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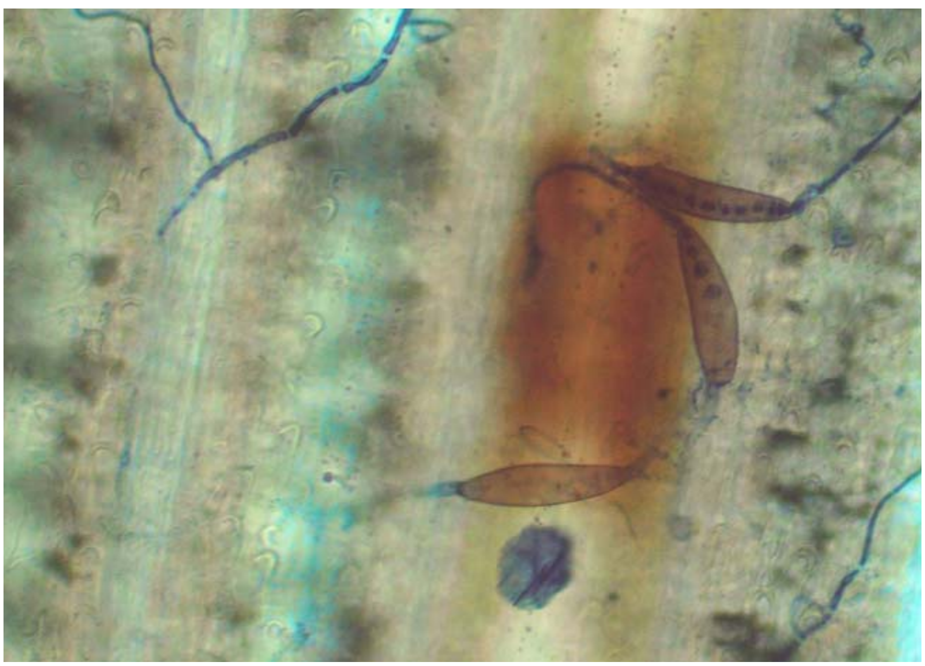

Scientists at the University of Florida tested whether applications of calcium silicate could reduce leaf spot and melting out symptoms of bermudagrass from infection by the fungal pathogen *Bipolaris cynodontis* (shown above).

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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 225 projects at a cost of $21 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Accumulation of Silicon by Bermudagrass to Enhance Disease Suppression of Leaf Spot and Melting Out

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SUMMARY

Soluble silicon (Si) has enhanced the growth and development of several plant species including rice, sugarcane, and most other cereals crops. Researchers at the University of Florida conducted experiments to determine if bermudagrass can accumulate silicon and if silicon could enhance host plant resistance to *Bipolaris cynodontis*, the causal organism of leaf spotting and melting out of bermudagrass. They found:

- There was a significant linear increase in silicon that accumulated in the leaves of bermudagrass as the rate of calcium silicate amended to the soil increased.
- Silicon also was very effective in suppressing leaf spot development on bermudagrass caused by *B. cynodontis*. Final % leaf spot severity was reduced by 38.9% compared to untreated controls.
- These results suggest that when soils low or limiting in plant available silicon are amended with a soluble source of silicon, 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.

Silicon is the second most abundant element after oxygen 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 comprised 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). These include six macroelements (N, P, K, S, Ca, and Mg) and seven microelements (Fe, Mn, Zn, B, Mo, Cl and 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 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, sugarcane, most other cereals, and several dicotyledons such

Bipolaris cynodontis was isolated from common bermudagrass exhibiting symptoms of leaf spot and melting out to test the ability of applied calcium silicate to suppress this disease.

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as cucumber and watermelon.

Higher plants vary in their capacity to accumulate silicon (5). Wetland gramineae (rice) absorb silicon as monosilicic acid, $Si(OH)_4$, on a dry matter basis ranging from 4.6 to 6.9%. Silicon accumulation in dryland gramineae (sugarcane, cereals, St. Augustinegrass) have been reported to be between 0.5 to 1.5%, and dicotyledons (i.e., broadleaf plants) less than 0.2%. 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 nitrogen in rice.

Silicon amendments also have proved effective in controlling both soilborne and foliar fungal diseases in cucumber, rice, sugarcane, turf and several other plant species (5). In rice, silicon has been demonstrated to control rice blast (teleomorph = *Magnaporthae grisea*, anamorph = *Pyricularia grisea*) as effectively as a fungicide and even reduce the rate or number of fungicide applications (4). In addition, partially blast resistant rice cultivars amended with silicon had their resistance augmented to the same level as those considered completely resistant (9).

Because this element had proven effective for controlling rice blast (2, 4, 8), Datnoff and Nagata (3) 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 44% and 78%, final disease severity between 2.0% and 38.8%, and final whole plant infection between 2.5% to 50.5%. Plant silicon content in Si-amended treatments increased between 2.2- to 3.5-fold over the non-treated 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 potentially be used as

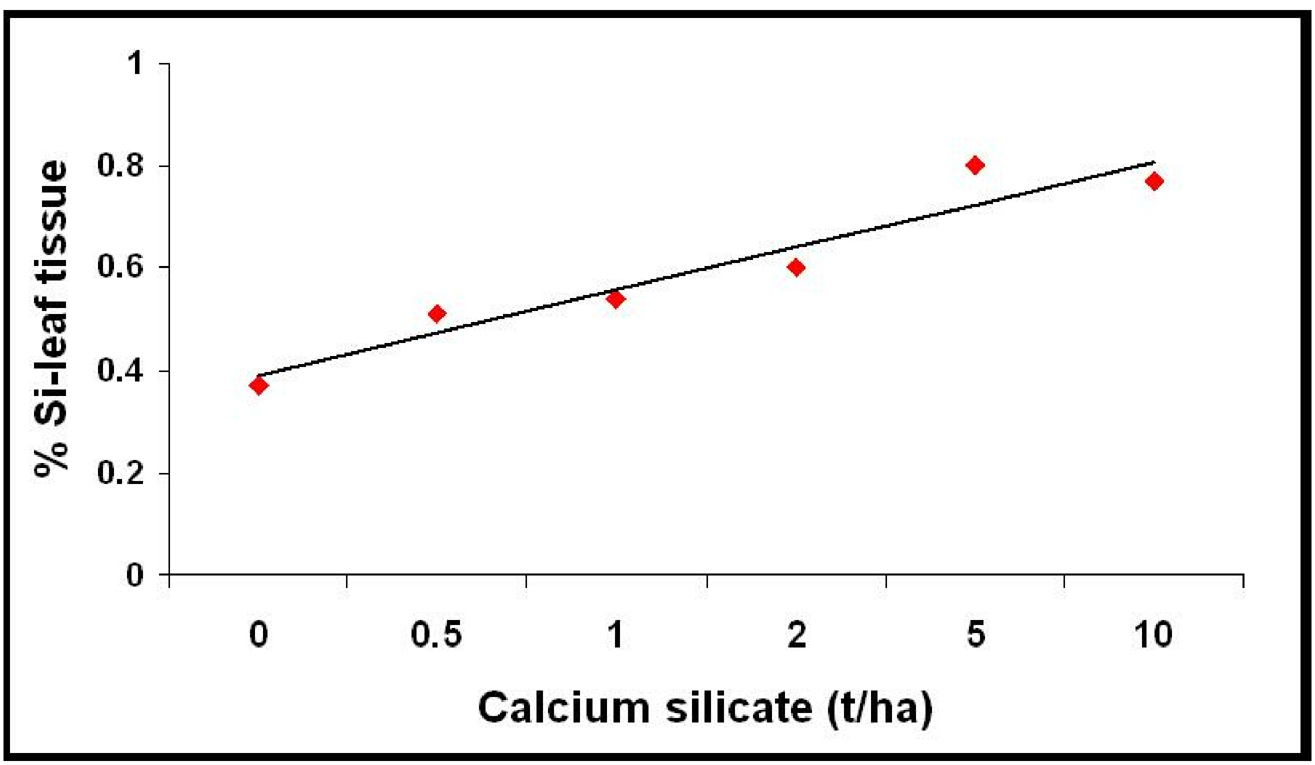

Figure 1. Silicon accumulation in bermudagrass leaves

an important component of an integrated management program for controlling diseases in bermudagrass. The objective of this study was to determine 1) if bermudagrass accumulates Si and 2) if Si could enhance host plant resistance to *Bipolaris cynodontis*, the cause of leaf spotting and melting out of bermudagrass in Florida.

Material and Methods

Sprigs of bermudagrass (173) 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 (20-22% Si, Calcium Silicate Corporation, Inc., Lake Harbor, FL) at several rates ranging from 0.5 to 10 tons/ha (0.4 to 8.9 tons/acre). After eight weeks, plants were collected and processed for silicon analysis utilizing the autoclaved-induced digestion method for plant tissue (6). Shoot biomass also was recorded

Number 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 ton/ha (8.9 tons/acre), while the other was the non-amended control. Five sprigs of bermudagrass ('Tifway') 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. This isolate was single spored and grown on Sach's media that contained autoclaved bermudagrass leaves ('Tifway'). Plates were placed in an incubator at 20° C with a 12-hour photoperiod. Sporulation on media and leaves occurred in seven to 14 days.

Leaves colonized by *B. cynodontis* were removed from three plates of Sach's media and placed in a 50-ml test tube. In addition, each of the three plates received 5 ml of deionized water and was scrapped with a rubber soldier. This was

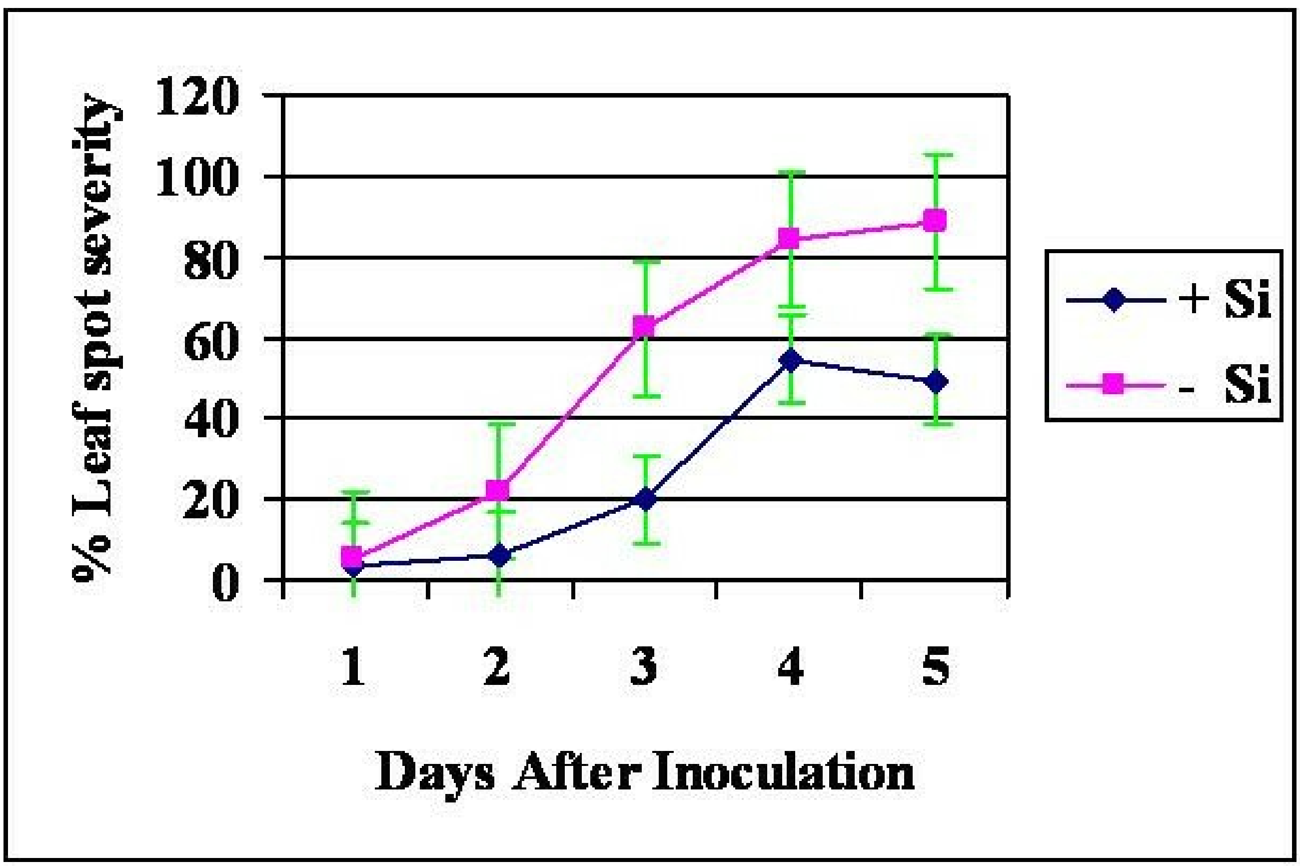

Figure 2. Development of bermudagrass leaf spot severity caused by *Bipolaris cynodontis* (10^4 CFU) over a five-day period. (Bars represent standard error)

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 (wetting agent) were added. The tube was then capped and placed on a vortex (Fisher Vortex Genie 2TM) 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 1×10^4 conidia/ml was prepared.

This inoculum was transferred to a two-part Spra Tool used for atomizing the plants. Stoloniferous plugs (4.76 cm diameter) of Tifway bermudagrass were wrapped in moist paper towels and placed within 10.2-cm azalea pots. Five plugs amended with silicon (10 t/ha, 8.9 ton/acre) and five plugs without silicon were sprayed with the propellant container till 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.

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 for five consecutive days, approximately every 24 hours. After the fifth-day, plants were collected and processed for silicon analysis as described previously. Data analysis included the use of linear regression, Student's t-test and Fisher's Protected LSD ($P<0.05$).

Results and Discussion

There was a significant linear increase in % silicon that accumulated in the leaves of bermudagrass as the rate of calcium silicate amended to the soil increased (Figure 1). The content of silicon (%) in the leaf tissue increased between 38 to 105% 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 Florida and the rest of the US.

Silicon also was very effective in suppressing leaf spot development on bermudagrass

Figure 3. Bermudagrass leaf spot symptoms caused by *Bipolaris cynodontis* (1×10^4 conidia/ml) four days after inoculation (control plant on left) and bermudagrass treated with silicon with very few leaf spot symptoms (treated plant on right).

Treatment [a]	Control[b]	10^4 [c]	X [d]
With Silicon	1.13 a	1.20 a	1.17 a
Without Silicon	0.63 b	0.68 b	0.66 b

[a]Treatment, With Silicon = silicon applied as calcium silicate slag (2,000 kg Si/ha) and Without Silicon = non-amended control. Values represent combined bermudagrass tissue of five replications.

[b] Non-inoculated bermudagrass tissue

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

[d] Mean value of With Silicon and Without Silicon treatments. Values followed by different letters are significantly different based on Student's t-test ($P< 0.05$).

Table 1. Silicon analysis (%) of digested bermudagrass tissue ('Tifway') non-inoculated and inoculated with *Bipolaris cynodontis*

caused by *B. cynodontis* (Figures 2 and 3). Final % leaf spot severity was reduced by 38.9%. Plant tissue levels of silicon dramatically increased when soil was amended with calcium silicate slag. There was an 80% increase in %Si in leaf tissue over the non-amended control (Table 1).

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 mangement - 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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