

GROWERTALKS

Features

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Do You Know What Your Soilless Media is Missing?

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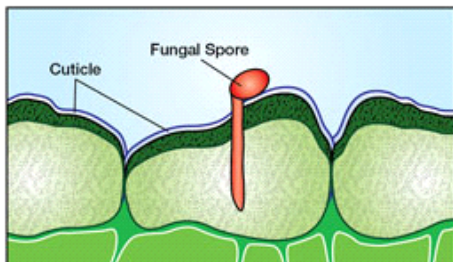
GrowerTalks: Tell me a little bit about silicon. Isn't it already present in soil?

Shiv Reddy: Silicon is the second most abundant element—second only to oxygen—in the Earth's crust, where soil is. Soil, of course, is the natural growing media for plants, so roots growing in natural soil are always in contact with a soil solution that has silicon. Of course, plants don't take in indiscriminately all the elements they encounter in a soil solution; plants take in elements selectively. Plants do take in and accumulate silicon, indicating they're using it. In fact, most plants growing in natural soils take in as much silicon as some of the nutrients that are essential to their life, like phosphorus, calcium, magnesium and sulfur. And some plant species take in more silicon than even nitrogen and potassium.

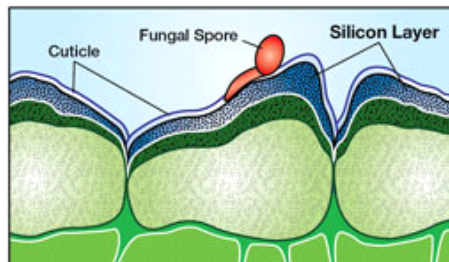
GT: What about silicon in potting media? Aren't some potting media components—like sand, perlite, vermiculite, etc.—silicon materials?

SR: Virtually no container grower uses mineral or topsoil in potting media anymore. Container growers use soilless media that's mostly made of organic materials, like peat, bark, coir, etc. These organic materials have hardly any minerals, let alone silicon. Although sand, pumice, perlite, vermiculite and rockwool are technically silicon materials, silicon from these materials is hardly available to plants. In fact, silicon content in the plants growing in these soilless media is remarkably lower compared to the same plant species growing in natural soil.

Without Silicon



With Silicon



Silicon reinforces the plant's defense system both physically and chemically. Physically, solidified silicon deposits just below the leaf surface increase the resistance to penetration by fungal spores and insects.

GT: So soilless media is silicon-less media. Does that mean growers are depriving their plants of silicon when growing in soilless media?

SR: Yes, compared to the natural world, where silicon is the norm in natural soil and where silicon is an integral part of natural plants, lack of silicon in soilless growing media is not a normal growing environment for plants.

GT: Then why is silicon not included in soilless growing? Most growers have been growing plants in soilless media without silicon without any problems.

SR: Silicon got neglected, although unknowingly, during the historical, gradual transition from using all field soil to some field soil to completely soilless media in containers. Silicon isn't essential to plants—meaning plants can grow, flower and finish their life without silicon. You don't see any obvious symptoms on plants when silicon is deficient, so you don't pay any attention to silicon.

Silicon is a beneficial element. It's similar to fluoride for our teeth. Fluoride isn't essential for humans, but fluoride is beneficial in that it strengthens tooth enamel, making it less vulnerable to cavities.

GT: So how does silicon benefit plants?

SR: In nature, plants have evolved to absorb and use silicon to become not just structurally, but also biochemically, strong. Plants use silicon to cope with a variety of adverse conditions they encounter—such as pest attacks, strong winds, water shortages, toxic elements, etc. Think of plants using silicon to build a more solid house for themselves against the huffs and puffs of adversaries!

GT: What actually happens when silicon is available to the plants?

SR: Plant roots take in silicon in the form of silicic acid and transport a majority of it to the shoot with the water stream. Along the way, some silicic acid is deposited in the roots and some in the xylem in the shoot. After reaching leaves, silicic acid is deposited in the walls of epidermal cells, just beneath the cuticle. As water is lost through transpiration, silicic acid concentrates and polymerizes to solid silica gel. This results in the formation of a double layer of cuticle-silicon. The solid silica gel bodies are called phytoliths or plant opals, as they give toughness to plant tissues. In fact, fossilized phytoliths are what archeologists find years later and use to identify what kind of plants existed at a site.

GT: So the double layer of cuticle-silicon in plants acts as armor for the plant?

SR: Yes, to enter into a plant, fungal spores or insects have to puncture and penetrate the plant surface or cuticle first. When there's a silicon-reinforced barrier there, the resistance to the puncture increases and the progress of pest entry, along with the incidence of pest attack, decreases. The solidified silicon wears off mandibles of insect larva when they chew plant tissue, thereby limiting plant damage by insects.

GT: You mentioned silicon protects plants biochemically, too—how?

SR: Solidified silicon acting as armor is not the whole story in silicon's role in protecting the plants. When pathogen fungal spores attempt to penetrate the leaf, the fraction of silicon that's still in solution form there—that is, silicic acid not yet solidified—triggers the synthesis of organic defense compounds within the plant by the plant itself. These compounds also obviate the fungal infection process. For this kind of protection, silicon in the plant should be in the form of silicic acid during the pest attack because silicon that's already solidified cannot reverse back to silicic acid. Solidified silicon within the plant cannot move from one location to another, either—thus, a continuous availability of silicon is needed for growing plant tissues

GT: Which pests does silicon help to prevent?

SR: There are many examples of reduced incidence of diseases and insects due to silicon in the plants. Examples of reduced pathogens include those causing foliar diseases like blights, blight, powdery mildews, leaf spots, rusts, Botrytis, and stem rots and root diseases like Pythium and Phytophthora. Examples of reduced insect pests include stem borers, hoppers, leaf miners, aphids and thrips, as well as non-insect pests like spiders and mites. Often, scientists focused their research on the effects of silicon in rice crops and in model research plants like cucumber or Arabidopsis for a basic understanding of how silicon works in plants.

Then some tentative generalizations about the effects of silicon that have been found are extended to all the plants since all plants absorb silicon. Stirred by these benefits of silicon, some scientists started studying the effects of silicon in more crops. So the evidence for silicon benefits is accumulating in a wide variety of crops, including zinnia, sunflower, gerbera, aster, carnation, chrysanthemum, calibrachoa, geranium, marigold, African violets, New Guinea impatiens, impatiens, begonia, kalanchoe, salvia, snapdragon, vinca, verbena, poinsettia, lily, ferns, orchids, pumpkin, cabbage, strawberry, citrus and also forestry pines.

GT: How does silicon in plants affect their strength and looks?

SR: In nature, plants absorb, deposit and solidify silicon in cell walls to gain structural rigidity, so as to be erect and strong and resist falling during strong winds. The same effect of strong stems translates to fewer branch breaks during handling and shipping of container plants, which are often top heavy. Such strong stems also help in cut flowers not being bent in floral arrangements. In nature, silicon-solidified stiff leaves hold wide and intercept and capture more light. Such an effect counteracts straggly plants with soft, droopy leaves, which often occur from the use of high nitrogen fertilizers in greenhouse plants. The silicon layer formed below the cuticle in leaves acts as a barrier against water loss from transpiration through the cuticle. This effect reduces withering of leaves and prolongs the shelf life of container plants at retail.

GT: Are there any other effects from silicon?

SR: Silicon has such diverse effects on plants that it's difficult to settle on one major effect of silicon in any plant species. Silicon mitigates toxicity from micronutrient metals like manganese, copper, zinc, iron and balances their levels in plants. For example, you may have seen ugly brown spots on the foliage of ornamental plants like pothos, palms, etc. due to toxic accumulation of oxidized manganese, coming from high manganese bark mix or low pH in growing media. Silicon prevents the buildup of such spots of toxic concentrations of manganese by distributing manganese evenly, thereby suppressing the appearance of ugly spots on ornamental plants.

Similarly, silicon prevents copper toxicity, which plants can encounter from composts, fungicides or ionization of irrigation water. Growers may even have seen a copper toxicity symptom in their growing and probably mistook it as iron deficiency—for instance, chlorosis on the leaves of petunias. Interestingly, silicon ameliorates true iron deficiency, too, modulating iron in the plants under iron-deficiency conditions, resulting in significantly greener leaves and slower senescence. Silicon also helps plants cope with high salinity or high EC by reducing the level of salts getting into the shoots by blocking salt flow through the roots. This effect is especially important if your irrigation water isn't of high quality or you're recycling your water, which tends to have high salinity.

GT: It seems silicon benefits are more obvious when plants face adverse conditions.

SR: When the going gets rough, with silicon, plants get tough! As you perceived, effects of silicon aren't so evident or are muted when plants are growing under benign conditions, but the effects become more apparent when plants come under stress. Stress is a universal condition all organisms face, so like you, plants do face stress conditions in real world, even in commercial greenhouse growing. In response, when plants have access to silicon, they use silicon as needed, sometimes acquiring silicon only under stress and reacting adaptively to those stresses. Effects of silicon are realized even more when a stress develops gradually, approximating the stress plants encounter in nature.

GT: Are there any examples of where silicon is used in hort or ag markets?

SR: Most sugarcane in Florida is grown in Everglade mucky soils, which are highly organic and, thus, poor in silicon—just like organic potting media. Response of sugarcane that's growing in sandy soils to the application of silicon shows insufficient plant-available silicon in sand—even though sand is technically a silicon material. The Japanese started using silicon very early as soon as they realized that their staple food crop—rice—wasn't growing very healthy without additional silicon. This is because native silicon, even in mineral soils, is depleted due to continuous, repeated cropping. Of late, application of silicon is becoming common in hydroponic production of crops like cucumbers, tomatoes, roses, etc.

GT: Do some plants accumulate more silicon than others?

SR: Yes, the amount of silicon accumulated varies not only among the crops, but even within the varieties of the same crop. Some varieties of rice accumulate silicon up to 10% of their dry weight. However, even 0.5% of silicon in any plant is still similar to the percentages of essential nutrients like phosphorus, magnesium and sulfur.

There are also differences among crops in their interaction with silicon. For example, there are variations in how much silicon is deposited in which plant organ (root, shoot, leaves, flowers, bracts, etc.) and where in the organ (lower leaves, upper leaves, lower or upper surface of a leaf, edges or middle of a leaf, etc.). The form (size, shape, texture) of silica structures or opal phytoliths formed among plants is also diverse. Uptake of silicon by plants differs under different conditions (summer versus winter). Such intrinsic differences in silicon accumulation patterns in turn influence the effects of silicon in various plants to various degrees under various conditions. Thus, less silicon in a plant doesn't mean it's less effective functionally or less beneficial. For instance, lettuce accumulates little silicon (0.05%), but still just that much silicon somehow alleviates manganese toxicity, a plague in heading of lettuce. What exact role silicon plays in all

the plant species under what context is still not fully understood.

GT: How can growers provide silicon to plants growing in soilless potting mixes?

SR: Providing silicon effectively to the plants growing in soilless media is a significant challenge, which is another reason why the use of silicon in soilless culture is hampered. Recall that silicon is abundant on the Earth, so not surprisingly, there are many natural silicon compounds, as well as industrial byproducts. However, just because a compound has silicon in its name doesn't mean it's a suitable source for plants in soilless media. Similarly, a material that contains more silicon doesn't mean it provides more silicon to plants. After all, we just learned that plants hardly obtain silicon from sand, which literally is silicon! If you want to evaluate a silicon source, remember labs don't test for plant-available silicon routinely.

Providing silicon to plants through irrigation is complicated, too. Silicon sources for such use aren't stable and when mixed into a regular feed solution, precipitation and severe clogging of irrigation nozzles occur. Such a precipitation interaction occurring in the growing media can obstruct watering and drainage of the growing media.

Roots of plants growing in natural field soils explore a large volume of soil for silicon. However, roots of plants growing in containers can explore just the media limited to the container. Thus, a silicon source in soilless media in containers should be sufficiently available for the plants in the containers. The source should be pure and free of contaminants. It should be consistent from batch to batch. It shouldn't compromise physical and chemical qualities of the growing media. Of course, low cost helps. Such a silicon source already embedded in the growing media would be convenient, so you don't need to change your existing practices of watering, fertilizing, etc. Promising efforts have been made to embed such a silicon source into soilless growing media. Growers should discuss this with their growing media supplier.

Though the subject of silicon in plants still poses many fascinating questions, we have come a long way in our understanding of it and now there's enough evidence showing how silicon benefits plants. So silicon can now become an integral part of soilless growing technology and then plants in soilless culture can grow naturally—just like in nature. **GT**