ROOT GROWTH OF SODDED CREEPING BENTGRASS AS INFLUENCED BY NITROGEN FORM[1]

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ABSTRACT

Root growth of `Penncross' creeping bentgrass (Agrostis palustris Huds.) plugs sodded into a sandy loam soil and fertilized with five difference ratios of NH_4^+:NO_3^- (1:0, 3:1, 1:1, 1:3, and 0:1) was evaluated. Root growth and root to shoot ratios were higher with NO_3^- as the predominant N form. Results from this study indicate NO_3^- 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 utilized extensively with 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 which enables prompt play. Nutritional requirements for root development of sodded bentgrass have not been clearly established. Previous research evaluating the effect of N form on turfgrass has focused on top growth and chemical composition of above ground tissue. Data from greenhouse studies with various turfgrass species indicate high rates of NH_4^+ decrease top growth (Darrow, 1939; Eggens and Wright, 1985; Harrison, 1933; Mazur and Hughes, 1976; Nittler and Kenny, 1976) while, high NH_4^+ or NO_3^- rates may reduce root growth over time. Overall, NH_4^+-N appears to reduce turfgrass root growth more than NO_3^--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 will hopefully 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 (Agrostis palustris Huds.) putting green at the University of Georgia Turfgrass Demonstration Plots in Athens, Georgia. Existing soil was washed from the plugs and roots were removed below the thatch layer. Plugs were planted in pots (15.3 cm diameter x 13.0 cm deep) containing 2.88 kg of sandy loam soil (18% clay, 2% silt, 80% sand, pH 5.4, 0.6% organic matter). Plug establishment occurred under greenhouse conditions (13.5 hr of day light and day/night temperatures of 25° and 20° C, respectively). Pots were arranged in a completely randomized block design and rotated every 3-5 days. During the first week of growth, pots were maintained at field capacity with no nutrients applied. Treatments consisting of 5 N ratios and 5 replications per treatment were initiated the second week. Each N application remained constant (15.6 kg N ha^{-1}), while ratios of NH_4^+-N to NO_3^--N varied: 1:0, 3:1, 1:1, 1:3, and 0.1. A modified nutrient solution was applied weekly (Maynard and Barker, 1970), using Ca $(NO_3)_2$ and $(NH_4)_2SO_4$ as N sources. Calcium levels were balanced with $CaCl_2 \cdot 2H_2O$, with SO_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 clipping to 2.5 cm.

Thirty-seven days after transplanting, turfgrass color was evaluated using 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 roots, consisting of at least 3 roots. Root masses were cut at the bottom of the thatch layer, removed, dried at 80°C for 24 hr and then weighed. Shoot to root ratio was determined from dry weight of all clippings and the dry weight of roots. Root tissue was analyzed for Kjeldahl N.

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

Root growth was significantly influenced by the form of N and ratio of NH_4^+ to NO_3^- (Table 1). Root mass of treatments high in NO_3^- was at least 56 percent greater than NH_4^+ treatments, but contained less N on a percentage basis (Kjeldahl N).

A comparison of N ratios shows the 1:3 ratio (NH_4^+:NO_3^-) produced the greatest root mass, approximately three times more root growth 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_3^- increased. Root length followed a similar trend. The 1:1 produced longer roots than all treatments 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 NH_4^+:NO_3^- ratio of 1:0 to 0:1. Bowman and Paul (1988) reported that NO_3^- increased perennial ryegrass (Lolium perenne L.) root growth more than NH_4^+.

Shoot to root ratio decreased as the ratio of NH_4^+ to NO_3^- increased (Table 1). The 0:1 ratio produce the most desirable shoot to root ratio which was at least 40 percent greater than other treatments.

Along with altered growth rates, NH_4^+:NO_3^- ratios influenced above ground tissue color. Shoots receiving all N as NH_4^+ were darkest green. At the highest NO_3^- 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 of the 1:0 was 5/4 7.5GY, and the 0:1 was 6/6 7.5GY. Harrison (1933), and Nittler and Kenny (1976) also indicated N form affects turfgrass color. These results suggest the desirable dark green color 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 NH_4^+ utilization/assimilation is near neutral, whereas acid conditions do not affect NO_3^- uptake until pH drops below 4.5 (Barker and Mills, 1980). Darrow (1988) found NH_4^+ fertilized Kentucky bluegrass (Poa pratensis) produced more shoots, roots, and rhizomes at pH 6.5 compared to 5.5 and 4.5, while NO_3^- treated plants grew equally well at all three pH levels.

Since soil promotes nitrification more rapidly than sand (Quastel and Scholefield, 1951), previous research (Eggens and Wright, 1985) indicating high NH_4^+ 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 NH_4^+-N produced less root growth with darker green shoots. Ratios of 1:3 produced the most favorable root weights. Ratios of 1:1 produced the most 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 versus single plants), soil type (sandy loam versus sand), total applied N (265 versus 3472 kg N ha^{-1}), soil pH, and mowing height. Previously the ratio of NH_4^+ to NO_3^- 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 NO_3^--N on greens established with bentgrass sod.

LITERATURE CITED

1. Adams, F. and C. E. Evens. 1962. A rapid method for measuring lime requirement of red-yellow podzolic soils. Soil Sci. Soc. Am. Proc. 26:355-357.

2. Barker, A. V. and H. A. Mills. 1980. Ammonium and nitrate nutrition of horticultural crops. Hort. Rev. 2:395-425.

3. Bowman, D. C. 1988. Uptake and assimilation of NH_4^+ and NO_3^- by nitrogen deficient perennial ryegrass turf. Plant Physiol. 88:1303-1309.

4. Darrow, R. A. 1939. Effects of soil temperature, pH, and nitrogen nutrition on the development of Poa pratensis. Botan. Gaz. 101:109-128.

5. Eggens, J. L. and C. P. M. Wright. 1985. Nitrogen effects on monostands and polystands of annual bluegrass and creeping bentgrass. HortScience 20(1):109-110.

6. Harrison, C. M. 1933. Responses of Kentucky bluegrass to variations in temperature, light, cutting and fertilizing. Plant Physiol. 9:83-106.

7. Markland, F. E. and E. C. Roberts. 1969. Influence of nitrogen fertilizer on Washington creeping bentgrass, Agrostis palustris Huds. I. Growth and mineral composition. Agron. J. 61:698-700.

8. Maynard, D. N. and A. V. Barker. 1970. Nutriculture: A guide to the soilless culture of plants. Coop. Ext. Ser. Pub. No. 41.

9. Mazur, A. R. and T. D. Hughes. 1976. Chemical composition and quality of Penncross creeping bentgrass as affected by ammonium, nitrate, and several fungicides. Agron. J. 68:721-723.

10. Munsell Color Charts for Plant Tissues (2nd ed.). 1977. Macbeth. Baltimore, Maryland.

11. Nittler, L. W. and T. J. Kenny. 1976. Effect of ammonium to nitrate ratio on growth and anthocyanin

development of perennial ryegrass cultivars. Agron. J. 68:680-683.

12. Quastel, J.H. and P.G. Scholefield. 1951. Biochemistry of nitrification in soil. Bacteriol. Rev. 15:1-53.

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

$NH_4^+:NO_3^-$	Root Weight (g)	Root Length (cm)	Root N (%)	Shoot:Root Ratio
1:0	0.38[c2]	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(.05)	0.36	1.9	0.68	

1 Data are means of five observations.
2 Values followed by the same letter in each column are not statistically different using the LSD test at the 5% level.

Table 2. Final sand pH.[1]

$NH_4^+:NO_3^-$	pH_w[2]	pH_b
1:0	4.1[c3]	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(.05)	0.76	0.07

1 Data are the means of five observations.
2 Beginning pH_w=5.4.
3 Values followed by the same letter in the columns are not statistically different using the LSD test at the 5% level.