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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 400 projects at a cost of $30 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***.

Silicon and the Development of Gray Leaf Spot of Perennial Ryegrass Turf

U. N. Nanayakkara, W. Uddin, and L. E. Datnoff

SUMMARY

Silicon amendments have been proven effective in controlling fungal diseases of various crops. However, effects of silicon amendments on gray leaf spot (*Magnaporthe oryzae*) of perennial ryegrass are not known. Studies were conducted at The Pennsylvania State University in controlled-environment chambers and microplots where perennial ryegrass pots were buried among perennial ryegrass turf to determine the effects of silicon amendments on gray leaf spot development.

- Plants were grown in two soil types: peat:sand mix (soil Si = 5.2 mg/liter) and Hagerstown silt loam (soil Si = 70 mg/liter). Both soil types were amended with two sources of silicon—wollastonite and calcium silicate slag—at 0, 0.5, 1, 2, 5, and 10 metric tons/ha and 0, 0.6, 1.2, 2.4, 6, and 12 metric tons/ha, respectively.
- Nine-week-old perennial ryegrass was inoculated with *M. oryzae*. Gray leaf spot incidence and severity were assessed two weeks after inoculation.
- Gray leaf spot incidence and severity of perennial ryegrass significantly decreased by different rates of wollastonite and calcium silicate slag applied to both soils under both experimental conditions.
- Tissue silicon content increased consistently with increasing amount of silicon in the soils, while disease incidence decreased consistently with increasing tissue silicon content in all four soil and source combinations under both experimental conditions.
- These findings suggest that silicon amendments may be utilized in integrated gray leaf spot management programs on perennial ryegrass.

Gray leaf spot, caused by *Magnaporthe oryzae*, is a serious disease of perennial ryegrass (*Lolium perenne*) turf. Severe outbreaks of gray leaf spot have occurred on golf course fairways in various regions of the United States in recent years, resulting in extensive loss of turf (13, 17, 19, 20). Cultural management practices often do not provide adequate control of gray leaf spot due to rapid development of the disease, high susceptibility of currently available cultivars (21), and host susceptibility at all stages of development. Currently, fungicides are considered to be the best method available for managing gray leaf spot (18). However, turf managers often prefer employing integrated disease management strategies with major emphasis on cultural practices coupled with chemical approaches that are cost effective.

Although silicon (Si) is the second most abundant element after oxygen in the earth's crust, certain soils tend to be low in plant-available silicon (5). Low-silicon soils are typically highly weathered, leached, acidic, and low in base saturation. These soils may be found in some golf

Characteristic gray leaf spot necrotic lesions on a perennial ryegrass leaf blade.

U. N. NANAYAKKARA, Ph.D, Former Graduate Student, and W. UDDIN, Ph.D., Professor, Department of Plant Pathology, The Pennsylvania State University, University Park, PA; and L. E. DATNOFF, Ph.D., Professor, Department of Plant Pathology, University of Florida, Gainesville, FL.

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Extensive damage of perennial ryegrass turf by gray leaf spot.

courses, athletic fields, and home lawns where perennial ryegrass is cultivated. In addition, repeated growing of perennial ryegrass and removal of grass clippings may reduce the level of plant-available Si in these soils.

Silicon amendments have been proven effective in controlling both soilborne and foliar fungal diseases of several crops including turfgrass. In rice, silicon reduces the severity of several economically important diseases. Application of calcium silicate slag and other sources of silicon has become a routine disease management practice in many rice-growing countries including the United States.

Silicon amendments also have been shown to reduce several diseases of turfgrass. Severity of dollar spot (*Sclerotinia homoeocarpa* Bennett) and brown patch (*T. cucumeris*) decreased due to silicon fertilization in creeping bentgrass (12, 22). Datnoff and Nagata (6) demonstrated that silicon amendments significantly reduced the area under the disease progress curve (AUDPC) for gray leaf spot of St. Augustinegrass (*Stenotaphrum secundatum*) between 19 and 78% among several cultivars in the greenhouse.

Datnoff and Rutherford (7) showed that silicon amendments enhanced resistance of bermudagrass to leaf spotting and melting out caused by *Bipolaris cynodontis*. The enhanced resistance to disease in crops has been correlated with the applied amount of silicon and with the concentration of silicon in tissue of rice, sugarcane, St. Augustinegrass, and bermudagrass (2, 6, 7, 8, 14, 16). Effects of silicon amendments on gray leaf spot (*M. oryzae*) of perennial ryegrass are not known.

Rice, which is known to be responsive to silicon fertilization, has been observed to be non-responsive when grown in certain soils. Datnoff et al. (9) attributed this failure to the use of low


Characteristic gray leaf spot (twisting and flagging) on perennial ryegrass leaf blade.

rates of silicon fertilizers or to soils that were not deficient in plant-available silicon. Therefore, soil type may influence the effects of silicon amendments on gray leaf spot of perennial ryegrass. Although several sources of silicon have been utilized quite extensively, their concentrations, solubility of silicon, and the content of other elements varied widely. This study investigated the effects of soil type, source of silicon, and rate of silicon application on incidence and severity of gray leaf spot in perennial ryegrass turf.

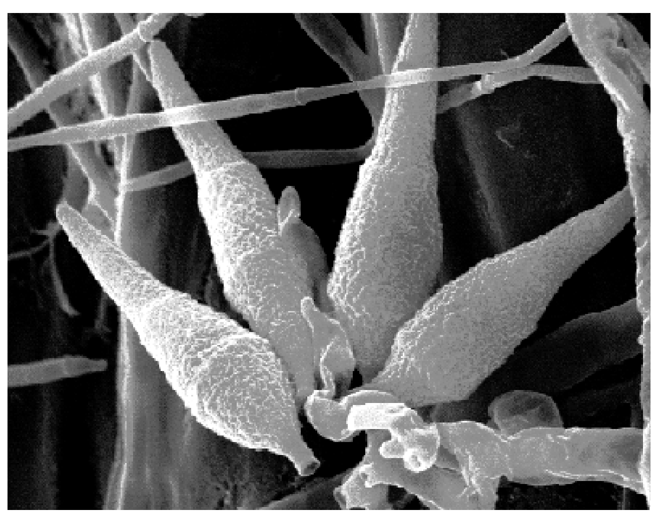
Materials and Methods

Experiments were conducted in controlled-environment chambers and microplots. The experiments were laid out as split-split-plot designs with soil type as the main-plot factor, source of silicon as the split-plot factor, and rate of silicon as the split-split-plot factor. The soil types used were: (i) peat:sand mix (50:50 by volume) and (ii) a Hagerstown silt loam soil collected from Joseph A. Valentine Turfgrass Research Center. Hagerstown silt loam is an Alfisol described as fine, mixed, mesic, typic hapludalfs (1).

Peat:sand mix contained a soil silicon level of 5.2 mg/liter with a soil pH of 6.3, while Hagerstown silt loam had a soil silicon level of 70 mg/liter and a soil pH of 7.3. Both soil types were amended with two commercially available sources of silicon: (i) calcium silicate slag and (ii) wollastonite.The soils were amended at the rates of 0, 0.5, 1, 2, 5, and 10 metric tons/ha and 0, 0.6, 1.2, 2.4, 6, and 12 metric tons/ha with wollastonite and calcium silicate slag, respectively. Each treatment was replicated four times, and trials were conducted three times at different periods for both controlled-environment and microplot experiments.

'Legacy II' perennial ryegrass was seeded at the rate of 20 g/m^2 and maintained in the greenhouse. Three-week-old plants were trimmed to 8-cm height, then weekly thereafter to the same height. In microplot experiments, perennial ryegrass was grown in the greenhouse for 6 weeks as described above. Holes in the ground were then made with a cup cutter in an area of established perennial ryegrass turf at the Joseph A. Valentine Turfgrass Research Center, University Park, PA. The pots were then placed in the holes, keeping the rims of the pots at ground level. Fertilization was continued weekly, and grass was mowed to the same 2.5-cm height as the grass surrounding the buried pots until inoculation with *M. oryzae*.

Grass blades were collected from 9-week-old perennial ryegrass from each replicate of all treatments. The grass blades were dried in a drying oven and ground for analysis of silicon. The silicon content in plant tissue (% by dry weight) was determined by the method described by Elliott and Snyder (11). Soil samples collected


Cryo-scanning electron micrograph of spores of gray leaf spot pathogen, *Magnaporthe oryzae*.

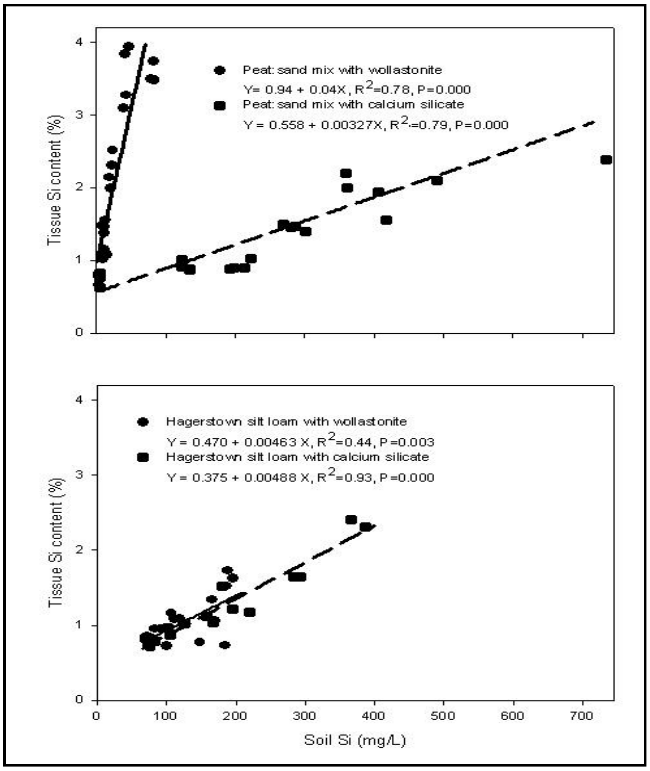


Figure 1. The relationship between soil silicon level and tissue silicon content of perennial ryegrass grown in peat:sand mix and Haagerstown silt loam amended with wollastonite and calcium silicate slag in controlled-environment experiments.

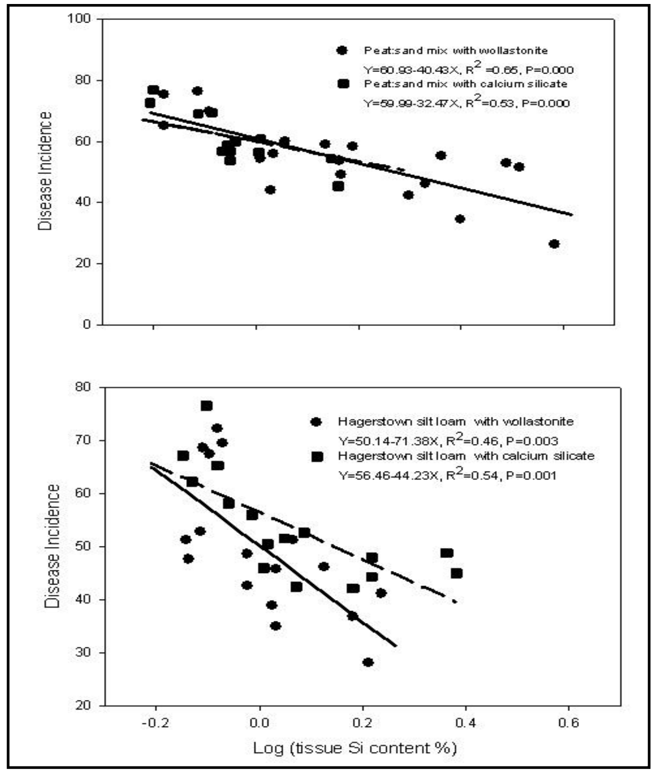


Figure 2. Relationship between disease incidence and tissue silicon content (transformed to logarithmic values) of perennial ryegrass grown in peat:sand mix and Hagerstown silt loam amended with wollastonite and calcium silicate slag.

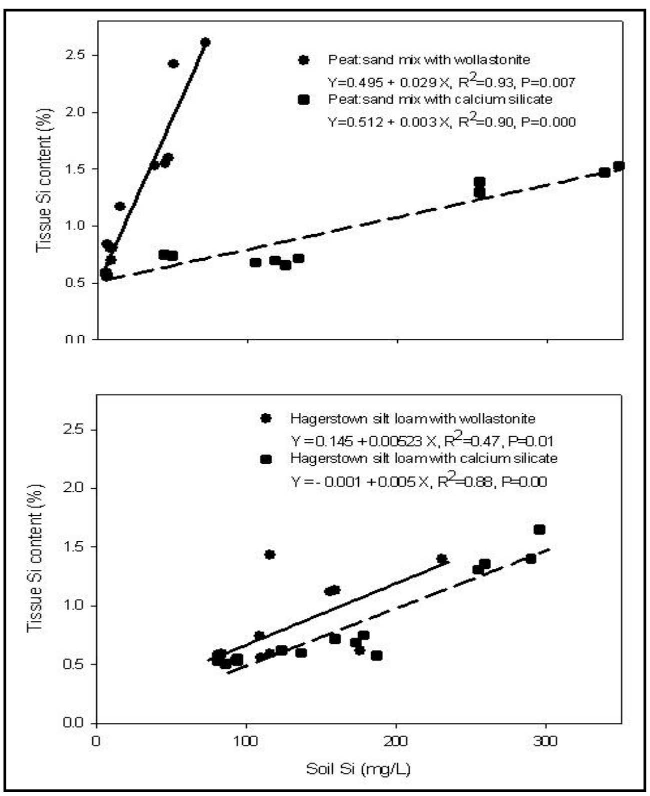


Figure 3. Relationship between tissue silicon content and soil silicon level of perennial ryegrass grown in peat:sand mix and Hagerstown silt loam amended with wollastonite and cacium silicate slag in microplot experiments.

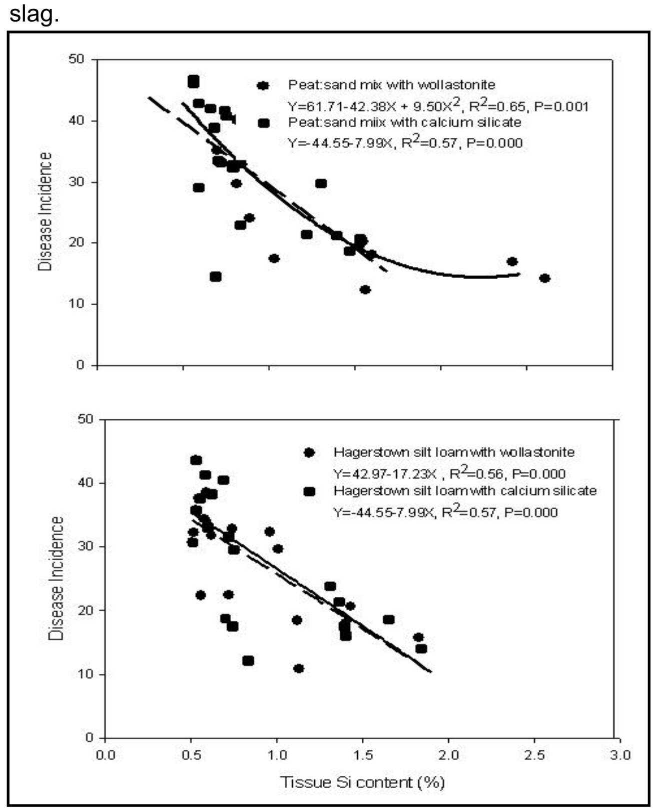


Figure 4. Relationship between disease incidence and tissue silicon content of perennial ryegrass plants grown in peat:sand mix and Hagerstown silt loam amended with wollastonite and calcium silicate slag in microplot experiments.

from two replicates of each treatment were tested for silicon at the University of Florida, Belle Glade EREC soil testing facility. Soil samples were collected after silicon sources were mixed with the soils and before perennial ryegrass was seeded. Soil silicon levels were determined.

Nine-week-old perennial ryegrass plants were inoculated with the conidial suspension by atomizing the leaves until they were completely wet in both controlled environment experiments and microplot experiments. Plants atomized with distilled water served as the noninoculated control. Disease incidence and severity were assessed two weeks after inoculation with *M.oryzae* in all trials conducted under both experimental conditions.

Results

Disease incidence was generally higher in the perennial ryegrass grown in the peat:sand mix than in Hagerstown silt loam in all three trials. Disease incidence significantly decreased compared with the non-amended control up to 63, 71, and 60% for peat:sand mix amended with wollastonite, peat:sand mix amended with calcium silicate slag, and Hagerstown silt loam amended with both sources, respectively.

Regression analysis showed that tissue silicon content consistently increased with increasing amount of silicon in the soil in all four soil and source combinations for all three trials (Figures 1 and 3). Regression analysis also showed that disease incidence decreased consistently with increasing tissue silicon content for all four soil and source combinations for all three trials (Figures 2 and 4).

Discussion

Results from this study are in agreement with the findings from several crop species where silicon amendments have been shown to suppress various diseases (3, 4, 6, 7, 8, 12, 15, 22). Gray leaf spot incidence and severity of perennial ryegrass were significantly reduced by silicon applications to both soils in controlled-environment chambers and microplot experiments. Therefore, it appears that at least in these trials, silicon amendments can reduce disease development even in the soils that are not deficient in silicon such as Hagerstown silt loam.

Although differences in disease incidence were not consistent between soil types under both experimental conditions, disease severity did not differ between the two soil types in any of the trials under both experimental conditions. This suggests that level of disease suppression in both soil types appears to be similar. Several rates of wollastonite and calcium silicate slag applied to soils reduced both disease incidence and severity compared with a non-amended control under both experimental conditions.

Although disease severity was significantly reduced in silicon-amended treatments compared with the non-amended control, this study did not evaluate the effects of silicon on other components of resistance. Future studies may be conducted to determine the effects of silicon on components of resistance in the gray leaf spot–perennial ryegrass pathosystem.

This study investigated the effects of preplanting silicon applications on a single cultivar of perennial ryegrass. However, most golf course fairways and roughs have different blends of perennial ryegrass cultivars. There may be a genotypic variation in silicon accumulation and disease resistance among the cultivars of perennial ryegrass as reported in rice (10) and St. Augustinegrass (6). In addition, established perennial ryegrass stands on golf courses that are managed as fairways and roughs may differ in their response to soil amendments with silicon, since mowing height and frequency vary in these areas.

Acknowledgements

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