient for the needs of other commodities. However, like the availability of nitrogen from our air, silicon availability from our soils is 100 MILLION times lower than total content, dropping from 27% (or 270,000 ppm Si) to below 17 ppm Si. In highly cultivated soils, the available silicon pool is quickly depleted, creating silicon deficiencies in the crop, resulting in susceptibility to stress and disease. This is true for all plants from rice to tobacco. Fertilizing with a proper form of plant-available silicon replenishes the available silicon pool.

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Table 1:
A short list of agronomically important crops that exhibit silicon tolerance to environmental stress.

	Salt	Drought	Nutrient Deficiency	Nutrient Toxicity	Cold	Heat	Lodging/ Hypoxia
Rice	✓	✓	✓	✓	✓	✓	
Wheat	✓	✓	✓	✓	✓	✓	✓
Tomato	✓	✓	✓	✓		✓	
Corn	✓	✓		✓	✓	✓	
Cotton	✓	✓	✓	✓	✓		
Cucumber	✓	✓	✓	✓	✓	✓	
Strawberry	✓	✓	✓	✓		✓	
Citrus	✓		✓		✓	✓	✓
Alfalfa	✓	✓	✓	✓	✓		
Oat	✓	✓	✓				
Peanut	✓	✓	✓	✓			
Tobacco	✓	✓		✓			
Soybean	✓	✓	✓	✓	✓		
Potato	✓	✓					
Almond		✓					
Rye							✓

Stress tolerance reported in the literautre is marked with a '✓'. Blank spaces indicate not tested nor reported in the literature.

Rate and timing of silicon fertilization is hard to summarize, as it is for any nutrient. Application rates vary depending on the fertilizer's formulation and specific crop. The labeled rates should be followed. Timing of silicon applications are similar to other fertilizers. That is, silicon should be applied at key growth stages, where nutrient inputs have the largest impact on yield or produce quality. In addition, providing a silicon application 24-72 hours prior to predictable stress (reduced rainfall for a prolonged period, high heat, or frost) can help boost the defense responses within the plant.

Silica X-Treme® is a soil and foliar available bio-nutrient with 3% soluble Si. In studies it was shown to increase silicon content in corn, cucumber, soybean, and wheat, with faster recovery in corn following heat stress. **Silica X-Treme®** has the potential to protect yields, especially in seasons with high stress, through enhanced water and nutrient use efficiency, and improved stress tolerance.

Silicon goes beyond a beneficial nutrient, as it is absorbed in significant quantities and promotes growth and health in crops spanning a wide range of species. Including silicon in your nutritional program will enhance the efficacy of inputs you've already invested in, while increasing the quality and productivity of your crops.