Silicon in the life and performance of turfgrass

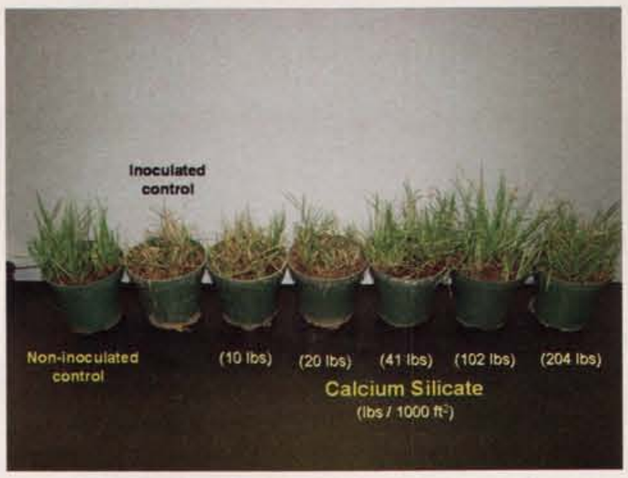
BY **DR. LAWRENCE E. DATNOFF**

There has been a growing interest in the element silicon and its effects on the life and performance of plants over the past few years. Silicon (Si) is the second most abundant mineral element in soil after oxygen and comprises approximately 28% of the earth's crust. Despite the abundance of Si in most mineral soils worldwide, Si deficiency can still occur due to Si depletion from continuous planting of crops that demand high amounts of this element, such as rice. Silicon deficiency occurs more often in highly weathered, low base saturation and low pH soils such as Oxisols and Ultisols in Asia, Africa, and Latin America.

Heavy rainfall in regions where these two types of soils occur can cause high degrees of weathering, leaching, and desilification. Organic soils (Histosols) are also deficient in plant-available Si because of the greater content of organic matter and low content of minerals. Those Entisols having a high content of quartz sand (SiO_2) are also low in plant-available Si. Such Si-deficient condition may be prevalent on USGA-based quartz sand greens and tees.

Soil solutions generally have a Si concentration of 3-17 ppm. This is considered low, but nevertheless it is 100 times greater than phosphorus in most soil solutions.

Many plants are able to uptake Si. Plants absorb Si from the soil solution in the form of monosilicic acid, $Si(OH)_4$, which is carried by the transpiration stream and deposited in plant tissues as amorphous silica gel, SiO_2nH_2O, also known as opal. Depending upon the species, the content of Si accumulated in the biomass can range from 1 to greater than 10% by dry weight.



Influence of silicon on gray leaf spot development in perennial ryegrass. Calcium silicate was the silicon source applied at 10 to 204 lbs. / 1000 ft2.

Si in turfgrass

Fertilization with Si has shown positive effects in alleviating abiotic stress as well as improving plant growth and development in several turfgrass species. Since Si improves leaf and stem strength through deposition in the cuticle and by maintaining cell wall polysaccharide and lignin polymers, the possibility exists that Si could improve wear tolerance. Saiguisa and his colleagues demonstrated significant improved wear resistance in the Zoysiagrass cultivar 'Miyako'. Foliar spraying potassium silicate, 0.02 or 0.04 lbs. Si/1000 ft2, or applying as a soil drench, 0.45 lbs. Si/1000 ft2, also significantly reduced the injury caused by wear around 20% to seashore paspalum. However, K alone or together with Si provided the same effect.

In another study, several cultivars of creeping bentgrass and Zoysiagrass had improved turf quality, growth, and resistance to traffic and heat stress. Under severe drought stress, Si fertilized St. Augustinegrass plants had a better response than those non-fertilized. Leaf firing and density were significantly greater by 13% and 23.5%, respectively, in Si-fertilized plants. Quality, color, and density also were significantly enhanced when fertilized with Si over the controls by 19%, 13.6% and 8.5%, respectively. However, under these test conditions, visual scores were all below what would be considered acceptable for turfgrass use. Nevertheless, this demonstrates that Si may improve these turfgrass qualitative factors under extreme drought stress. Schmidt and his associates also showed that foliar applications of Si significantly enhanced photosynthetic capacity increasing chlorophyll content especially during the summer when plants were influenced by environmental stress.

Gussak et al. demonstrated increased growth and establishment of creeping bentgrass (Agrostis palustris Huds.) fertilized with Si. Brecht et al. and Datnoff et al. also demonstrated similar results in St. Augustinegrass. A percent bare ground coverage (vertical prostrate growth) rating was recorded 11-12 weeks after sprigging a field with St. Augustinegrass by estimating a visual percent area of bare ground covered by grass in a 21.5 ft2 area. They demonstrated that the final percent bare ground coverage was significantly increased by using Si by 17 to 24% over the control. Ten months after sprigging, one pallet, containing about 500 ft2 of St.Augustinegrass, was harvested from each treatment-silicon and a control. Sod pieces (mat), 12x24 inches, were washed to remove soil, dried for 48 hours and weighted.

In addition, fresh, intact sod pieces (mats) from each treatment were transplanted to a sand site and monitored for turf quality and root length development for 21 days. At harvest, the treatment that had been fertilized with Si had a dry sod mat weight that was 13% significantly higher than the control. Sod pieces amended with Si also had improved turf quality ratings, 7.1 to 7.6 vs. 6.6 to 7.1 in comparison to the non-fertilized control, 14 and 21 days after being transplanted to the field. In addition, Si treatments had a significantly greater increase in newly generated roots, 2.0-2.5 inches in root length, in comparison to the non-fertilized control.

Silicon also has been effective in suppressing diseases in a number of warm and cool season turfgrass species. Silicon has increased the resistance of zoysiagrass to Rhizoctonia solani creeping bentgrass to Pythium aphanidermatum, Sclerotinia homoeocarpa and R. solani and in Kentucky bluegrass to powdery mildew (Sphaerotheca fuliginea). Si reduced Gray leaf spot development over a range of 19-78% on several cultivars of St. Augustinegrass under greenhouse conditions. In field experiments, Si alone was compared to foliar sprays of chlorothalonil, and Si plus chlorothalonil for managing gray leaf spot development. Gray leaf spot was reduced by 17-27, 31-63 and 56-64% for Si alone, chlorothalonil alone, and Si plus chlorothalonil, respectively, compared to a non-treated control. Recently, Nanayakkara et al. demonstrated similar results in perennial ryegrass turf. They showed that gray leaf spot severity was reduced from 11-24%.

Datnoff and Rutherford recently evaluated the ability of Si to enhance disease resistance in Tifway bermudagrass to Bipolaris cynodontis, the cause of leaf spot and melting out. They found that plants fertilized with Si had 39% fewer lesions than plants non-fertilized. Silicon increased in leaf tissues 38-105% over the control.

Resistance to plant diseases

The effect of Si on plant resistance to disease is considered to be due either to an accumulation of absorbed Si in the epidermal tissue, or expression of pathogensis-induced host defense responses. Accumulated monosilicic acid polymerizes into polysilicic acid and then transforms to amorphous silica, which forms a thickened Si-cellulose membrane. By this means, a double cuticular layer protects and mechanically strengthens plants. Silicon also might form complexes with organic compounds

IN ANOTHER STUDY, SEVERAL CULTIVARS OF CREEPING BENTGRASS AND ZOYSIAGRASS HAD IMPROVED TURF QUALITY, GROWTH, AND RESISTANCE TO TRAFFIC

in the cell walls of epidermal cells, therefore increasing their resistance to degradation by enzymes released by fungi.

Research also points to the role of Si in planta as being active and this suggests that the element might be a signal for inducing defense reactions to plant diseases. Silicon has been demonstrated to stimulate chitinase activity and rapid activation of peroxidases and polyphenoxidases after fungal infection. Glycosidically bound phenolics extracted from Si amended plants when subjected to acid or B-glucosidase hydrolysis displayed strong fungistatic activity. More recently, flavonoids and momilactone phytoalexins, low molecular weight compounds that have antifungal properties, were found to be produced in both dicots and monocots, respectively, fertilized with Si and challenged inoculated by the pathogen in comparison to non-fertilized plants also challenged inoculated by the pathogen. These antifungal compounds appear to be playing an active role in plant disease suppression.

That Si plays an important role in the mineral nutrition of plant species such as rice and sugarcane is not in doubt nor is its ability to enhance plant development and efficiently control plant diseases. Now evidence is accumulating that similar effects occur in certain turfgrasses. Effective, practical means of application, affordable sources of Si, and methods for identifying conditions under which Si fertilization will be beneficial are needed for use in turfgrass management. However, research on the use of Si for turfgrass is in its infancy. For example, no soil tests for gauging amounts of plant-available Si have been calibrated for turfgrass. Furthermore, most analytical laboratories do not routinely assay plant tissue for Si.

In fact, the current standard tissue digestion procedures used in most laboratories would render Si insoluble, making an analysis of the digested tissue meaningless. Thus, the two analytical tools (soil and plant tissue) most often used for determining the need for fertilization with plant nutrients are not widely available for Si. While a number of beneficial responses of turfgrass to Si applications have been documented in controlled experiments, particularly in the laboratory, few large-scale field effects have been observed to date. Conditions under which beneficial responses to Si fertilization will occur are not well known for turfgrass.

Nevertheless, as the need for environmentally friendly strategies for management of abiotic and biotic stress increases, Si could provide a valuable tool for use in plants capable of its accumulation. The use of Si for improving plant performance while controlling plant diseases in turf would be well-suited for inclusion in integrated pest management strategies and would permit reductions in fungicide use. As researchers and turfgrass managers become aware of Si and its turf potential, it is likely that this often overlooked element will be recognized as a viable means of enhancing turfgrass health and performance. ST

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