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ABSTRACT

There are roughly 220 golf courses in Arkansas, and as many as 50% of these courses were constructed using common bermudagrass fairways. Although resilient, common bermudagrass loses density and quality over time. In this experiment physical and chemical properties of the soil were analyzed to determine the causes of decline in turf quality observed on several fairways of a local golf course. Once a particular fairway was selected for study and preliminary soil sampling conducted, GS+, a geostatistical computer program, was used to map the location of certain chemical deficiencies. A moderate to severe Mg deficiency was detected throughout the fairway. Twelve different fertility treatments were designed to enhance the overall density, texture, and color of the turf. Magnesium sulfate ($MgSO_4$), Primo™ (a plant growth regulator), and Nitron (an organic nitrogen source) all showed significant improvements in turf quality. Extensive and comprehensive soil testing was found to be very beneficial; "hidden" nutrient deficiencies were discovered, which allowed site-specific treatments to be included in the test.

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INTRODUCTION

Common bermudagrass, (*Cynodon dactylon*), is a hardy grass species that is widely used for sports fields and lawns in the southern United States. Many golf course fairways in Arkansas consist partly or entirely of common bermudagrass. Advancements have been made to increase vitality and appearance of grasses, but problems can arise. Common bermudagrass, though hardy, can experience problems with color, texture, and density, which may reduce its desirability as a fairway grass (D.E. Longer, personal communication). A number of factors may lead to poor stands. Disease, pest damage, mineral deficiencies, water stress, and physical properties of soil can all affect the overall appearance of a bermudagrass fairway. Golf courses are usually monitored closely for disease and pests; therefore, any noticeably reduced turf quality might result from chemical and physical soil properties.

Numerous nutrient amendments are available and can be added to a soil to increase the color, texture, and density of turf. However, in some cases standard nutrient management programs are not always effective in improving grass quality. The lack of micronutrients can be the cause for poor quality stands (Hummell, 1996). Also, soil physical properties can significantly affect the availability of applied nutrients to the plants. Bulk density and soil texture are the two main physical properties that may alter nutrient availability (Turner, 1992).

Bulk density is soil mass per unit of volume and is usually expressed in kg/m^3. If the soil has a high bulk density, plant roots may not be able to reach water and nutrients that exist deeper in the soil. Root growth and penetration is often inhibited in soils with a bulk density equal to or greater than 1600 $kg\ m^{-3}$ (Brady and Weil, 1999). Increased bulk density also impedes water infiltration and may cause ponding of water on the surface, which can lead to water logging in the roots, cre-

Meet the Student-Author

I am from Hampton and graduated from Hampton High School in 1998. I am a senior majoring in crop management in the Department of Crop, Soil and Environmental Sciences. I have received the Romeo E. Short, Joseph E. Fleming, Arkansas Plant Food Association, Staple Cotton, and Fontaine R. Earle Crop Science scholarships. I have been involved in many activities while attending the University of Arkansas, including being a New Student Orientation Leader, an active member and officer in Collegiate 4-H/FFA, an executive officer in FarmHouse Fraternity for three years, and serving as a Dale Bumpers College of Agricultural, Food and Life Sciences Student Ambassador. This past summer I was honored to be a part of the Adair/Bollenbacher internship program in the Department of Plant Pathology here at the University.

I decided to do this project upon the encouragement of my advisor, Dr. David Longer. I learned many things about turf grass, soil testing, soil fertility, and general factors that affect plant growth. After completing my bachelor's degree, I plan to continue on with graduate school and further my education in some agronomic field. I learned a lot about the research process, and I feel better prepared to enter a graduate degree program. All in all, I consider this a great experience that will assist me in the future.

Matt Cordell

ating an anaerobic environment that is not conducive to nutrient uptake or plant growth (Brady and Weil, 1999).

Soil texture refers to the relative amounts of sand, silt, and clay in a soil. The texture of the soil may also play a vital role in turf vigor and growth. In finer textured soils, such as clay loams, there is an increase in water holding capacity and cation exchange capacity. In coarse textured soils, such as sandy loams, there is increased infiltration of water and leaching of surface applied nutrients. This increased water infiltration in sandy soils may cause leaching of essential nutrients that are not commonly applied.

Turf texture and density are commonly rated on a scale from 1 to 9, 9 being the most desirable. Initial observations were taken in June 2000; the fairway showed poor leaf color, reduced turf density, and overall poor quality, resulting in texture, density, and color ratings ranging from 4 to 6. Based on the results of physical and chemical soil analyses, and experiment was designed to incorporate site-specific treatments designed to correct mineral deficiencies and bring about improvements in turf texture, density, and color.

MATERIALS AND METHODS

This experiment was conducted during the spring and summer of 2000. Samples were collected from the sixteenth fairway at Fayetteville Country Club. Prior to the establishment of the test plots in June, the entire fairway was plotted with global positioning systems (GPS) equipment and soil test samples were obtained at each coordinate to allow plot mapping. The experimental area was established in a uniform appearing section of the fairway and the individual plots were 1.55 m x 1.55 m with 12 plots (treatments) per block and four blocks (replications) for a total of 48 plots. Soil samples were taken from 60 points within the experimental area. These 60 samples were tested for both chemical and physical properties including texture and bulk density.

The chemical analyses were determined at the University of Arkansas Agricultural Diagnostic Laboratory for macronutrients and micronutrients. Bulk density and particle size analyses were determined in the fairway. Bulk density was determined by taking undisturbed cores of soil and dividing the oven-dry mass of soil by the soil volume. Particle size analyses were determined by the methods outlined by Day (1965).

After the bulk density and texture tests were evaluated, bulk density and soil texture was found to be uniform throughout the plot, and thus it was determined that the soil's physical properties were not likely limiting the overall turf quality. All of these measurements were in a uniform and acceptable range. Therefore, using these observations, along with the initial quality ratings, an experiment was designed to evaluate 12 fertility and plant growth regulator combinations to determine if any treatment could improve the color, texture, or density of common bermudagrass.

All treatments were combinations of rates and time of application of commercially available fertilizer products with the exception of Primo™, which is a plant growth regulator that promotes turf density. The experimental design was a randomized complete block with all treatment rates, applications, and descriptions shown in Table 1.

Table 1. Descriptions and rates of fertility and growth regulator treatments.

Treatment	Description and Application
1. Control	No fertilizer, plant growth regulator, or cultural treatments
2. Primo™	Applied monthly (May-September) at 0.05 ai/1000 ft^2
3. Agrilizer™ 100	Slow release N fertilizer (24%N) single application at 2.3 lbs/1000 ft^2
4. Agrilizer™ 200	Slow release N fertilizer (24%N) single application at 4.6 lbs/1000 ft^2
5. Poly O Urea 100	Polyolefin coated slow release urea (40% N) single application at 2.3 lbs/1000 ft^2
6. Poly O Urea 200	Polyolefin coated slow release urea (40% N) single application at 4.6 lbs/1000 ft^2
7. Urea 100 split	Urea (45% N) at 2.3 lbs/1000 ft^2 (split application in June, July, August)
8. Urea 200 split	Urea (45% N) at 4.6 lbs/1000 ft^2 (split application in June, July, August)
9. Nitron™	Natural Organic (9% N) single application at 20 lbs/1000 ft^2
10.Superintendent's choice	Urea in blends (45% N) in split applications at 4.6 lbs/1000 ft^2
11. Urea	(45% N) at 4.6 lbs/1000 ft^2
12. Urea + Mg	(45% N) at 4.6 lbs/1000 ft^2 with $MgSO_4$

*Note: (1) All weed control was standard for all plots. (2) All plots were irrigated at the same time and rate.

All texture, density, and color evaluations were visual and based on the accepted 1 to 9 scale with 9 being most desirable. Texture and density ratings were done in July, August, and September. Color ratings were taken only in September. Analysis of variance was performed on the data to statistically differentiate between treatments and control and Superintendent's choice (JMP4, 2000).

Geostatistics is a statistical tool for determining the distribution of spatial parameters. Geostatistics exploits the spatial relationship of parameters and ultimately enables optimal land management, especially when regarding fertilization. Ca:Mg ratios were computed for the entire sixteenth fairway and analyzed in GS+ a geostatistical software package (Gamma Designs Software, 2000).

No significant differences were observed across the fairway for bulk density and particle size. Soil nutrients were found to be normal with the exception of low soil Mg levels. Evaluation of soil chemical analysis revealed a highly reduced level of soil Mg as expressed by the Ca to Mg ratio (Fig. 1) . The low Ca:Mg values indicated a

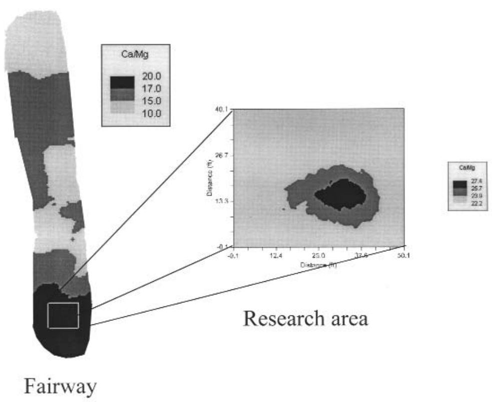

Fig. 1. Kriged map of calcium to magnesium ratio for the fairway and research plot.

Mg deficiency, which could cause poor turf quality and color, since Mg is part of the chlorophyll molecule and is essential for proper nitrogen (N) utilization. If plants do not utilize N properly, poor color and quality often result. Ca to Mg ratios found in our samples ranged from 16:1 to 35:1; much higher than optimal. Optimum Ca:Mg ratio should range from 10:1 to 15:1 (Tisdale, 1993). The location and severity of these deficiencies can be illustrated well in a geostatistical map (Fig. 1).

Analysis of the treated plots showed no visual differences or influence on turf texture. Several of the treatments affected turf color and density. Poly O (100), Poly O (200), Urea 200 and Nitron™ were found to produce higher density ratings in July compared to the control. All remaining treatments showed no influence at all. (Fig. 2). No differences were observed during the second month; however, in the

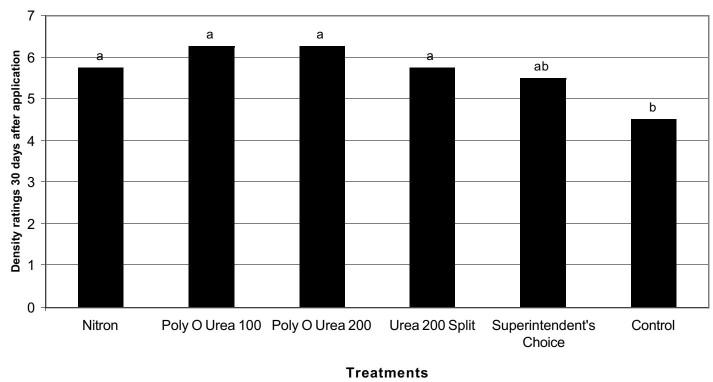

Fig. 2. Turf density ratings in July 2000 for five treatments compared to the control for bermudagrass plots on the sixteenth fairway, Fayetteville Country Club. (P≤0.05)

third month Primo™ and Nitron showed significant differences in turf density when compared to the control (Fig. 3) while other treatments did not. Nitron is a slow release organic source of N, which may explain the delay in having an effect.

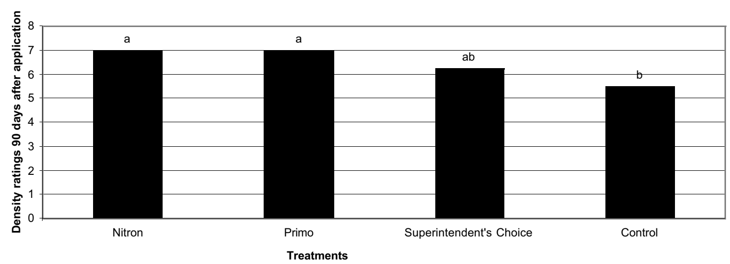

Fig. 3. Turf density ratings in September 2000 for three treatments compared to the control for bermudagrass plots in the sixteenth fairway, Fayetteville Country Club. (P≤0.05)

Plots treated with Primo™ showed significant color change when compared to the Superintendent's choice. Applications of magnesium in the form of $MgSO_4$ were included in an attempt to correct Mg deficiencies found in the soil samples. A significant increase in color ratings resulted from the $MgSO_4$ treatments. In addition

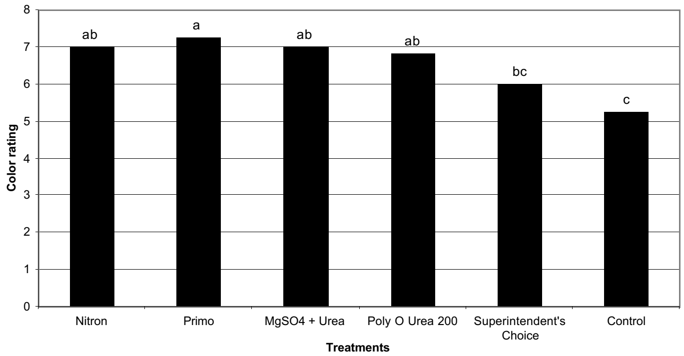

Fig. 4. Final turf color readings in September 2000 for five treatments compared to the control for bermudagrass plots in the sixteenth fairway, Fayetteville Country Club. ($P \leq 0.05$)

to $MgSO_4$ treatments, Agrilizer 100, Nitron, and Poly O Urea 200 showed significant increases in color when compared to the control (Fig. 4) while other treatments showed no increase in color.

Kriged maps reveal the spatial distribution of Ca/Mg. Although not used on golf courses at this time, site-specific application of Mg could be used to decrease the Ca/Mg ratio, which would, optimize fertilizer management, and reduce costs, and while improve application efficiency.

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