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Effects of silicon on leaf spot and melting out in bermudagrass

Silicon may help fungicides do their job.

Lawrence E. Datnoff, Ph.D., and Brenda A. Rutherford, M.S.

After oxygen, silicon is the most abundant element in the earth's crust, and most soils contain considerable quantities of the element (8). 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 composed mainly of quartz sand (SiO_2) also may be very 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 (8), including six macroelements (nitrogen, phosphorus, potassium, sulfur, calcium and magnesium) and seven microelements (iron, manganese, zinc, boron, molybdenum, chlorine and copper). These elements are considered essential because a deficiency of any one of them adversely affects physiological plant function, resulting in abnormal growth and/or an incomplete life cycle.

Photos courtesy of L. Datnoff

Figure 1. *Bipolaris cynodontis* was isolated from common bermudagrass exhibiting symptoms of leaf spot and melting out.

KEY points

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Amending the soil with calcium silicate significantly increased silicon in bermudagrass leaves.

Silicon was effective in suppressing leaf spot development on bermudagrass.

Amending silicon-deficient soils with a soluble source of silicon may enhance the resistance of bermudagrass to leaf spot.

Fungicides might be better managed if used in combination with silicon for controlling diseases in turf.

Silicon in plants

Silicon is considered a plant nutrient anomaly because it is presumably not essential for plant growth and development. However, soluble silicon 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 (5). Wetland gramineae (rice) absorb silicon as monosilicic acid, $Si(OH)_4$, equivalent to 4.6% to 6.9% of the dry matter of the rice. Silicon accumulation has been reported to range from 0.5 to 1.5% in dryland gramineae (sugar cane, cereals, St. Augustinegrass) and less than 0.2% in dicotyledons (that is, broadleaf plants). Therefore, plants can accumulate silicon from soil in amounts that are several times higher than those of other essential macro- or micronutrients. For example, rice may accumulate twice as much silicon as it does nitrogen.

Silicon amendments also have proved effective in controlling both soilborne and foliar fungal diseases in cucumber, rice, sugar cane, turf and several other plant species (5). In rice, silicon has been as effective as a fungicide in controlling rice blast (*Magnaporthae grisea, Pyricularia grisea*) and has even reduced the rate or number of necessary fungicide applications (4). In addition, amending partially blast-resistant rice cultivars with silicon increased their resistance to the same level as completely resistant cultivars (9).

Because silicon had proved effective for controlling rice blast (2,4,8), researchers (3) studied its effect on gray leaf spot development in St. Augustinegrass under greenhouse conditions. They demonstrated that silicon significantly reduced area under the disease progress curves for gray leaf spot by 44% to 78%, final disease severity by 2.0% to 38.8% and final whole plant infection by 2.5% to 50.5%. In silicon-amended treatments, plant silicon content was 2.2 to 3.5 times higher than in 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 (1). Silicon also has been shown to reduce the incidence of powdery mildew in Kentucky bluegrass (7).

As documented in rice and St. Augustinegrass, silicon may be used as an important component of an integrated management program for controlling diseases in bermudagrass. The objectives of this study were to determine whether bermudagrass accumulates silicon; whether silicon could enhance host plant resistance to *Bipolaris cynodontis*, which causes leaf spotting and melting out of bermudagrass (Figure 1) in Florida, and whether fungicides for leaf spot suppression could be applied successfully at reduced rates on bermudagrass grown in silicon-amended soil.

Material and methods

For four weeks, sprigs of 173 bermudagrass were grown in flats with a 1:1 mix of Fafard-2 and sand. Afterward, the sprigs were transplanted into pots containing this mixture and silicon applied as calcium silicate slag (20-22% silicon; Calcium Silicate Corp.) at several rates ranging from 0.4 to 8.9 tons/acre (0.5 to 10 metric tons/hectare). After eight weeks, plants were collected and processed for silicon analysis using the autoclaved-induced digestion method for plant tissue (6). Shoot biomass also was recorded.

SILICON IN BERMUDAGRASS

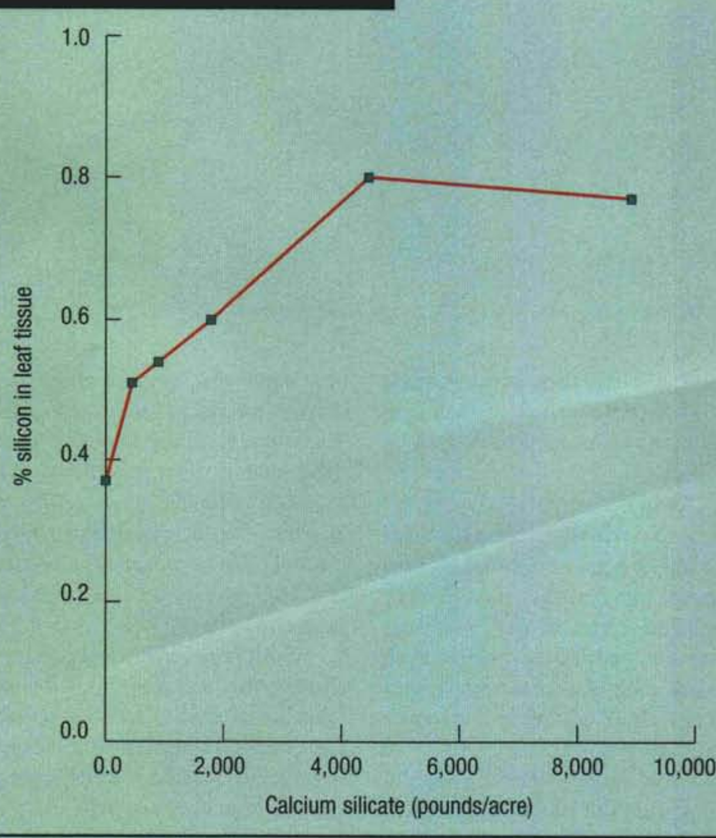

Figure 2. Silicon accumulation in leaves of 173 bermudagrass.

Growing trays were filled with a 1:1 mix of Fafard-2 and sand. One tray containing this mix was amended with calcium silicate slag at 8.9 tons/acre (10 metric tons/hectare); the other tray containing only this mix served as the nonamended control. Five sprigs of Tifway bermudagrass were transplanted into each cell (255 sprigs). 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. In the lab, spores were grown on media containing Tifway bermudagrass leaves. From the spores, an inoculum was prepared and sprayed on stoloniferous Tifway plugs that were wrapped in moist paper towels and placed in 4-inch (10.2-centimeter) pots. Five plugs amended with silicon (8.9 tons/acre [10 metric tons/hectare]) and five plugs without silicon were sprayed with the propellant container until runoff. Afterward the pots were covered with opaque plastic cups to enhance relative humidity and infection by *B. cynodontis*. The containers were then transferred to the greenhouse.

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% leaf area infected). The plants were evaluated, approximately every 24 hours for five consecutive days. After the fifth day, plants were collected and processed for silicon analysis.

Chlorothalonil (Daconil Ultrex) and propiconazole (Banner Maxx) were applied at 0%, 10%, 25% or 100% of their labeled rates to Tifway bermudagrass that was either not amended or amended with calcium silicate (8.9 tons/acre [10 metric tons/hectare]) as previously described. Four hours after application of the fungicides, inocula of *Bipolaris cynodontis* (1×10^5 conidia/milliliter) were atomized onto the leaf surface of bermudagrass until runoff, as previously described. Plastic bags were placed over inoculated plants for 18 hours to promote infection by enhancing the relative humidity and temperature. Plants were rated for leaf spot development over a four-day period, as described previously. By the end of four days, approximately 94% of the leaf area of the control plants had become infected.

Results and discussion

There was a significant linear increase in

Figure 4. Bermudagrass leaf spot symptoms caused by inoculation with *Bipolaris cynodontis* four days after inoculation. The control plant (left) exhibited numerous areas of infection, whereas the plant treated with silicon (right) showed very few.

the percentage of silicon that accumulated in the leaves of bermudagrass as the rate of calcium silicate amended to the soil increased (Figure 2). The percentage of silicon in the leaf tissue was 38% to 105% greater than the silicon in the control. No linear response was found between increasing silicon rates and leaf dry weight (data not shown). However, these plants were grown under optimal environmental conditions and experienced no abiotic or biotic stresses.

LEAF SPOT SEVERITY

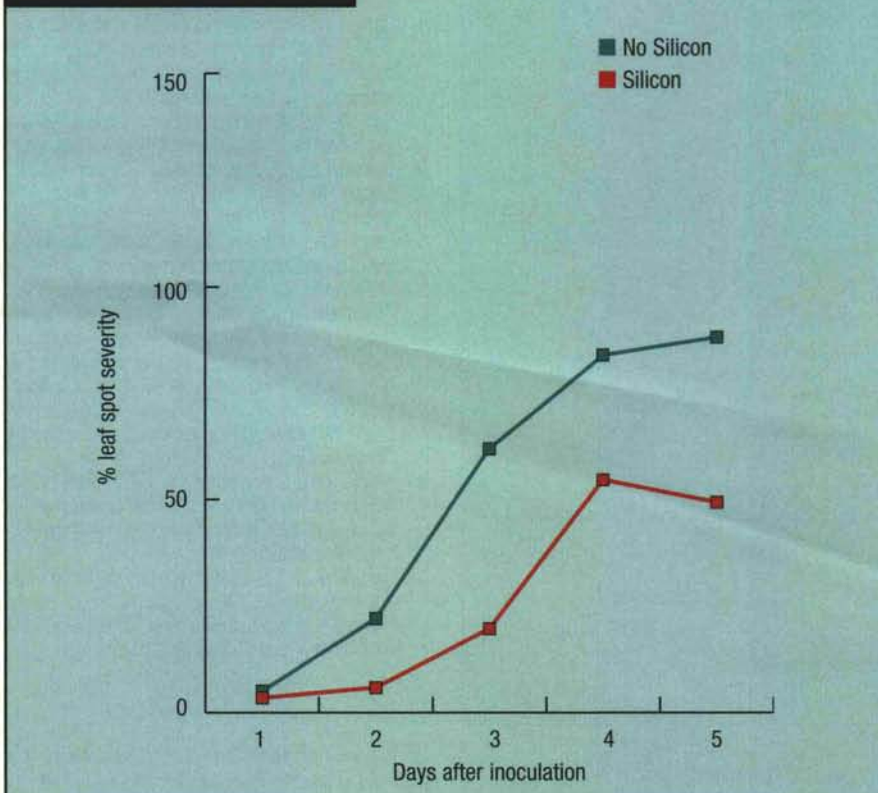

Figure 3. Development of bermudagrass leaf spot severity caused by *Bipolaris cynodontis* over a five-day period in untreated plants and in plants treated with silicon.

We have demonstrated for the first time that bermudagrass can accumulate silicon, especially when the soil is low or limiting in this element. The bermudagrass in this experiment was grown in a peat/sand mixture representative of many golf course greens throughout the United States. The results give credence to the idea that low silicon conditions may be prevalent on many golf course greens in the United States.

Silicon also was very effective in suppressing leaf spot development on bermudagrass caused by *Bipolaris cynodontis* (Figures 3, 4). The final percentage of leaf spot severity was reduced by 38.9%. Plant tissue levels of silicon dramatically increased when soil was amended with calcium silicate slag: The percentage of silicon in leaf tissue increased 80% compared with the nonamended control (Table 1).

Both fungicides were effective in suppressing leaf spot caused by *B. cynodontis* (Figure 5). Silicon alone was able to reduce leaf spot development by 64% in comparison to the nonamended control. For chlorothalonil, nonamended plants and plants amended with silicon showed no differences in suppressing *Bipolaris* leaf spot development at any of the applied rates. Similar results were observed for propiconazole, except at the 10% rate. Using the 10% rate of propiconazole + silicon resulted in a reduction in *Bipolaris* leaf spot that was 26% greater than the reduction achieved with the 10% rate of propiconazole alone.

These results suggest that using a soluble

SILICON IN BERMUDAGRASS

Treatment*	Control†	Inoculated‡	Mean§
With silicon	1.13 a	1.20 a	1.17 a
Without silicon	0.63 b	0.68 b	0.66 b

*With silicon = silicon applied as calcium silicate slag (8.9 tons/acre [10 metric tons/hectare]); without silicon = not amended. Values represent combined bermudagrass tissue of five replications.

†Noninoculated bermudagrass tissue.

‡Inoculated = inoculum concentrations of *B. cynodontis* at 1×10^4 conidia/milliliter.

§Values in the same column that are followed by different letters are significantly different.

Table 1. Percentage of silicon found in digested bermudagrass tissue that either has or has not been inoculated with *Bipolaris cynodontis*.

SILICON AND FUNGICIDES

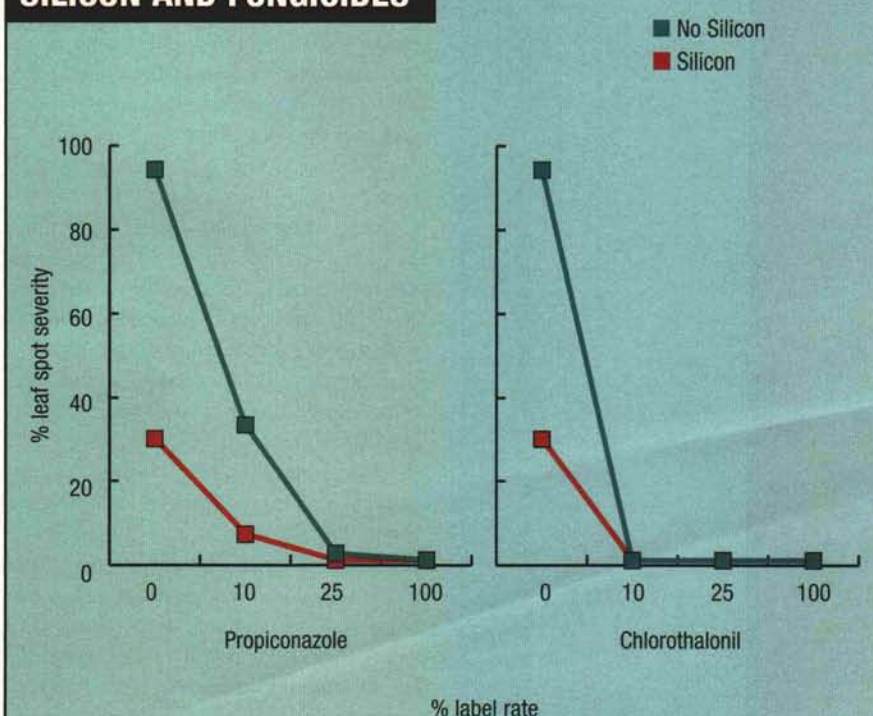

Figure 5. Effect of silicon and fungicides on severity of leaf spot caused by *Bipolaris cynodontis*.

source of silicon to amend soils that are low or limiting in plant-available silicon can enhance the resistance of bermudagrass to leaf spotting caused by *B. cynodontis*. In addition, to control this type of turf disease, fungicides applied at the label rate might be used more efficiently and effectively in combination with silicon. However, further research needs to be conducted to determine whether rates can be further reduced when used on bermudagrass grown in silicon-amended soil and whether other classes of fungicides perform similarly.

Acknowledgments

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