Silicon Suppresses Leaf Spotting on Bermudagrass

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Soluble silicon has enhanced the growth and development of several plant species.

Silicon is the second most abundant element after oxygen in the earth's crust, and most soils contain considerable quantities of the element (Savant*et al.*, 1997). However, some soils contain little plant-available silicon in their native state, and repeated cropping can reduce the levels of plant-available silicon to the point that supplemental silicon fertilization is required for maximum production.

Low silicon soils are typically highly weathered, leached, acidic and low in base saturation. Highly organic soils that contain little mineral matter may also contain little silicon, and soils comprised mainly of quartz sand (SiO2) also may be low in plant-available silicon. Such conditions are presumably prevalent on many sod farms and golf course greens throughout the United States.

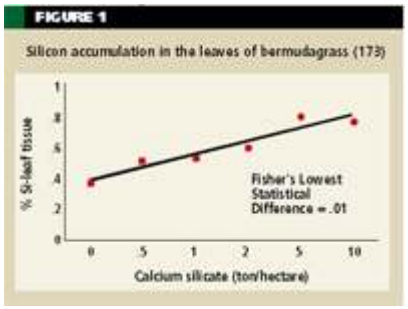
Plant nutritionists and plant physiologists generally concentrate on improving the management of 13 essential elements (Savant *et al.*, 1997). These include six macro-elements (nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), and magnesium (Mg) and seven microelements (iron (Fe), manganese (Mn), zinc (Zn), boron (B), molybdenum (Mo), chlorine (Cl) and copper (Cu). These elements are

considered essential because deficiency of any one of them adversely affects physiological plant function, resulting in abnormal growth and/or an incomplete life cycle.

Silicon (Si) is considered a plant-nutrient anomaly because it is presumably not essential for plant growth and development. Soluble silicon, however, has enhanced the growth and development of several plant species including rice, sugar cane, most other cereals and several dicotyledons such as cucumber and watermelon.

Higher plants vary in their capacity to accumulate silicon (Datnoff *et al.*, 2001b). Wetland gramineae (rice) absorb silicon as monosilicic acid, Si(OH)4, on a dry-matter basis ranging from 4.6 percent to 6.9 percent, dryland gramineae (sugar cane, cereals, St. Augustinegrass) between .5 percent to 1.5 percent and dicotyledons less than .2 percent. Therefore, silicon can be accumulated from soil by plants in amounts that are several folds higher than those of other essential macro- or micronutrients. For example, silicon accumulation may be twice that of N in rice.

Silicon amendments also have proved effective in controlling both soil-borne and foliar fungal diseases in cucumber, rice, sugar cane, turf and several other plant species (Datnoff *et al.*, 2001b). In rice, silicon has been demonstrated to control rice blast, as effectively as a fungicide and even reduce the rate or number of fungicide applications (Datnoff*et al.*, 2001a). In addition, partially blast-resistant rice cultivars amended with silicon had their resistance augmented to the same level as those considered completely resistant (Seebold *et al.*, 2000).



Because this element had proven effective for controlling rice blast (Datnoff *et al.*, 2001a; Datnoff *et al.*, 1997; Savant *et al.*, 1997), Datnoff and Nagata (1999) studied the effect of silicon on gray leaf spot development in St. Augustinegrass under greenhouse conditions. They demonstrated that silicon significantly reduced area under the disease progress curves (AUDPC) for gray leaf spot between the 44 percent and 78 percent, final disease severity between 2 percent and 38.8 percent, and final whole-plant infection between 2.5 percent to 50.5 percent. Plant silicon content in Si-amended treatments increased between 2.2 times to 3.5 times more than the nontreated controls.

Similar results were obtained in the field, and silicon appears to be as effective as a fungicide in controlling gray leaf spot development (Brecht *et al.*, 2001). Silicon also has been shown to reduce the incidence of powdery mildew in Kentucky bluegrass (Hamel and Heckman, 2000).

As documented in rice and St. Augustinegrass, silicon may potentially be used as an important component of an integrated management program for controlling diseases in bermudagrass. The objective of this study was to determine if bermudagrass accumulates Si, and if Si could enhance host plant resistance to *Bipolaris cynodontis*, the cause of leaf spotting and melting out of bermudagrass in Florida.

Materials and methods

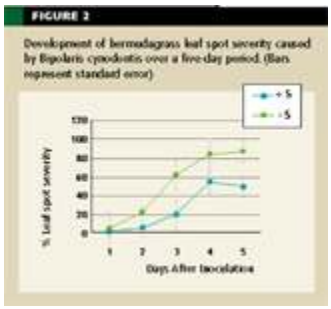
Sprigs of bermudagrass were grown in flats filled with Fafard-2 mix and sand (1:1) for four weeks. Afterwards, these sprigs were transplanted into

pots containing this mixture with silicon applied as calcium silicate slag (20 percent to 22 percent Si) at several rates ranging from .5 tons to 10 tons per hectare.

After eight weeks, plants were collected and processed for silicon analysis, using the autoclaved-induced digestion method for plant tissue (Elliott and Snyder, 1991). Shoot biomass also was recorded.

No. 51 growing trays (Hummert, 2002) also were filled with Fafard-2 mix and sand (1:1). One tray was amended with calcium silicate slag at a 10 tons per hectare while the other was the nonamended control. Five sprigs of bermudagrass were transplanted into each cell. Trays were fertilized weekly with Peters Professional Fertilizer 20-20-20 for four weeks.

Bipolaris cynodontis was isolated from common bermudagrass exhibiting symptoms of leaf spot and melting out. This isolate was single-spored and grown on Sach's media that contained autoclaved bermudagrass leaves. Plates were placed in an incubator at 68 degrees Fahrenheit with a 12-hour photoperiod. Sporulation on media and leaves occurred in seven days to 14 days.



Leaves colonized by *B. cynodontis* were removed from three plates of Sach's media and placed in a 50 millileters (ml) test tube. In addition, each of the three plates received 5 ml of de-ionized water and was scrapped with a rubber soldier. This was poured into the same test tube that received the colonized leaves. The plates were then rinsed again over the test tube with 5 ml of deionized water. After the contents of the three plates were transferred to

the tube, five drops of Tween 20 were added. The tube was then capped and placed on a vortex for one to two minutes. Afterwards, the volume of the tube was adjusted to 50 ml of water and shaken manually for 30 seconds.

The contents of the tube were then poured through two-ply cheesecloth into a 200 ml beaker. Quantification of conidia was achieved with a hemacytometer and light microscope. Inoculum density of 10,000 conidia/ml was prepared.

This inoculum was transferred to a two-part spray tool used for atomizing the plants. Stoloniferous plugs (1.9 inches in diameter) of Tifway bermudagrass were wrapped in moist paper towels and placed within 4-inch azalea pots. Five plugs amended with silicon and five plugs without silicon were sprayed with the propellant container until run-off.

The pots were then covered with opaque plastic cups afterwards to enhance relative humidity and infection by *B. cynodontis*. The containers were then transferred to the greenhouse.

Bermudagrass leaf spot symptoms caused by Bipolaris cynodontis, four days after inoculation.

After 24 hours, the plastic cups were removed and five randomly selected leaves per plant were evaluated for overall leaf spotting (0 = no disease, 10 = 100 percent leaf area infected). The plants were evaluated for five consecutive days, approximately every 24 hours. After the fifth day, plants were collected and processed for silicon analysis as described previously.

The data were then analyzed using the Student's t-test and Fisher's Protected LSD (P) is less than .05). The data sets were also used to generate AUDPC's.

Results and discussion

There was a significant linear increase in percent of silicon that accumulated in the leaves of bermudagrass as the rate of calcium silicate amended to the soil increased (Figure 1).

The percent of silicon in the leaf tissue increased between 38 percent to 105 percent over the control. No linear response was found between increasing silicon rates and leaf dry weight (data not shown). However, these plants were grown under optimum environmental conditions and experienced no abiotic or biotic stresses.

This demonstrates for the first time that bermudagrass can accumulate silicon, especially when the soil is low or limiting in this element. This grass was grown in a peat/sand mixture that would represent many golf course greens found within Florida and throughout the United States. This provides credence to the idea that low silicon conditions are prevalent on many golf course greens throughout the country.

Silicon also was effective in suppressing leaf spot development on bermudagrass caused by *B. cynodontis* (Figures 2 and 3). Final percent of leaf spot severity was reduced by 38.9 percent.

Plant tissue levels of silicon dramatically increased when soil was amended with calcium silicate slag. There was an 80 percent increase in percentage of Si in leaf tissue over the nonamended control (Table 1).

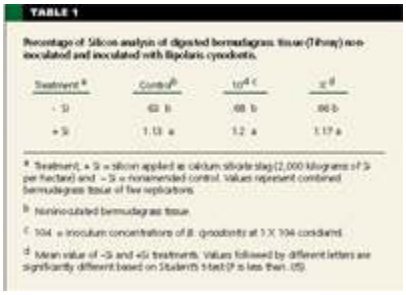


TABLE 1

Percentage of Silicon analysis of digested bermudagrass tissue (Tifway) non-inoculated and inoculated with Bipolaris cynodontis.

Treatment [a]	Control [b]	10^4 [c]	$\bar{x}$ [d]
- Si	63 b	68 b	66 b
+ Si	1.13 a	1.2 a	1.17 a

[a] Treatment; + Si = silicon applied as calcium silicate slag (2,000 kilograms of Si per hectare) and - Si = nonamended control. Values represent combined bermudagrass tissue of five replications.

[b] Non-inoculated bermudagrass tissue.

[c] 10^4 = inoculum concentrations of *B. cynodontis* at 1×10^4 conidia/ml.

[d] Mean value of -Si and +Si treatments. Values followed by different letters are significantly different based on Student's t-test ($P \leq 0.05$).

These results suggest that when soils low or limiting in plant available Si are amended with a soluble source of Si, the resistance of bermudagrass against leaf spotting caused by *B. cynodontis* can be enhanced. This also suggests that fungicides might be better managed if used in combination with silicon for controlling diseases in turf. This would fulfill two areas of interest by the USGA:

1) integrated turfgrass management - investigating practices that utilized IPM and reduce inputs ; and

2) turfgrass germplasm enhancement - reducing the need for pesticides by increasing disease resistance.

Future research will focus on the interaction of silicon and fungicides for managing leaf spotting and melting out of bermudagrass.

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