THE SOIL PROFILE

A newsletter providing information on issues relating to soils and plant nutrition in New Jersey

Volumes 14 & 15 Double Issue 2004 - 2005

Soil Fertility Targeted for Turfgrass Disease Suppression

The Center for Turfgrass Science at Rutgers University has an active interdisciplinary research and Extension program involving the study of soil fertility and plant disease interactions. This issue of *The Soil Profile* summarizes the findings and disease control recommendations based on soil fertility and plant pathology research conducted on turfgrass at Rutgers University over the last 15 years. This research program has resulted in the development of specific soil fertility practices designed for disease control. Following these recommendations not only suppresses disease but also significantly reduces the need for some pesticide applications.

Soil Fertility and Summer Patch Disease Control

Summer patch is caused by the ectotrophic, root-infecting fungus *Magnaporthe poae* Landschoot & Jackson. The disease can be difficult to control because root infection often occurs six to eight weeks before the appearance of foliar symptoms. Once the disease is established the overall appearance and quality of sports and recreational turf is markedly reduced. On Kentucky bluegrass, symptoms begin to appear in the early summer as circular patches of wilted turf 2 to 4 inches in diameter. As the disease progresses during the warm summer months, the patches may enlarge to more than 24 inches in diameter. The patches may take on irregular shapes such as rings and crescent patterns. Leaves on affected turf quickly fade from a grayish-green to a straw color during periods of hot weather (Fig. 1 and 2).

Figure 1. Summer patch symptoms on an annual bluegrass golf fairway (photo by B. Clarke).

Figure 2. Growth of perennial ryegrass within a patch of Kentucky bluegrass killed by *Magnaporthe poae* (photo by B. Clarke).

Nitrogen fertility management can affect disease severity in many crops and in the case of Kentucky bluegrass turf, the type of N fertilizer applied is a key factor that strongly influences the severity of summer patch.

Table 1. Effect of nitrogen source on pH in the rhizosphere and on the severity of summer patch disease on a Kentucky bluegrass turf in 1991. Nitrogen fertilizers were applied in 1990 and 1991 at the rate of 4 lbs/1000 sq. ft./year.

Nitrogen Source	Rhizosphere pH	Summer Patch Disease Severity[1]
No nitrogen	5.9	550
Potassium nitrate	6.3	830
Calcium nitrate	6.1	770
Ammonium chloride	5.2	110
Ammonium sulfate	5.3	210
Urea	5.7	640
Methylene urea	6.0	720
Sulfur coated urea	5.8	410

[1]Area under the disease progress curve.

Table 2. Influence of nitrogen source and lime application rate on summer patch disease severity and turf quality on a Kentucky bluegrass turf evaluated on September 14, 1998 after following three years of treatment regimes.

Nitrogen Source	Lime Rate	Summer Patch Severity Diam. x Intensity	Turf Quality 10=Best
None	None	12.1	5.0
$Ca(NO_3)_2$	None	8.6	7.8
	Low	7.6	8.5
	Medium	6.6	9.0
	High	7.8	8.8
$(NH_4)_2SO_4$	None	2.2	7.6
	Low	1.4	8.3
	Medium	2.0	8.7
	High	1.7	8.7
	$LSD_{0.05}$	2.8	0.7

Studies (Table 1 and 2) conducted during the last decade have consistently demonstrated that use of ammonium sources of nitrogen, such as ammonium sulfate, ammonium chloride, or ammonium thiosulfate, can reduce disease severity, compared to the use of either nitrate sources or urea sources (Table 1 and 2).

The effect of different nitrogen sources on summer patch disease severity is associated with changes in soil pH that accompany the use of a particular fertilizer (Table 1). In general, ammonium sources of nitrogen acidify the soil and nitrate sources of nitrogen tend to increase soil pH. Urea, and other urea-like fertilizer compounds, break down in soil to supply nitrogen in the form of ammonia. The urea hydrolysis reactions that are associated with these nitrogen sources initially cause an elevation of soil pH. Urease, the enzyme that facilitates urea hydrolysis, is especially active in the rhizosphere (zone immediately surrounding the root). These increases in rhizosphere pH that result from the use of either nitrate or urea sources of nitrogen provide a pH environment that is conducive to growth of the root-infecting fungus that causes summer patch disease.

Ammonium sources of nitrogen can cause soil acidification by two different processes. In the bulk soil, nitrification, or the process of converting ammonium to nitrate, releases acidity causing a lowering of the soil pH.

Nitrification

$$\underset{\text{Ammonium-N}}{NH_4^+} + \underset{\text{Oxygen}}{O_2} \xrightarrow{\text{Microbial Activity}} \underset{\text{Nitrate-N}}{NO_3^-} + \underset{\text{Acidity}}{H^+}$$

In the rhizosphere, the uptake of ammonium by plant roots is directly associated with the release of hydrogen ions, i.e., acidity from the roots (Fig. 4). Both processes are active in the turfgrass soil ecosystem but the extent to which one process predominates depends on how favorable the soil environment is for rapid nitrification versus how quickly the turf root system can take up the applied ammonium nitrogen before nitrification begins.

Because turfgrass normally takes up applied nitrogen fertilizer very rapidly (as much as 75% of a typical 1 lb/1000 sq. ft. application in the

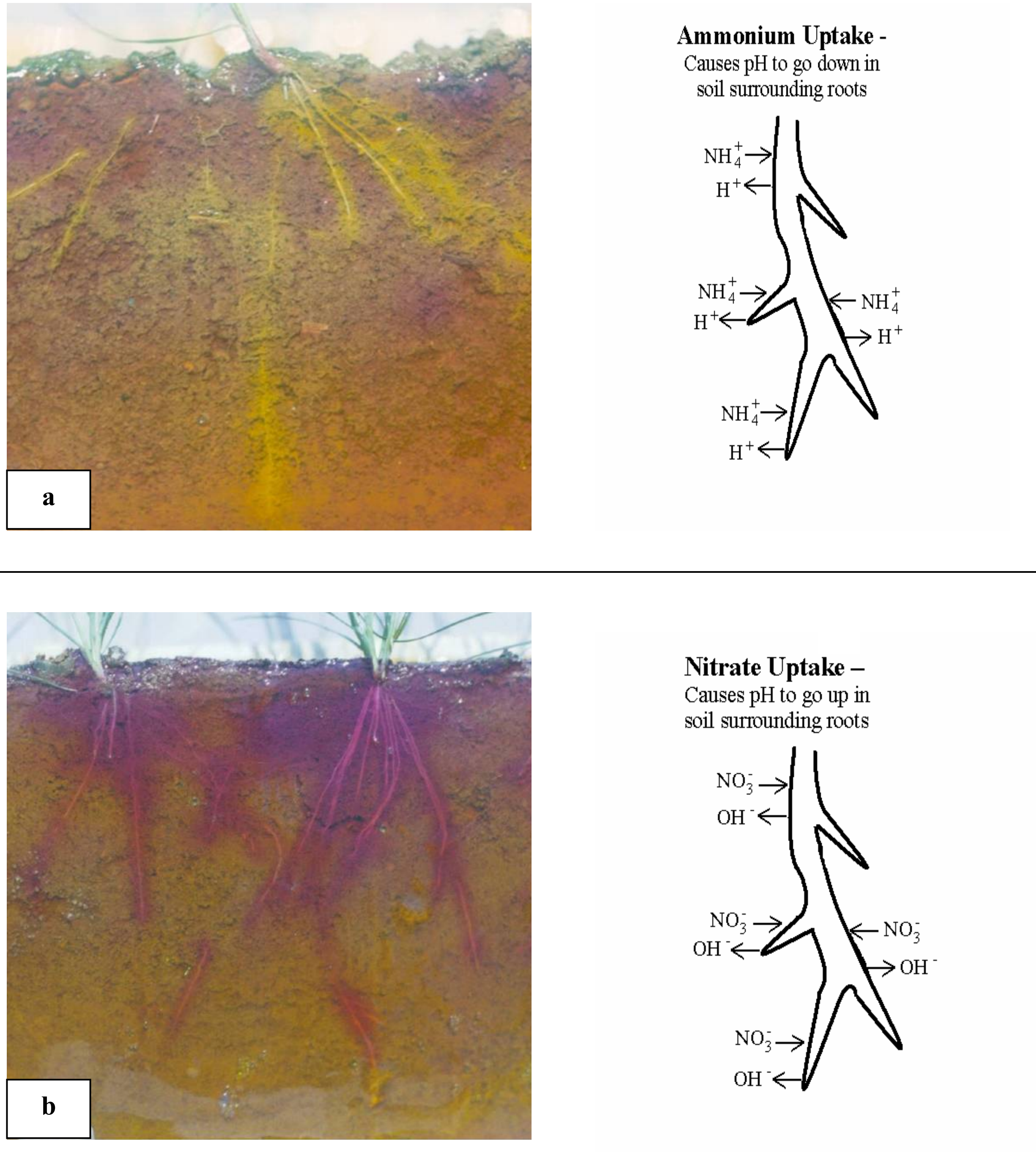

Figure 4. Rhizosphere pH as indicted by using bromocresol purple pH indictor. The yellow color (**a**) indicates that the rhizosphere pH is near 4.0, as a result of ammonium uptake and H^+ ion excretion from the root. The purple color (**b**) indicates that the rhizosphere pH is near 7.0, as a result of nitrate uptake and OH^- ion excretion from the root.

first day), a significant portion of the applied ammonium is likely taken up as ammonium (before nitrification converts ammonium to nitrate). This rapid uptake effectively enables rhizosphere acidification and suppression of summer patch disease.

A concern with the long-term continuous use of ammonium fertilizers without the application of limestone is that they have the potential to result in strongly acid soils that are detrimental to plant growth and turf quality. Our field research has shown that limestone should be applied as needed to maintain an acceptable soil pH level and turf quality. Findings demonstrate that a judicious liming program to maintain soil pH in the desired range of 6.2 to 6.5 does not decrease the effectiveness of ammonium fertilizers to control summer patch disease on Kentucky bluegrass (Table 2).

Another concern with the application of ammonium fertilizers (ammonium sulfate, ammonium chloride, or ammonium thiosulfate) is the potential to cause burn of turfgrass. Fertilization burn can be prevented by immediately applying irrigation water following fertilizer application.

Soil Fertility Recommendations for Summer Patch Disease Control

1. Maintain the soil pH between 6.0 and 6.2.
2. Ammonium sources of nitrogen, such as ammonium sulfate or ammonium thiosulfate, are effective fertilizers for suppression of summer patch.
3. Apply these ammonium sources according to the nitrogen needs of the turf (typically 2 to 4 lbs of N per 1000 square feet per year).
4. Avoid the use of nitrogen fertilizers that contain either nitrate or urea.
5. Apply irrigation immediately following the application of ammonium fertilizers.
6. A liming program should be used on turf treated with ammonium fertilizers to suppress summer patch disease and maintain soil pH levels for optimum turf quality.

Soil Fertility and Take-all Disease Control

Take-all patch disease in creeping bentgrass is caused by the fungus *Gaeumannomyces graminis* var. *avenae.* A related organism, *G. graminis* also causes take-all disease in wheat. Soil fertility practices such as manganese fertilization, ammonium nutrition, and soil pH adjustment are effective management strategies for controlling these diseases occurring on both bentgrass and wheat.

The fungal pathogens attack roots and stems of bentgrass during cool, wet weather. The disease symptoms are most evident during the months of April through June and September through November. Symptoms appear as reddish-brown to orange-bronze colored circular patches that are at first only 2 to 3 inches in diameter. On sites that are chronically affected, the patches may range up to 36 inches in diameter (Fig. 5). Weeds often colonize the centers of the affected patches.

Figure 5. Take-all patch is a perennial disease. Patch centers are often colonized by weeds and resistant grasses.

Take-all disease is most commonly found on newly constructed golf courses or on older courses that have undergone renovation. Soils with low levels of plant available manganese are especially vulnerable to the infection. Manganese availability deceases rapidly as soil pH level increases. Soils with high pH levels favor the development of take-all patch, as do coarse-textured (sandy) soils, low organic matter content soils, poorly drained soils, and recently fumigated sites. Heavy applications of lime or the use of alkaline irrigation water can stimulate severe outbreaks of the disease.

The pathogen thrives at a pH of 7.0 and has the ability to rapidly convert plant available manganese or applied fertilizer manganese to forms that are unavailable for plant uptake. The disease is also encouraged by applications of the nitrate form of nitrogen fertilizer.

Recent experiments conducted on a golf course in central New Jersey have demonstrated that manganese fertilization can effectively suppress this devastating disease. The experiments evaluated different times and rates of foliar spray applied to fairway turf. Manganese fertilization reduced disease severity on average by 75 percent. Spring or fall applications of manganese fertilizer were found to be equally effective in suppressing disease symptoms (Fig. 6). The application of 2 pounds of manganese per acre was found to be generally as effective as higher rates. It is possible, however, that higher application rates (6 to 8 pounds per acre) may be more effective when treating soils that have very low soil test levels of manganese.

The beneficial effect of applied manganese in suppressing take-all patch generally did not persist for more than 12 to 18 months (Fig. 7). The long-term effectiveness of manganese fertilizer is usually very limited because the pathogen and some other soil microorganisms rapidly convert plant available manganese to forms that are unavailable for plant uptake. Also, removing the clippings from playing surfaces can remove significant amounts of manganese from the soil. Clipping removal on golf course fairways is estimated to remove from 0.2 to 1.7 pounds of manganese per acre each year. For these reasons, reapplication of manganese fertilizer is necessary. An annual application of 2 or more pounds of manganese per acre is recommended for the most effective suppression of take-all patch. Manganese fertilizer may be applied more frequently or in split applications during the year, but the treatments have not been found to enhance disease control over a single annual application.

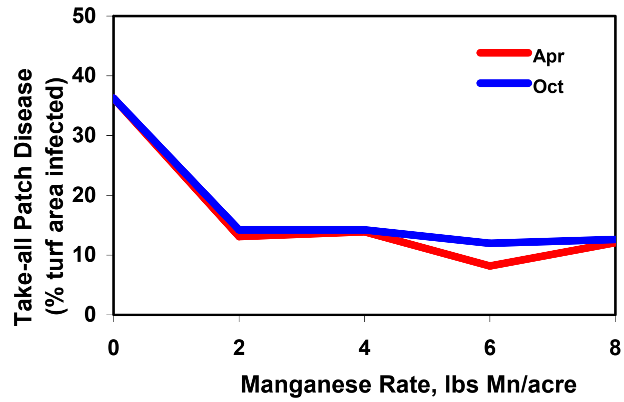

Figure 6. Take-all patch disease in spring 2000 in response to various rates of Mn fertilizer application in April 1998 or October 1998.

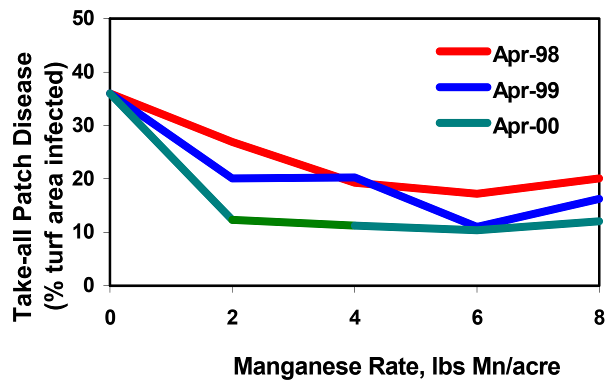

Figure 7. Take-all patch disease in spring 2000 in response to various rates of Mn fertilizer application in April 1998, April 1999, or April 2000.

More research is needed to develop guidelines about how to best interpret soil test levels of manganese in relation to the potential occurrence of take-all patch disease. Nevertheless, soil testing can help identify sites that are likely to be manganese deficient and are therefore more vulnerable to take-all patch disease. Interpretation of a soil test for manganese should consider both the soil test level of manganese and the soil pH. Previous observations suggest that soils growing bentgrass at pH 6.5 and with a Mehilch-3 extractable Mn level of only 12 ppm are susceptible to take-all disease. Rutgers Cooperative Extension fact sheet 973 (www.rce.rutgers.edu/pubs/pdfs/fs973.pdf) provides some general guidelines for interpretation of soil test levels of manganese.

Manganese fertilization should be viewed as only one part of an overall soil fertility program that is designed to minimize the incidence and severity of take-all patch. Because the pathogen grows well at a high soil pH (7.0) and because nitrate forms of nitrogen fertilizer tend to raise soil pH and reduce manganese availability, soil pH management and choice of nitrogen fertilizer are additional important factors for disease suppression.

For the best disease suppression and turf quality, maintain soil pH between 6.0 and 6.2. Soil pH levels above 6.2 will encourage take-all patch development, while pH levels below 6.0 can result in nutrient deficiencies and a general decline in turf quality. Soil pH in the upper two inches should be monitored annually or even more often to follow possible changes in pH as a result of the application of any soil amendment. Be especially careful to avoid excessive applications of limestone, and check the calibration of your lime spreader to reduce the possibility of over-application.

Because nitrate sources of nitrogen tend to enhance the severity of take-all disease, take care to avoid the use of nitrate containing fertilizers such as calcium nitrate or potassium nitrate. Ammonium sources of nitrogen, such as ammonium sulfate, are recommended because they acidify the soil, which improves manganese availability and helps to control the disease. The application of ammonium fertilizers should be followed by irrigation because they have the potential to cause foliar burn on turf.

Soil Fertility Recommendations for Take-all Patch Disease Control

1. Maintain the soil pH between 6.0 and 6.2.
2. Avoid heavy applications of limestone.
3. Check your lime spreader to ensure that it is properly calibrated to apply the correct rates of limestone for pH adjustment.
4. Apply manganese (Mn) fertilizer as manganese sulfate, $MnSO_4$, 32% Mn.
5. Apply 2 to 8 lbs of Mn per acre in April each year where bentgrass is known to be susceptible to take-all disease. Use the higher application rate of Mn on soils that have low soil test levels of manganese.
6. Interpretation of manganese soil fertility levels also depends on the soil pH level.
7. Ammonium sources of nitrogen are preferred because ammonium nutrition improves manganese uptake.
8. Apply the ammonium sources of nitrogen according to the nitrogen needs of bentgrass.
9. Avoid the use of nitrogen fertilizers that contain either nitrate or urea.
10. Apply irrigation immediately following the application of manganese or ammonium fertilizers.

Silicon Fertilization for Powdery Mildew Disease Suppression

Powdery mildew disease on Kentucky bluegrass is caused by *Erysiphe graminis*. Environmental conditions that favor infection are low light intensity and poor air circulation. The disease is very common on Kentucky bluegrass grown under greenhouse conditions. Powdery mildew symptoms initially appear as isolated colonies of fine white mycelia on leaves. As the disease progresses, the colonies enlarge and coalesce to cover much of the leaf surface. Heavily infected leaf tissue turns yellow or brown as it dies.

Although the powdery mildew fungi that infect turfgrass are different from those that cause diseases on other crops, fertilization with silicon may provide a new approach to suppression of this disease on Kentucky bluegrass. Enhanced silicon nutrition has already been shown to have a role in suppression of powdery mildew diseases on several horticultural crops such as pumpkin, cucumber, muskmelon, and zucchini. In addition to disease suppression, the benefits of silicon fertilization may include resistance to insects and tolerance to stress. Research on silicon fertilization of turfgrasses is limited but greenhouse experiments indicate that amending soils with silicon can delay the onset and reduce the severity of powdery mildew disease (Fig. 8).

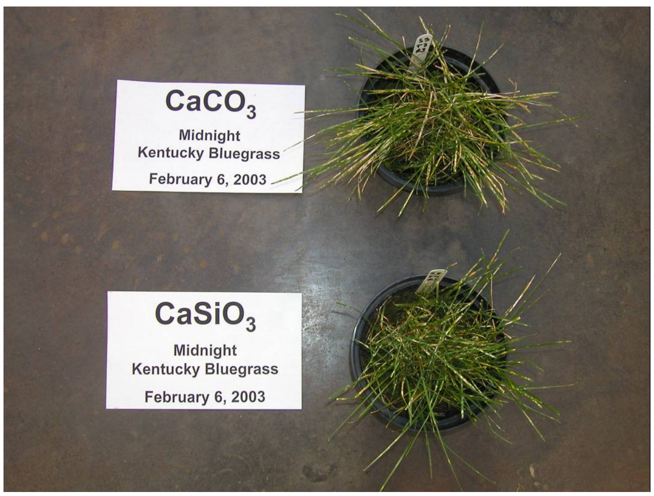

Figure 8. Powdery mildew disease on Kentucky bluegrass growing on soil amended with either calcium carbonate or calcium silicate.

Our greenhouse study compared the application of calcium silicate to calcium carbonate at rates needed to match the lime requirement of each of three different soils. Both calcium silicate and calcium carbonate can be used as liming materials and they have about the same ability to neutralize soil acidity (i.e., same calcium carbonate equivalent or CCE). There is no significant cost difference in applying either material as a liming agent. The selection of calcium silicate as a liming material, however, has the further benefit of enhancing silicon nutrition and providing some suppression of powdery mildew (Table 3). The potential benefits of amending soils with silicon may vary depending on the silicon supplying capacity of different soils. Additional research is planned for evaluating responses of turfgrass to silicon application in a field environment.

Table 3. Influence of liming material (calcium carbonate vs. calcium silicate) on powdery mildew disease ratings on Kentucky bluegrass grown on three soil types. Powdery mildew disease ratings: 0=no disease, 10=total disease coverage.

	Adelphia Woods	Adelphia Farm	Quakertown Farm	Average
	---------Powdery Mildew Disease Rating---------			
$CaCO_3$	4.1	5.6	5.7	5.1
$CaSiO_3$	1.7	3.9	5.0	3.5
	P>F			
	0.0004	0.52	0.19	0.002

Soil Fertility Recommendations for Powdery Mildew Disease Control

1. Use calcium silicate as an alternative to regular agricultural limestone.
2. Apply the calcium silicate based on its CCE and the lime requirement as determined by soil test.

Acknowledgements:

The research reported here on soil fertility and turfgrass disease suppression was supported by grants from the Center for Turfgrass Science, the New Jersey Agriculture Experiment Station, and the fertilizer and turfgrass industry. Soil fertility and plant pathology research described in this newsletter was labor intensive and required the conduct of many field trials. Research cooperators included Dr. Bruce Clarke, Specialist in Plant Pathology, Dr. James Murphy, Specialist in Turfgrass Management, David Thompson, Postdoctoral Research Associate, Stephanie Hamel, Postdoctoral Research Associate, and Wendy Hill, Graduate Student Research Assistant, Dennis Haines, Pradip Majumdar, and William Dickson provided technical assistance.

References

Heckman, J.R., B.B. Clarke, and J.A. Murphy. 2003. Optimizing Manganese Fertilization for the Suppression of Take-all Patch Disease on Creeping Bentgrass. Crop Science. 43:1395-1398.

Heckman, J.R., S. Johnston, and W. Cowgill. 2003. Pumpkin Yield and Disease Response to Amending Soil with Silicon. HortScience. 38(4):552-554.

Hill, W., J.R. Heckman, B.B. Clarke, and J.A. Murphy. 2003. Summer Patch Disease Severity on Kentucky Bluegrass in Response to Fertilizer Source. Journal of Plant Nutrition. 26:1499-1512.

Hill, W.J., J.R. Heckman, B.B. Clarke, and J.A. Murphy. 2001. Influence of Liming and Nitrogen on the Severity of Summer Patch of Kentucky Bluegrass. International Turfgrass Society Research Journal. 9:388-393.

Heckman, J.R., H. Liu, W.J. Hill, M. DeMillia, and W.L. Anastasia, 2000. Kentucky Bluegrass Responses to Mowing Practice and Nitrogen Fertility Management. Journal of Sustainable Agriculture. 15:25-33.

Hill, W.J., J.R. Heckman, B.B. Clarke, and J.A. Murphy. 1999. Take-all Patch Suppression in Creeping Bentgrass with Manganese and Copper. HortScience. 34:891-892.

Heckman, J.R., and J. Strick. 1996. Teaching Plant Soil Relationships with Color Images of Rhizosphere pH. Journal of Natural Resources and Life Sciences Education.25:13-17.

Thompson, D.C., B.B. Clarke, and J.R. Heckman. 1995. Nitrogen Form and Rate of Nitrogen and Chloride Applications for the Control of Summer Patch in Kentucky Bluegrass. Plant Disease. 79:51-55.

Heckman, J.R., H. Liu, and W.J. Hill. 1994. Impact of Mowing Practices and Fertilizer Sources on Turfgrass Quality. Rutgers Turfgrass Proceedings. 26:7-20.

Thompson, D.C., B.B. Clarke, J.R. Heckman, and J.A. Murphy. 1993. Influence of Nitrogen Source and Soil pH on Summer Patch Disease in Kentucky Bluegrass. International Turfgrass Society Research Journal 7. R.N. Carrow, N.E. Christians and R.C. Shearman (Eds.) Intertec Publishing Corp., Overland Park, Kansas. 7:317-323.

Heckman, J.R. 2001. Long-Term Study Confirms Clippings Sustain Fertility. TurfGrass Trends. 10:4-5.

Heckman, J.R., and J. Strick. 1998. Nitrification in Soil and Plant Nitrogen Nutrition Relationships. Focus on Microbiology Education.5:7-8.

Heckman, J.R., B.B. Clarke, and J.A. Murphy. 2003. Manganese Fertilization Suppresses Take-all Patch Disease on Creeping Bentgrass. Grounds Maintenance. October. pp.G22-G24.

Heckman, J.R. and B. Clarke. 1996. Ammonium Sulfate Affects Summer Patch Control. Lawn and Landscape. May 1996. pp.20-21.

Hamel, S.C., and J.R. Heckman. 1999. Impact of Mineral Silicon Products on Powdery Mildew in Greenhouse Grown Turf. Rutgers Turfgrass Proceedings. 31:215-220.

Heckman, J.R., 1997. Suppression of Powdery Mildew on Kentucky Bluegrass with Monopotassium Phosphate. Rutgers Turfgrass Proceedings. 29:145-146.

The Soil Profile

Rutgers Cooperative Extension
Plant Biology and Pathology Department
Rutgers, The State University of New Jersey
59 Dudley Road
New Brunswick, NJ 08901-8520
Email: heckman@aesop.rutgers.edu

Joseph R. Heckman, Ph.D.
Specialist in Soil Fertility

Desktop Publishing by Stephanie Romelczyk