Phosphorus Availability in Some Acid Soils Influences Bentgrass and Annual Bluegrass Growth

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Additional index words. clipping yield, phosphorus uptake, phosphorus soil test, *Poa annua*, *Agrostis palustris*

Annual bluegrass (*Poa annua* L.) is usually considered a weed in turf. Phosphorus fertilization has been implicated in infestations of annual bluegrass in turf, as high and repeated P fertilizer application increases growth and density of annual bluegrass in bentgrass stands (Goss et al., 1975). Application of S to acidify soil or limited or no P application has been recommended, because reduced P availability can decrease annual bluegrass density (Goss et al., 1975). However, nothing is known about the relationship between available soil P and the growth of bentgrass and annual bluegrass in acid soils. The objective of this experiment was to determine the growth responses of bentgrass and annual bluegrass to P over a wide range of available P levels using 21 acid soils collected from various locations in western Washington.

The soils were air-dried and crushed to pass through a 2-mm sieve. Soil chemical characteristics determined included pH (4.67 ± 0.56 SD) [1 soil : 2 water (w/v) ratio], organic matter ($5.82 \pm 4.74\%$ SD), oxalate-extractable Al (171.6 ± 139.4 mmol·kg⁻¹ SD) and Fe (151.4 ± 96.8 mmol·kg⁻¹ SD) (Khalid et al., 1977). Each soil was mixed with 220 kg K/ha as KCl, placed in cone-shaped pots (6-cm i.d., 25 cm long) and replicated three times. Each pot was fertilized with 1 ml of nutrient solution containing 0.26 M N as NH₄NO₃ and (NH₄)₂SO₄, 3.6×10^{-5} M MnCl₂, 2.6×10^{-4} M ZnSO₄, 1.2×10^{-4} M CuSO₄, 6.8×10^{-4} M H₃BO₃, 3.5×10^{-6} M H₃MoO₃, and 2.3×10^{-2} M MgSO₄, and seeded with ≈80 seeds of annual bluegrass or 'Pennncross' creeping bentgrass (*Agrostis palustris* Huds.). The pots were arranged in a completely randomized design and watered twice daily to maintain the soil

moisture level at field capacity. The greenhouse was maintained at $21 \pm 1^\circ\text{C}$, and daylight was supplemented by metal halide lights for 16 h·day⁻¹, with a photon flux density ranging from 500 to 900 μmol·m⁻²·s⁻¹, depending on the location on the bench.

The grass was clipped 3 to 5 mm above the soil surface, beginning 4 weeks after seeding, and then weekly for 12 weeks. The clippings were oven-dried at 65°C for 48 h, and the cumulative dry matter yields were determined. There was no apparent edge effect, despite the small container size. A por-

tion of the clippings was digested in HNO₃-HClO₄ acids before P analysis (Murphy and Riley, 1962). Soil samples from the pots were analyzed for NaHCO₃-extractable P (Olsen and Sommers, 1982). The graphical method of Cate and Nelson (1965) was used to determine the critical available P level for optimum growth. The method divides the X-Y scatter diagram into four quadrants, maximizing the number of points in the positive quadrants (lower left and upper right) while minimizing the number in the negative quadrants. The point where the vertical line crosses the X-axis is defined as the critical soil test level.

The response pattern for the relationship between clipping yield (expressed as dry weight) of bentgrass and annual bluegrass and available soil P by NaHCO₃ extraction (Fig. 1A) was similar to that for Kentucky bluegrass (*Poa pratensis* L.) in a soil with very low available P (1.1 mg P/kg, Bray-1) (Hall and Miller, 1974). Clipping yields, tissue P concentration (Fig. 1B), and P uptake (Fig. 1C) for bentgrass and annual bluegrass responded markedly to increased soil NaHCO₃-P at low P levels. The P test level critical for optimum yields, tissue P concentration, and P uptake was ≈18 mg P/kg for both grasses.

Bentgrass had slightly higher tissue P concentrations and total P uptake (Fig. 1 B,C) than annual bluegrass at similar soil test levels. The tissue P and P uptake averaged across the soil NaHCO₃-P levels were 1.78 mg P/g and 1.18 mg P per pot, respectively, for bentgrass as opposed to 1.48 mg P/g and 0.80 mg P per pot for annual bluegrass. The result indicates that bentgrass is more capable than annual bluegrass of absorbing P in acidic soils. However, the relative growth response of the grasses to P fertilization needs to be determined when the species are mixed.

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Fig. 1. The effect of NaHCO₃-extractable P levels of 21 acid soils on (A) dry weights of clippings, (B) tissue P concentration, and (C) P uptake for bentgrass and annual bluegrass. The intercept of the vertical line on the X-axis represents the critical NaHCO₃-extractable P level.

Received for publication 26 Apr. 1991. Accepted for publication 27 Dec. 1991. Washington State Univ. Research and Extension Center, Puyallup, WA 98371-4998. Scientific Paper no. 91-01-15. Dept. of Crop and Soil Sciences, Washington State Univ., College of Agriculture and Home Economics, Research Center, Washington State Univ., Pullman, WA 99164-6420. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.