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Executive Summary

The Effects Of Turfgrass Root Architecture On Nitrate Leaching And N Use Efficiency

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✓ An initial study demonstrated that nitrate leaching could be reduced during turf establishment by supplementing the fertilizer with sugar, thus stimulating microbial immobilization of the fertilizer. Mass emission of N from the controls amounted to 23%, 28%, 9% and 7% of the applied N for months one through four, respectively. The reduction over time corresponds to root development. Sucrose addition reduced both NO_3 concentration and mass emission 40-65% compared to controls, suggesting significant increases in microbial immobilization.

✓ A second experiment investigated the effects of trinexapac-ethyl (Primo ®) on nitrate leaching potential and N budget in 'Tifway' bermudagrass. TE reduced leaf growth by 30-40% compared to the control. There was no effect of TE on nitrate leaching following the first two N applications. Following the third AN application, however, approximately 50% less nitrate leached from the TE treated columns compared to the control, even though growth effects from TE had mostly disappeared. The results indicate that growth regulators can be used without increasing the potential for nitrate leaching.

✓ The effect of root distribution on NO_3 leaching was investigated using hybrid bermudagrass, zoysiagrass, centipedegrass and St. Augustinegrass. Different root distributions are established by staggering the planting time from one week to four months. Nitrate leaching was high from the most recently planted sod of both species. As little as one to two months establishment reduced leaching losses considerably, presumably due to root growth (depth and density). Bermudagrass established deeper and denser root systems more rapidly than did zoysiagrass, which is reflected in the cumulative leaching profiles. This experiment is currently being repeated using centipedegrass and St. Augustinegrass.

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An experiment was conducted in large lysimeters to compare six warm-season grasses [common bermudagrass (*Cynodon dactylon* (L.) Pers.), 'Tifway' hybrid bermudagrass (*Cynodon dactylon x transvaalensis*), centipedegrass (*Eremochola ophiuroides* (Munro.) Hack.), 'Raleigh' St. Augustinegrass (*Stenotaphrum secundatum* (Walt.) Kuntze), 'Meyer' zoysiagrass (*Zoysia japonica* Steud.), and 'Emerald' zoysiagrass (*Zoysia japonica x tenuifolia*)] for N leaching, N efficiency, and root architecture. Commercially grown sod of each species was washed free of soil, cut to fit the lysimeters, and planted.

Nitrogen was applied as NH_4NO_3 (34-0-0) at a rate of 50 kg N ha^{-1} on seven dates during the twelve month experiment. The N source for the final application was $^{15}NH_4{}^{15}NO_3$ having an enrichment of 10.0%.

Columns were irrigated three times per week to provide a leaching fraction of 50%. Leachate was collected under tension following each irrigation and NO_3 and NH_4 in the leachate were determined. Clippings from each mowing were collected, dried, weighed and ground for total N determination. At the conclusion of the study, roots and verdure were also harvested and processed. Tissues were then analyzed for total N and ^{15}N enrichment by mass spectrometry. Root length density was determined at depths of 5, 18, 30, 43, 55 and 68 cm using the modified intersect.

Results

- Nitrate and ammonium leaching from the first N application to the recently-sodded turf was high, ranging from 48% to 100% of the applied N for St. Augustinegrass and Meyer zoysiagrass, respectively.
- Considerably less NO_3 and essentially no NH_4 leached from subsequent N applications, probably due to more efficient uptake by the developing root system and associated microorganisms. For example, leaching losses from the third N application ranged from 0.04% to 6.9%.
- There were consistent genotypic differences in NO_3 leaching potential, with St. Augustinegrass clearly the best and 'Meyer' zoysiagrass the worst species for NO_3 leaching.
- Based on two different analyses, N recovery by the six turf species ranged from 63% to 84%. St. Augustinegrass and the two bermudagrasses were the most efficient species, while Meyer zoysiagrass and centipedgrass were the least efficient.
- There were no significant differences in root length density (RLD) between species at the 5 and 18cm depths. At soil depths $\geq$ 30 cm, St. Augustinegrass and the bermudagrasses had significantly higher root length densities than the other species. Nitrate leaching loss, averaged over the final three N applications,

was negatively correlated with RLD averaged over 30 to 55 cm ($r = -0.80$, $P = 0.04$).

This research has documented genotypic differences among the warm-season turfgrasses for nitrate leaching potential, N absorption and root architecture. St. Augustinegrass and both common and hybrid bermudagrass were the most effective at reducing leaching, while 'Meyer' and 'Emerald' zoysiagrass were significantly less effective. Nitrate and ammonium readily leached from all species shortly after planting, but leaching declined substantially as the root systems developed. Volume weighted NO_3 concentrations in leachate from established turf were all below the 10 mg N L^{-1} threshold with a single exception of 'Meyer' zoysiagrass following the June N application. The data are consistent with root architecture being a primary determinant of nitrate leaching and nitrogen use efficiency, and highlight the importance of carefully managing both fertility and irrigation when establishing warm-season grasses from sod.

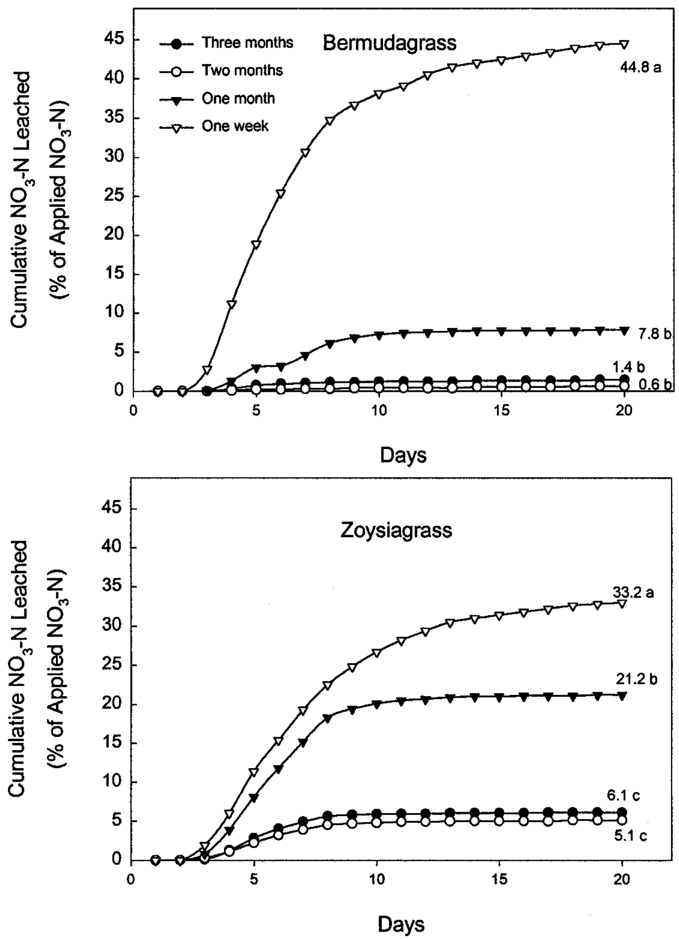
Effects of Root Architecture:

Experiments are being conducted in a walk-in growth chamber at the NCSU Phytotron. The day/night (12/12h) temperatures of the growth chamber is controlled at 27/21 °C, with photosynthetically active radiation at the grass surface of 500 $\mu mol \cdot m^{-2} \cdot s^{-1}$. Sod of hybrid Bermudagrass and "Emerald" Zoysiagrass was cut to fit 15.2 cm (6 inch) diameter column lysimeters. Two porous ceramic extraction cups, joined with a "Y' connector, were placed at the bottom of each column. The cups were connected to 3-L collection bottles, which were connected to a vacuum manifold. A thin layer of diatomaceous earth was added to the bottom to reduce plugging of the ceramic cups. The columns were then packed to a bulk density of 1.50 g cm^{-3} with a medium-sized washed sand.

Sod was washed and roots trimmed and then planted on March 29, April 26, May 24, and June 21, 2000. A starter fertilizer was mixed into the top 4 cm of sand before planting to supply 50 kg N, 100 kg P, and 50 kg K per hectare. The grass was watered twice a day with 600 ml of DI water during the first week after transplanting, and once a day with 600 ml DI water during the second week after transplanting. Beginning on week 3, the grass was watered with 300 ml/day of diluted nutrient solution supplying N, P, and K at rates of 52, 5, and 55 kg ha^{-1} $month^{-1}$, respectively until June 21, 2000, when all the lysimeters were heavily irrigated to flush any remaining NO_3 from the system.

Ammonium nitrate was applied at a rate of 50 kg N ha^{-1} on June 29, 2000. Leachate was collected daily over a three week period by applying a tension of 0.01 MPa to the columns via the manifold. Leachate volume was recorded and NO_3 and NH_4 were determined.

Nitrate leaching was high from the most recently planted sod of both species (figure below). As little as one to two months establishment reduced leaching losses considerably, presumably due to root growth (depth and density, table below). Bermudagrass established deeper and denser root systems more rapidly than did zoysiagrass, which is reflected in the cumulative leaching profiles. This experiment is currently being repeated using centipedegrass and St. Augustinegrass. Additionally, ^{15}N-labeled ammonium nitrate was used as the N source to determine uptake efficiency.



Soil Depth (cm)	Root Length Density (cm cm^{-3}) Establishment Period			
Bermudagrass	3 months*	2 months	1 month	1 week
0-15	18.0	13.2	10.4	7.5
15-30	10.1	7.6	4.3	2.4
30-45	5.7	6.1	2.4	1.6
45-60	5.5	4.0	1.8	1.9
Zoysiagrass				
0-15	12.9	14.4	11.2	4.3
15-30	7.8	4.7	3.7	0.7
30-45	4.9	3.4	0.8	0.1
45-60	2.8	0.7	0.7	0.1

* Establishment periods are from planting to fertilizer application and do not include the three week sampling period.