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Nitrogen Form Influences Root Growth of Sodded Creeping Bentgrass

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Abstract. Root growth of 'Pcnncross' creeping bentgrass {*Agrostis palustris* Huds.) plugs sodded into a sandy loam soil and fertilized with five NH4 : NO; ratios (1:0, 3:1, 1:1, 1:3, and 0:1) were evaluated. Root growth and root: shoot ratios were higher with NO3 as the predominant N form. Results from this study indicate NO, should be the predominant N form when rapid and extensive root development is desired for the establishment of sodded bentgrass.

Sodded turfgrass provides immediate ground coverage and is used extensively for home lawns, commercial plantings, and golf courses. Use of bentgrass sod in the establishment of golf greens has increased the need to determine factors promoting rapid root development to facilitate prompt play. Nutritional requirements for root development of sodded bentgrass have not been clearly established. Data from greenhouse studies with various turfgrass species indicate high rates of NH4 decrease top growth (Darrow, 1939; Eggens and Wright, 1985; Harrison, 1933; Mazur and Hughes, 1976; Nittler and Kenny, 1976), while high NH4" or NO; rates may reduce root growth over time. Overall, NH4-N appears to reduce turfgrass root growth more than NO;-N (Bowman, 1988; Darrow, 1939; Eggens and Wright, 1985). In previous studies evaluating N form and its effect on turfgrass, monostands and polystands of annual bluegrass and creeping bentgrass were not maintained as a mowed turf system (Eggens and Wright, 1985). Under golf course conditions, sodded bentgrass greens must develop an effective root system under conditions of frequent close mowing and traffic. This study evaluated the effect of N form on root growth of newly sodded 'Penncross' creeping bentgrass maintained at a 2.5-cm mowing height. Although normal green mowing heights range from 0.5 to 0.6 cm, the presented results possibly will supply useful information in determining needs for future research relating to N-form and turfgrass management.

Creeping bentgrass plugs (10.6 cm diameter x 7.6 cm deep) were removed from an existing 'Penncross' creeping bentgrass putting green at the Univ. of Georgia Turfgrass Demonstration Plots, Athens. Existing soil was washed from the plugs and roots were removed below the thatch layer. Plugs were planted in 1.4-liter pots (15.3 cm diameter x 15.0 cm deep) containing 2.88 kg of sandy loam soil (18% clay, 2% silt, 80% sand, 0.6% organic matter; pH 5.4). Plug establishment occurred under greenhouse conditions (13.5 hr of daylight and day/night temperatures of 25/20C). Pots were arranged in a completely randomized block design and rotated every 3 to 5 days. During the first week of growth, pots were maintained at field capacity with no nutrients applied. Treatments consisting of five N ratios and five replications per treatment were initiated the 2nd week. Each N application remained constant (15.6 kg N/ha), while NH4 : NO; ratios were 1:0, 3:1, 1:1, 1:3, and 0:1. A modified nutrient solution was applied weekly (Maynard and Barker, 1970), using $Ca(N0_3)_2$ and $(NH_4),S0_4$ as N sources. Calcium levels were balanced with $CaCl_2$-$2H_20$, with $S0_4$ and Cl_2 being variables. In addition to the weekly application of the modified nutrient solution (100 ml), a solution containing the same N forms and distilled water was applied every 3 days (100 ml). Solutions were added to the sand portion of the pots, so contact with foliage was avoided. Shoots were allowed to grow to a maximum of 7 cm before being clipped to 2.5 cm.

Turfgrass color was evaluated 37 days after transplanting by use of a Munsell Color Chart (Munsell Color Charts for Plant Tissues, 1977). After color evaluations, sand was gently sifted from the root mass and saved for pH analysis (water and buffer pH) (Adams and Evens, 1962). To further remove sand, root masses were washed with water. Once the sand was removed, an estimate of rooting depth was obtained by measuring from the base of the verdure to the tips of the longest group of at least three roots. Root masses were cut at the bottom of the thatch layer, removed, dried at 80C for 24 hr, and then weighed. Shoot : root ratio was determined from the dry weight of all clippings and the dry weight of roots. Root tissue was analvzed for Kjeldahl N (Issac and Johnson, 1976).

Data were analyzed as a completely randomized block design. After analysis of variance, mean separation was by the LSD test ($P < 0.05$).

Root growth was significantly influenced by the form of N and the NH^ : NO; ratio (Table 1). Roots of treatments high in NO; had a 56% or higher mass than those from the NH_4 treatments, but contained less N on a percentage basis.

A comparison of N ratios shows the 1:3 ratio (NH_4: NO;) produced the greatest root mass, about three times more than the 1:0 ratio. The 3:1, 1:1, and 0:1 ratios produced statistically equivalent root weights, with a trend towards greater weights as NO; increased. Root length followed a similar trend. The 1:1 ratio produced longer roots than all other treatements, except 1:3, while 1:0 produced the shortest roots. In a similar study, Eggens and Wright (1985) noted a linear decrease in rooting of monostands and polystands of annual bluegrass and creeping bentgrass associated with NH4 : NO; ratios of 1:0 to 0:1. Bowman (1988) reported that NO; increased perennial ryegrass *(Lolium perenne* L.) root growth more than NH4.

Shoot : root ratio increased as the ratio of NH; to NO; increased (Table 1). The 1:0 ratio produced the most desirable shoot: root ratio, which was at least 40% greater than other treatments.

Along with altered growth rates, NH4 : NO; ratios influenced above-ground tissue color. Shoots receiving all N as NH4 were darkest green. At the highest NO; levels, shoot color was lighter green in comparison to the 1:3, 1:1, and 3:1 ratios. Comparison of shoot color to a Munsell Color Chart showed the average color at 1:0 was 5/4 7.5GY, and at 0:1, it was 6/6 7.5GY. Harrison (1933) and Nittler and Kenny (1976) also indicated that N form affects turfgrass color. These results suggest that the desirable dark green of the shoots obtained with ammoniacal N may occur at the expense of root growth and/or development.

Differences in pH associated with N form (Table 2) reflect the effect of N form on soil pH levels. The most favorable pH for NH4 use/assimilation is near neutral, whereas acid conditions do not affect NO; uptake until pH

Table 1. Effect of $NH_4^+ : NO_3^-$ ratios on initial root growth of sodded creeping bentgrass.[z]

	Root			
$NH_4^+ : NO_3^-$	Wt (g)	Length (cm)	N (%)	Shoot : root ratio
1:0	0.38 c	5.4 c	3.83 a	72:1
3:1	0.66 bc	7.4 b	2.99 b	40:1
1:1	0.68 bc	9.7 a	2.89 b	43:1
1:3	1.14 a	8.1 ab	2.12 c	29:1
0:1	0.86 ab	7.8 b	1.96 c	37:1
LSD (0.05)	0.36	1.9	0.68	

[z]Data are means of five observations.

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Table 2. Final sand pH.[z,y]

$NH_4^+ : NO_3^-$	pH_w^x	pH_b
1:0	4.1 c	8.14 c
3:1	4.2 c	8.31 a
1:1	4.6 c	8:23 b
1:3	5.7 b	8.27 ab
0:1	6.6 a	8.28 ab
LSD (0.05)	0.76	0.07

[z]Data are the means of five observations.
[y]pH_w = water pH; pH_b = buffer pH.
[x]Beginning pH_w = 5.4.

drops below 4.5 (Barker and Mills, 1980). Darrow (1939) found NH^-fertilized Kentucky bluegrass *(Poa pratensis)* produced more shoots, roots, and rhizomes at pH 6.5 than at 5.5 or 4.5, while NOJ-treated plants grew equally well at all three pH levels.

Since soil microbial activity promotes nitrification more rapidly than sand (Quastel and Scholefield, 1951), previous research (Eggens and Wright, 1985) indicating that high NH4 ratios decreased root growth may be viewed as misleading, since most putting greens do not consist of 100% sand. However, our results indicate N form can significantly influence initial root length and weight and root : shoot ratio of sodded creeping bentgrass on sandy loam soils. Bentgrass sod fertilized with NH4-N produced less root growth and darker green shoots. The ratio of 1:3 produced the most favorable root weights. Ratios of 1:1 and 3:1 produced about equally favorable root lengths. The similarity of our results with that of Eggens and Wright (1985) suggest the effect of N form on root growth occurs over a wide range of circumstances; some of the differences in the two studies were the plant densities (sod vs. single plants), soil type (sandy loam vs. sand), total applied N (265 vs. 3472 kg N/ha), soil pH, and mowing height. Previously, NH4 : NO3 ratio was reported to have no effect on bentgrass root or shoot growth under field conditions (Markland and Roberts, 1969; Mazur and Hughes, 1976); however, these studies were conducted on established turf. The results reported here suggest further investigation should be made dealing with the use of NO3-N on greens established with bentgrass sod.

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