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A Comparison of Turfgrass Response to Biologically Amended Fertilizers

Charles H. Peacock[1] and Paul F. Daniel[2]
Department of Crop Science, North Carolina State University, Raleigh, NC 27695

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Abstract. **Initial release of N from waste materials used as natural organic N carriers for turfgrass may be slow due to the need for microbial degradation. In a greenhouse study, 'Rebel' tall fescue *(Festucau arundinacea* Schreb.) and 'Tifway' bermudagrass *[Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burtt-Davy] growth response to a natural organic fertilizer (Turf Restore) amended or not amended with a soil-derived microbiological inoculum were compared with soluble urea using sterilized and nonsterilized soil. No interactions of soil sterilization and fertilizers were noted at 19 days after treatment (DAT). Urea fertilizer increased tall fescue growth rates by 68% in the nonsterilized soil and 126% in the sterilized soil compared to rates for turf grown with inoculated Turf Restore. Nitrogen uptake rate was 419% higher with urea-fertilized turf in the sterilized soil than for turf fertilized with inoculated Turf Restore. Soil sterilization at 33 DAT no longer affected turf response, but turf growth rate was 133% higher and N uptake 353% higher with urea fertilization than with inoculated Turf Restore. Infection of the plants with *Rhizoctonia* spp. at 72 DAT was unaffected by fertilizer treatments. Bermudagrass response was similar to that of tall fescue. Growth rate was 67% and N uptake 51% higher with urea than with Turf Restore through 17 DAT, regardless of inoculant addition. Amendment of the natural organic fertilizer Turf Restore with a soil-derived biological inoculant did not enhance turf growth rate or N uptake nor impact infection with *Rhizoctonia* spp.**

Natural organic fertilizers are materials of plant and animal origin that require microbial activity for N release. Before 1850, almost all fertilizers were of natural origin. Since the 1960s, there has been a shift to the use of synthetic N fertilizers (Tisdale and Nelson, 1975). Processed organic wastes, such as activated sewage sludges, account for only ≈0.1% of the fertilizer N consumed in the United States, even though they represent the largest total tonnage of slow-release N fertilizers (Hauck, 1985). There is renewed interest in expanding the use of natural organic materials as turf fertilizers in response to the need to find alternatives to landfill dumping. Release of N from natural organic materials at a rate that is of practical benefit to turfgrasses depends on degradation by soil microorganisms. Turf response can be significantly reduced compared with other N sources depending on environmental conditions (Volk and Horn, 1975). Amending natural organic fertilizers with an inoculum of soil-derived microorganisms and enzymes may hasten N release and improve initial turfgrass response. Berndt (1986) found acceptable Kentucky bluegrass *(Poa pratensis* L.) performance in field trials using amended natural organic fertilizer materials. However, he concluded that while natural organic materials compared favorably with other slow-release N carriers, the turf did not respond as quickly as when fertilized with soluble urea. Our study compared turfgrass growth and N uptake under greenhouse conditions following applications of 1) natural organic fertilizer that was microbiologically amended, 2) an identical nonamended material, and 3) urea. Comparisons were made using sterilized and nonsterilized soil.

Separate greenhouse studies were conducted in 1990 at North Carolina State Univ., Raleigh, to evaluate the response of 'Rebel' tall fescue and 'Tifway' bermudagrass to Turf Restore (Ringer Corp., Minneapolis), a natural organic fertilizer. The greenhouse was maintained at 18 to 29C and under natural daylengths. Studies were conducted during March and April for tall fescue and July and August for bermudagrass. Duplicate samples of Turf Restore were provided that were (+) or were not (–) microbiologically amended with a soil-derived inoculum. The exact composition of the inoculum is confidential, but it contains bacteria including *Bacillus subtilis* and other *Bacillus* sp., fungi related to *Trichoderma viride,* actinomycetes, and enzymes with ≈1.5×10^6 total organisms per gram of material. Turf Restore is a 10N-0.9P-5.0K fertilizer derived from feather meal, soybean meal, blood meal, bone meal, and K_2SO_4. As a comparison, a third treatment consisted of an identical fertilizer ratio prepared from a mixture of urea (45N-0P-0K), triple superphosphate (0N–20P–K), and K_2SO_4 (0N-0P-41K).

Grasses were established in the greenhouse in 15-cm diameter plastic pots with a total volume of 2800 cm^3. Pots were sterilized with a 0.0025% sodium hypochlorite solution. A soil mix was used that consisted of 70% medium sand : 20% sphagnum peatmoss : 10% sandy loam soil (by volume). Half of the soil mixture was steam sterilized at 79C for 2 h to reduce initial competition from naturally occurring soil microbes with the inoculum. About 1700 g of soil was placed in each pot. Fertilizers were applied as a single application at 5 g N/m^2. Irrigation was provided at 12 mm three times per week by hand watering. We used a completely randomized design with four replications.

Tall fescue was seeded at 40 $g \cdot m^{-2}$ and seedlings were allowed to establish for 2 weeks before fertilizer application. At that time, grass in the pots was uniformly clipped to a 50-mm height. Topgrowth above the 50-mm clipping height was harvested at 19 and 33 days after fertilizer treatment (DAT). Clippings were dried at 75C for 24 h and weighed. Growth rate was determined as a daily average for the entire period between harvests based on dry weight and number of days of regrowth since last clipping. Tissue samples were ground (Udy Cyclone Sample Mill Model 3010; Udy Corp., Ft. Collins, Colo.) to pass a 0.5-mm screen, and a 10-mg sample was analyzed for N content (Perkin Elmer 2400 CHN Elemental Analyzer; Perkin Elmer Corp., Norwalk, Conn.). Disease incidence of *Rhizoctonia* spp. at 72 DAT

Table 1. Analysis of variance for tall fescue and bermudagrass growth rate, N uptake, and disease incidence as affected by fertilizer and soil sterilization.

Turf and treatment	Days after treatment				
	19	33	19	33	72
Tall fescue					
Fertilizer treatments (FT)	***	***	***	***	NS
Soil sterilization (SS)	***	NS	**	NS	***
FT × SS	NS	NS	NS	NS	NS
Bermudagrass	17	31	17	31	
FT	***	NS	***	NS	---
SS	NS	NS	NS	NS	---
FT × SS	NS	NS	NS	NS	---

[NS],**,***Nonsignificant or significant at P = 0.01 or 0.001, respectively.

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[1]Associate Professor, to whom reprint requests should be addressed.
[2]Graduate Assistant.

Table 2. Growth rate and N uptake of tall fescue between 0 and 19 days after treatment in response to soil sterilization and fertilizer treatment.

Fertilizer[z]	Growth rate ($mg \cdot m^{-2} \cdot day^{-1}$)		N uptake (mg N/m^2 per day)	
	Sterile[y]	Non-sterile[y]	Sterile[y]	Non-sterile[y]
Turf Restore +	381 b[x]	795 b	7.3 b	23.4 b
Turf Restore −	337 b	505 b	9.9 b	11.7 b
Urea (not amended)	862 a	1336 a	37.9 a	54.0 a

[z]Turf Restore biologically amended (+) or not amended with (-) microbes.
[y]Soil treatment.
[x]Mean separation in columns by the Waller-Duncan k-ratio t test (k ratio = 100).

Table 3. Growth rate and N uptake of tall fescue at 33 days after treatment as affected by fertilizer treatment.

Fertilizer[z]	Growth rate ($mg \cdot m^{-2} \cdot day^{-1}$)	N uptake (mg N/m^2 per day)
Turf Restore +	296 b[y]	5.7 b
Turf Restore −	312 b	8.8 b
Urea (not amended)	690 a	25.8 a

[z]Turf Restore biologically amended (+) or not amended (-) with microbes.
[y]Mean separation in columns by the Waller-Duncan k-ratio t test (k ratio = 100).

Table 4. Growth rate and N uptake of bermudagrass at 17 days after treatment as affected by fertilizer treatment.

Fertilizer[z]	Growth rate ($mg \cdot m^{-2} \cdot day^{-1}$)	N uptake (mg N/m^2 per day)
Turf Restore +	1903 b[y]	70.0 b
Turf Restore −	1722 b	56.7 b
Urea (not amended)	3187 a	105.8 a

[z]Turf Restore biologically amended (+) or not amended (-) with microbes.
[y]Mean separations in columns by the Waller-Duncan k-ratio *t* test (k ratio = 100).

where 1 = 100% dead and 5 = 100% alive shoot tissue. Samples of infected tissue were submitted to the North Carolina State Univ. Plant Disease Clinic for determination of the disease organism.

Bermudagrass was established from plugs taken from an existing turf field plot area of 'Tifway' bermudagrass. Plugs 100 mm in diameter were removed from a field plot and tops were uniformly trimmed for topgrowth to a 19-mm height. The root system below the rhizomes was removed and the plug was washed to remove all soil. Plugs were established in pots filled with the soil mix previously described. Fertilizer treatments were applied immediately after planting and topgrowth above the 19-mm clipping height was harvested at 17 and 31 DAT. Tissue analysis was conducted as previously described. Data were subjected to analysis of variance (ANOVA) procedures (SAS, 1985). Mean separation when appropriate used the Waller-Duncan k-ratio *t* test with k ratio = 100 (Waller and Duncan, 1969).

Fertilizer treatments influenced tall fescue growth rate and N uptake at 19 and 33 DAT (Table 1). Soil sterilization also affected growth rate and N uptake, but only at 19 DAT. Disease incidence of *Rhizoctonia* spp. at 72 DAT was influenced by soil sterilization, but not by fertilizer treatments. No interactions of fertilizer treatments and soil sterilization were found. At 19 DAT, tall fescue growth rates were 126% higher in the sterilized and 68% higher in the nonsterilized soil for the urea treatment than for turf grown with inoculated Turf Restore (Table 2). Nitrogen uptake rates by 19 DAT were positively related to growth rates. The relative differential was more pronounced for turf N uptake, which was 419% higher for the urea treatment than for turf fertilized with inoculated Turf Restore in the sterilized soil. Additionally, growth rates were 49% higher overall in nonsterilized than in sterilized soil. By 33 DAT, soil sterilization no longer affected tall fescue growth rates (Table 1). The growth rate to 33 DAT remained 133% higher with the urea treatment than with inoculated Turf Restore, and N uptake was 353% higher (Table 3). Soil sterilization reduced turfgrass growth, presumably by a reduction in the population of soil microorganisms, which could have impacted release of NH_4^+-N from urea and/or conversion to NO_3^--N.

Bermudagrass response to fertilizer treatments was similar to that of tall fescue. To 17 DAT, the growth rate of the urea-treated turf was 67% higher than for turf grown with inoculated Turf Restore. Further, no differences were found between turf fertilized with amended and nonamended Turf Restore (Table 4). Bermudagrass N uptake was 51% higher for the urea treatment than for turf fertilized with inoculated Turf Restore. Biological amendment did not affect bermudagrass N uptake rates. No differences were found due to soil sterilization, probably due to natural inoculum being introduced within the thatch layer from the transplanted plugs.

Use of natural organic materials has been linked to suppression of diseases in turf (Cook et al., 1964; Markland et al., 1969). However, Markland et al. (1969) could not correlate the use of sewage sludge or processed tankage and an increase in soil microbial activity with suppression of dollar spot *(Sclerotinia homoeocarpa* F.T. Bennett) on creeping bentgrass *(Agrostis palustris* Huds). Based on disease incidence of *Rhizoctonia* spp. of tall fescue in this experiment, fertilizer treatment had no effect on preventing disease incidence (Table 1). There was a significant reduction of incidence of *Rhizoctonia* infection of the tall fescue on sterilized (rating of 3.6; 1 = dead and 5 = alive) compared with nonsterilized (rating of 2.4) soil. This difference is probably related to suppression of disease activity from natural pathogen populations present in the soil that were eliminated or greatly reduced by soil sterilization. Apparently, the use of a natural organic fertilizer that had been microbiologically amended did not afford an advantage in disease suppression in this study, even with sterilized soil.

Turf Restore that had been biologically amended (+) did not provide for faster fertilizer availability, based on turf growth rates and N uptake rates, than nonamended material (–). Use of a *Pseudomonas* sp. inoculant to enhance organic N carrier degradation in the field was not effective on bermudagrass (Peacock and DiPaola, 1992). In this study, even under sterilized soil conditions, where naturally occurring soil microorganism populations presumably were eliminated or greatly reduced, the biologically amended fertilizer did not lead to an increased N release rate based on measurements of turfgrass growth or N uptake. Thus, the addition of soil microorganisms as a biological amendment to a natural organic fertilizer was not beneficial in this study.

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