research

Nitrate leaching in bentgrass greens

Auburn University researchers found that nitrate leaching in bentgrass greens was greatest in the initial months of the study when N was applied at high rates, but differences in nitrate leaching lessened as the greens aged and N fertilisation was reduced to maintenance levels

BY E.A GUERTAL

Unlike other fertiliser nutrients such as potassium (K), the availability of nitrogen for plant use is controlled by the complex and biologically based nitrogen (N) cycle.

Nitrogen is added to the N cycle via decomposition and addition of plant residues, fixation by lightning, and, most importantly in turf, fertilisation with N fertilisers.

Nitrogen is lost from plant availability via immobilisation (N incorporated into biological organisms), denitrification (loss to the air as NO_2 compounds), volatilisation (loss to the air as ammonia), and leaching (loss from the rootzone as nitrate).

In turfgrass research, the N uptake/loss areas which have received most exploration are N uptake as a result of fertilisation and N losses via nitrate leaching. For example, a 1990 review article on the fate of nitrogenous fertilisers applied to turfgrass cited 12 articles that studied N uptake by turf: seven examined ammonia volatilisation, four examined soil storage of N, two studied denitrification, and 10 examined N leaching (11).

Leaching is the downward loss of nitrogen as the nitrate anion (NO_3) is moved by water from the rootzone deeper into the soil with possible movement into underlying groundwater. Nitrate leaching receives attention because:

- There are concerns about increased nitrate in water and its effects on the populations at risk;
- Nitrate is a mobile anion and this path of N loss can be substantial, especially in sandy soils; and

Research at Auburn University in the US has examined the combined and separate effects of nitrogen rate and greens mix on nitrate and ammonium in leachate from bentgrass putting greens.

- Unlike other N loss paths such as denitrification or immobilisation, leaching is a relative easy loss path to study not requiring expensive labelling techniques or specialised, expensive equipment.

In turf systems, nitrate leaching papers first appeared in the referenced literature in the late 1970s and early 1980s with continued publication in this area to the present day. Many of these papers examined N leaching under turf managed as a lawn or fairway using species such as Kentucky bluegrass (*Poa pratensis L.*) (5, 6, 10, 12); Kentucky bluegrass/red fescue (*Festuca rubra L.*) mixtures (8, 9, 16), fairway-height hybrid couchgrass (*Cynodon dactylon x C. transvaalensis Pers.*) (7, 15) and Saint Augustinegrass [*Stenotaphrun secundatum* (Walt.) Kuntze] (4).

Studies often had N source and N rate as treatments, and, in general, concluded the following:

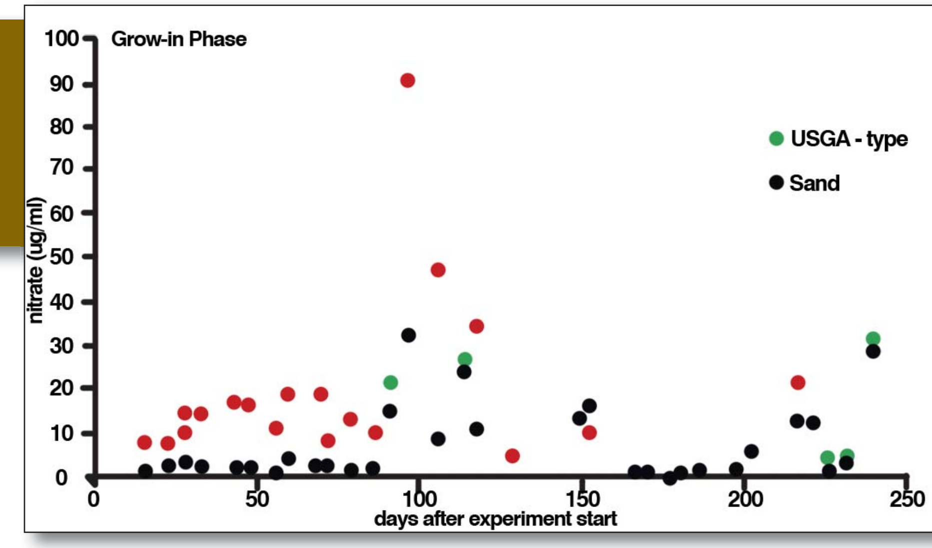
- Nitrate leached from high-sand soils during establishment (6) or when excessive rates (approximately six-times the recommended rate) were applied (12);
- Nitrate leaching into the soil profile was far less likely to occur in soils with a lower sand content (12, 16);
- N leaching from soil was reduced when a slow-release N source was used (10, 14, 15); and
- Irrigation applied at a correct frequency and rate resulted in little measurable nitrate leaching, even in a sandy soil (15).

Based on this work, we have developed our general recommendations to limit nitrate leaching in turfed soils – avoid over-application of N fertilisers, consider use of slow-release N sources or split application of soluble N sources, and do not irrigate to excess following N applications.

Constructed putting greens often fit the worst-case scenarios mentioned in the preceding paragraph, as they are built with 90 per cent or more sand and receive frequent inputs of N fertiliser and irrigation. Additionally, constructed greens are shallow and drain directly to an outlet, an additional potential environmental hazard.

Research which examined N leaching in greens typically used small individual golf greens with the greens mix itself sometimes a treatment variable (2, 3, 13). The percentage of N lost as leached nitrate varied by study, often less than two per cent of total N applied (13, 15). However, when N was over-applied at three-times the recommended rate, leachate nitrate was as high as 23 per cent of N applied, with greatest loss from soluble N sources (2).

Figure 1. Effect of greens mix on nitrate leaching in a newly established 'Crenshaw' bentgrass putting green. Red points indicate those sampling dates when USGA-type rootzones leached significantly higher concentrations of nitrate



Over the past 30 years, fairway-based research has shown that when N is applied at the recommended rate, at the correct time of year, with appropriate irrigation, the result is minimal nitrate leaching. Studies that evaluated putting green mixes are less prevalent and were either a greenhouse trial (1, 14) or conducted on 'Tifdwarf' couchgrass (2, 3).

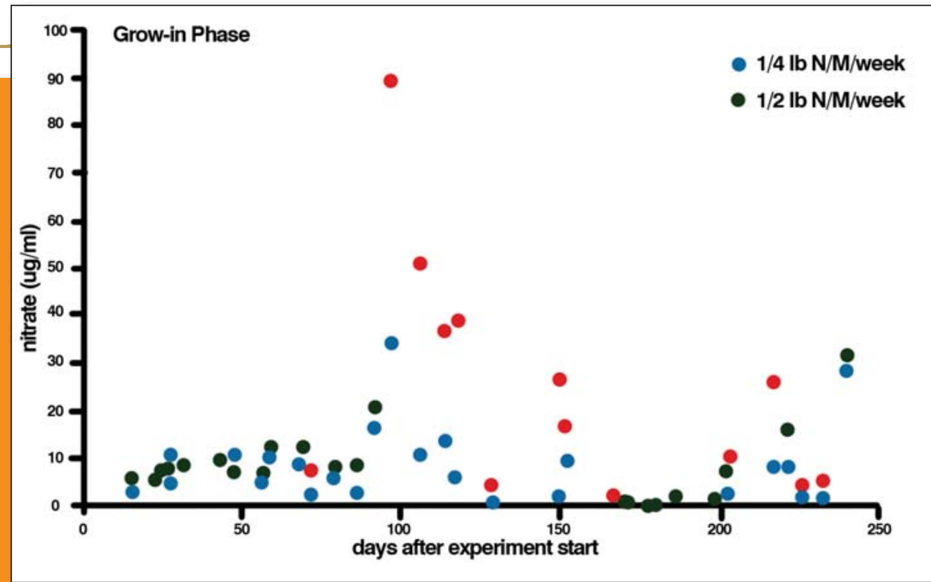
Given the widespread use of creeping bentgrass (*Agrostis stolonifera*) on USGA-type putting greens, the number of studies which have explored nitrate losses from such a system are few (11, 13). Thus, the objective of this research project was to examine the combined and separate effects of N rate and greensmix on nitrate and ammonium in leachate from bentgrass putting greens.

MATERIALS AND METHODS

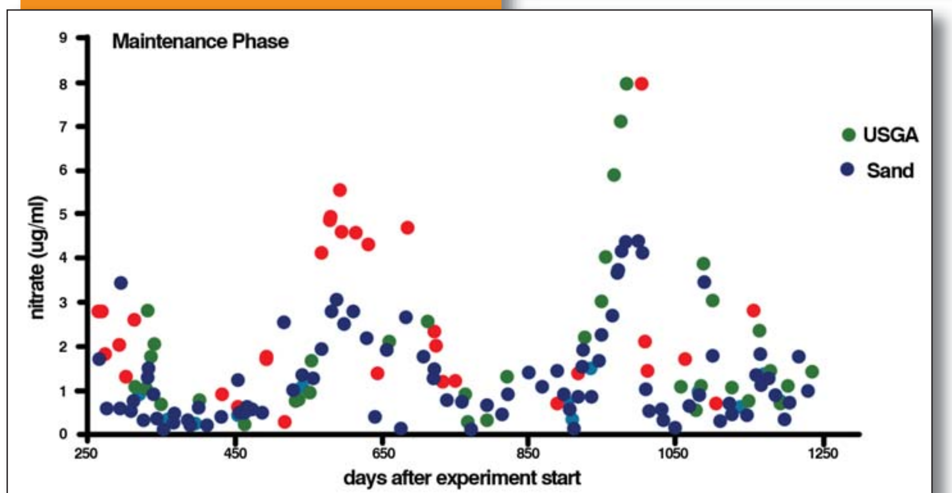
The experiment was located at the Auburn University Turfgrass Research Unit (TGRU). The study consisted of 16 individually constructed greens, each 1m x 0.5m in size. Each individual green was deep enough to hold 10cm of gravel and 40cm of overlying greens mix. No choker layer between the gravel and rootzone mix was used since prior analyses of the greens mix indicated that the sand would bridge.

Each green drained completely into a separate collection unit, allowing all leachate from each green to be collected as needed. The greens were constructed in December 1996 using washed 'Crenshaw' creeping bentgrass sod installed in each green on 2 January 1997.

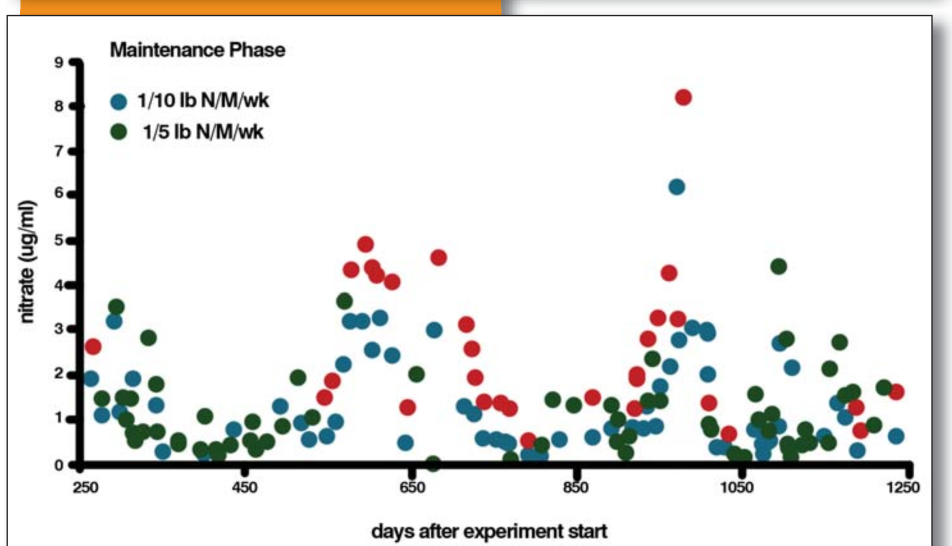
There were four replications of each



Right: Figure 2. Effect of nitrogen rate on nitrate in leachate in a newly established 'Crenshaw' bentgrass putting green. Red points indicate sampling dates where 1/2 lb treatments resulted in significantly higher nitrate concentrations in leachate compared to 1/4 lb/1000 sq. ft./week treatments



Below: Figure 3. Effect of greens mix on nitrate leaching in a 'Crenshaw' bentgrass putting green under a maintenance regime. Red dots indicate sampling dates where USGA rootzones had significantly higher concentrations of nitrate in leachate than 100% sand rootzones



Above: Figure 4. Effect of nitrogen rate on leachate nitrate in a 'Crenshaw' creeping bentgrass putting green managed under a maintenance regime. Red dots indicate those sampling dates where 1/2 lb treatments resulted in higher nitrate concentrations in leachate than 1/4 lb N/1000 sq. ft./week treatments

greens mix/N rate combination. Greens mix treatments were:

- 100 per cent sand; and
- A USGA-type mix of 80 per cent sand/20 per cent reed sedge peat (v/v).

Nitrogen rate treatments were 1/4 or 1/2 1b. N/1,000 ft^2 per week for the first eight months (grow-in phase), followed by 1/10 or 1/5 lb. N 1,000 ft^2 per week for the remainder of the test (maintenance phase).

The two N rate and two greens mix treatments were arranged as a 2 x 2 factorial design with four replications of each treatment combination. All N was applied as a spray application on the Monday of each week using 20-5-10 as the fertiliser source with additional urea (46-0-0) used to make up the higher N rate. The experiment ended on 5 May, 2000 representing three years and four months of leachate collection from the bentgrass putting greens.

At least twice monthly the following was done:

- Total leachate volume from each green was collected and determined; and
- A subsample of leachate was collected and returned to the lab for subsequent determination of nitrate and ammonium concentration.

Nitrate and ammonium in water samples were determined via standard colorimetric techniques. If rainfall in a sampling period exceeded 1/2 inch, the leachate containers were emptied as soon as possible, regardless of the sampling time. Thus, in periods of high rainfall the collection containers were emptied frequently as needed.

RESULTS

At most sampling dates there was not a significant N rate x greens mix interaction. The main effects of greens mix and N rate often resulted in significantly different N leaching losses.

Figures 1 and 2 illustrate N lost as nitrate in the grow-in phase of the experiment when N was applied at high rates (1/4 and 1/2 lb N/1,000 ft^2/week) simulating grow-in conditions. In Figure 1, a red dot indicates that nitrate loss from the USGA-type greens mix was significantly greater than that from the sand greens mix at that sampling date.

In Figure 2, a red dot indicates that nitrate loss from plots receiving 1/2 lb N/1,000 ft^2/week was significantly greater than nitrate loss measured from the 1/4 lb N/1,000 ft^2/week treatment at that sampling date.

As with previous research (2), highest N leaching was found when N was applied at rates above those that would be recommended for turf maintenance. High concentrations of nitrate in leachate were found during the establishment phase of this study. Agronomically and environmentally, such N rates were not needed to maintain newly laid bentgrass sod managed as a putting green.

In the first three months after construction, plots containing the USGA-type greens mix had significantly more nitrate in leachate, regardless of the N fertilisation rate (Figure 1). Initial degradation of the reed sedge peat in the greens mix was likely contributing to this N release.

This higher concentration of nitrate from the USGA-type greens mix was largely depleted by four months after construction, and from that point, differences due to greensmix were largely nonsignificant (Figure 1).

Figures 3 and 4 illustrate leachate nitrate during the maintenance phase of the research. Significant differences between treatments are indicated by a red dot for the USGA-type greens mix and 1/5 lb N rate, respectively.

The lower rates of N fertilisation applied during this maintenance period resulted in an overall reduction in leachate N, a result similar to that found in previous research. Over the length of this study, there were few times when turfgrass color or quality significantly differed due to N rate or greensmix, indicating that the lower rate of weekly N application (1/10 lb N/1000 ft^2/wk) would be adequate for a quality putting bentgrass green in the southeast of the US. When that rate was applied, N in leachate was typically well below 3µg/ml (3ppm) throughout the sampling period.

Over the years of data collection during the maintenance period, there was a cycling effect in nitrate leaching, with increased nitrate collected during July and August (northern hemisphere summer) of each year (Figure 4).

It is likely that increases in nitrate during the summer were partly due to reduced rooting in the bentgrass as summer stress thinned the turf and reduced root length in the heat-stressed bentgrass. Others have shown that root architecture will affect nitrate leaching with deeper-rooted bentgrass absorbing N more efficiently than shallow rooted bentgrass (1).

Although we did not measure root length or root density in this study, other bentgrass root research at the same location has shown reductions in rooting during July and August with subsequent root mass recovery by October of each year.

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