Turfgrass and Environmental Research Online

...Using Science to Benefit Golf

Using a unique floating green in Cour d'Alene, Idaho, researchers at Washington State University were able to track nitrogen leachate losses after nitrogen fertilizer applications.

Volume 1, Number 19
December 1, 2002

PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 215 projects at a cost of $21 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Nitrogen Leaching through a Sand-based Golf Green

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SUMMARY

Sand-based rootzones are prone to leaching. Washington State University researchers used the unique floating green at the Coeur d'Alene Resort Golf Course in Coeur d'Alene, Idaho, to measure the NO_3-N and NH_4-N leachate losses following nitrogen fertilizer applications. Their study revealed:

- N fertilization of sand-based golf greens poses little potential for ground water contamination when healthy turfgrass is maintained.
- Bentgrass was very efficient at taking up N with 47% of applied N removed in the clippings.
- The greatest amount of N moved through the soil profile when the turf was dormant and/or in response to precipitation events.
- A increase in N concentration and amount leached occurred for 7 to 21 days following fertilizer application.
- Tissue N was a better indicator than clipping dry wt. of when fertilizer was applied.
- The large, sand-based floating green used in this study was a unique field laboratory that could be utilized in future research to develop environmentally sound turfgrass BMPs.

Environmental concern by the turfgrass industry and the public has promoted the development and implementation of best management practices (BMPs) for golf courses. A major area of concern on golf courses is the application of fertilizer to potentially highly leachable sand-based putting greens.

Previous N leachate studies have been conducted (2, 3, 4, 6, 7, 8, 9). A golf course study using suction lysimeters is being conducted in Rhode Island to measure N concentration on golf greens (10). For a preliminary report on the research reported in this paper, and additional information on the use of suction micro-lysimeters on golf greens, the reader is referred to Johnston et al. (5). Except for the works of Johnston et al. (5) and Rummele (10), leaching studies tend to be conducted at small-scale university research plots under very controlled conditions and may not accurately represent golf course conditions of management and play.

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Why this study was different

Our research was unique since no study monitoring leachate flow and concentration had been conducted on an entire golf course green receiving play. In addition, the green received its normal maintenance by the golf course superintendent throughout the three years of the study. By accurately monitoring flow through the rootzone and sampling the leachate to obtain N concentrations, the total quantity of N being leached could be determined.

The overall goal of this study was to provide scientific data for the development of BMPs for sand-based turfgrass systems. To accomplish this goal, our research objectives were to measure flow through a sand-based putting green, under golf course management and play, and to determine the N concentration and quantity of N in the

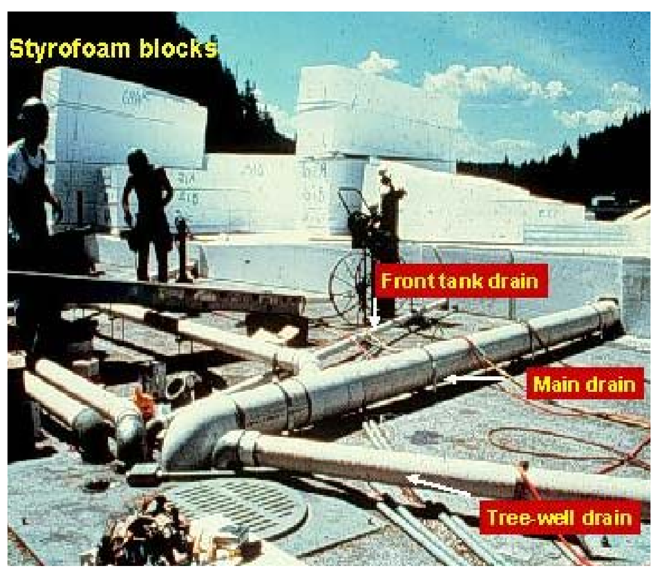

Figure 1. Buoyancy of the floating green was provided by approximately 100 polystyrene filled concrete cells (30 ft x 10 ft x 3.5 ft) staggered in two layers.

USGA Turfgrass and Environmental Research Online 1(19):1-7.
TGIF Record Number: 83193

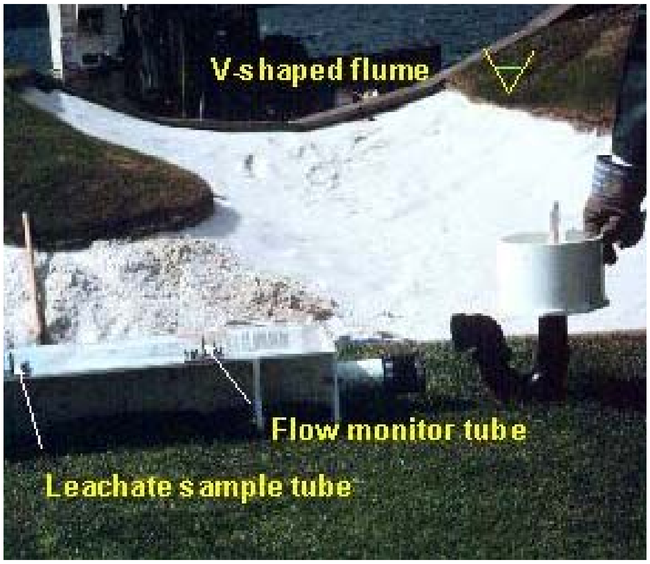

Figure 2. All leachate passing through the putting green profile flowed through a small trapezoidal flume attached to the main drain prior to flowing into the rear storage tank.

leachate and grass clippings.

The floating green - a massive field laboratory

The 15,000 ft^2 floating island green used in this study was constructed in 1990 at the Coeur d'Alene Resort Golf Course, Coeur d'Alene, ID (cover photo). Buoyancy was provided by approximately 100 polystyrene filled concrete cells (30 ft x 10 ft x 3.5 ft) staggered in two layers. To minimize weight, the green contours (subsurface grade) were constructed of styrofoam sections (Fig. 1).

The 7000 ft^2 putting green has a USGA-recommended rootzone with 14 inches of sand above a 4-inch layer of pea gravel. The putting surface was sodded to 'Penncross' creeping bentgrass (*Agrostis stolonifera* L.). The green was irrigated with water pumped directly from Lake Coeur d'Alene. Since Lake Coeur d'Alene is a large body of water (approximately 25,000 acres), as expected, there was little fluctuation in lake water NO_3-N and NH_4-N concentrations during the study. NO_3-N and NH_4-N were 40 and 80 ppb, respectively (0.04 mg L^{-1} and 0.08 mg L^{-1}, respectively).

Monitoring flow and sampling leachate for N

Downward flow of leachate into the styrofoam was prevented by an impermeable liner placed above the styrofoam sections and beneath a herringbone drainage system connected to two 850 gal storage tanks located under the front and rear bunkers. The putting green drainage was isolated from the surrounding area by a vertical liner. All leachate passing through the putting green soil profile flowed through a small trapezoidal flume (Plasti-Fab, Tualatin, OR) attached to the main drain prior to flowing into the rear storage tank (Fig. 2). When the rear tank was nearly full, leachate was pumped via a 4-inch flexible tube to a drainage field on shore.

From the flume a leachate sample was collected daily and flow was recorded every 30 minutes. Leachate samples were stored within an automatic sampler (Fig. 3) at 1 C to insure sample stability, transported to Washington State University, and frozen until N analysis with an Alpkem flow solution analyzer.

A weather station (Coastal Environmental, Seattle, WA) was installed at the site to record environmental parameters. Soil moisture potential and temperature probes were placed 39 inches onto the green and 5 inches below the surface.

Figure 3. Leachate samples were taken every 30 minutes and stored within an authomatic sampler.

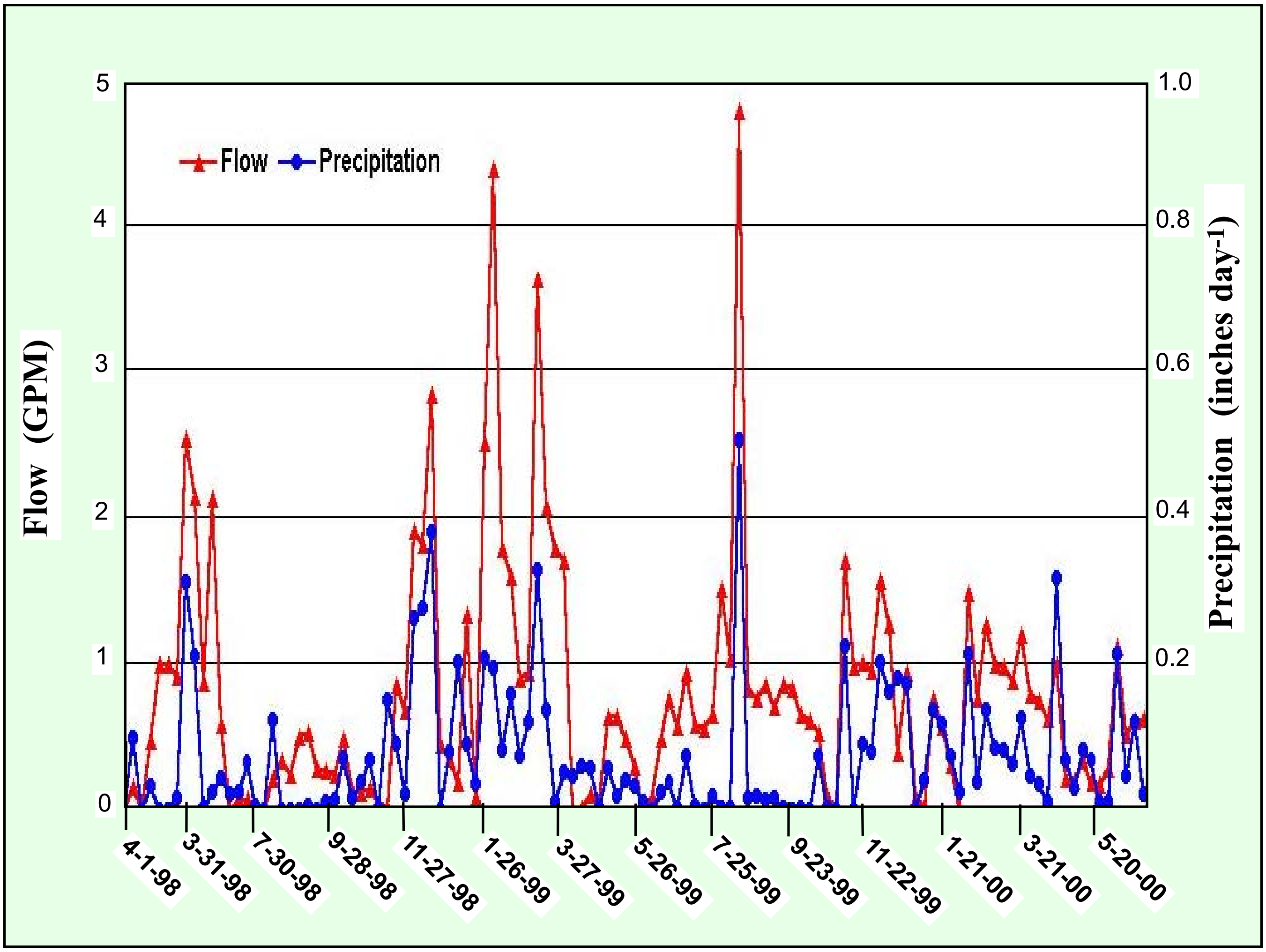

Figure 4. Leachate flow (gallons per minute) and precipitation (inches per day) through a golf green at Coeur d'Alene, ID, 1998-2000.

Data was collected every 30 minutes to correspond to the collection of the flow sample.

Fertilizer applications

A foliar fertilizer, 24-0-24 Nitro-K Plus II at 0.1 lb N per 1000 ft^2 (1.75% ammoniacal N, 3.0% nitrate N, 19.3% urea N), was applied by the golf course superintendent every 7 to 10 days during the growing season. In addition, Ferromec (15% urea N) was added to the foliar fertilizer at a rate of 1 oz per 1000 ft^2. The total N applied annually to the green ranged from 3.4 to 4.2 lb N per 1000 ft^2.

Nitrogen was increased to 0.3, 0.6, 0.7, 0.9, or 1.2 lb N per 1000 ft^2, one application at each rate, to observe the effects of higher N rates. Nitro-K Plus II was applied at 0.3 or 0.6 lb N per 1000 ft^2 on August 5 and September 4, respectively. Scotts 26-4-13 with minor elements (0.6% ammoniacal N, 9.9% urea N, 10.8% water soluble organic N, and 4.7% water insoluble N) was applied at 0.9 lb N per 1000 ft^2 on April 8, 1999, and 0.7 lb N per 1000 ft^2 was applied September 17, 1999, as Scotts Starter Fertilizer 19-25-5 (4.3% ammoniacal N, 7.4% urea N, 6.3% water soluble organic N, and 1.0% water insoluble N). In 2000, 1.2 lb N per 1000 ft^2 was applied on May 2 as Scotts 17-3-17 (3.3% ammoniacal N, 6.9% urea N, 3.9% water soluble organic N, and 2.9% water insoluble N).

Collecting clippings for N analysis

Grass clippings were collected from the green daily during the growing season by the golf

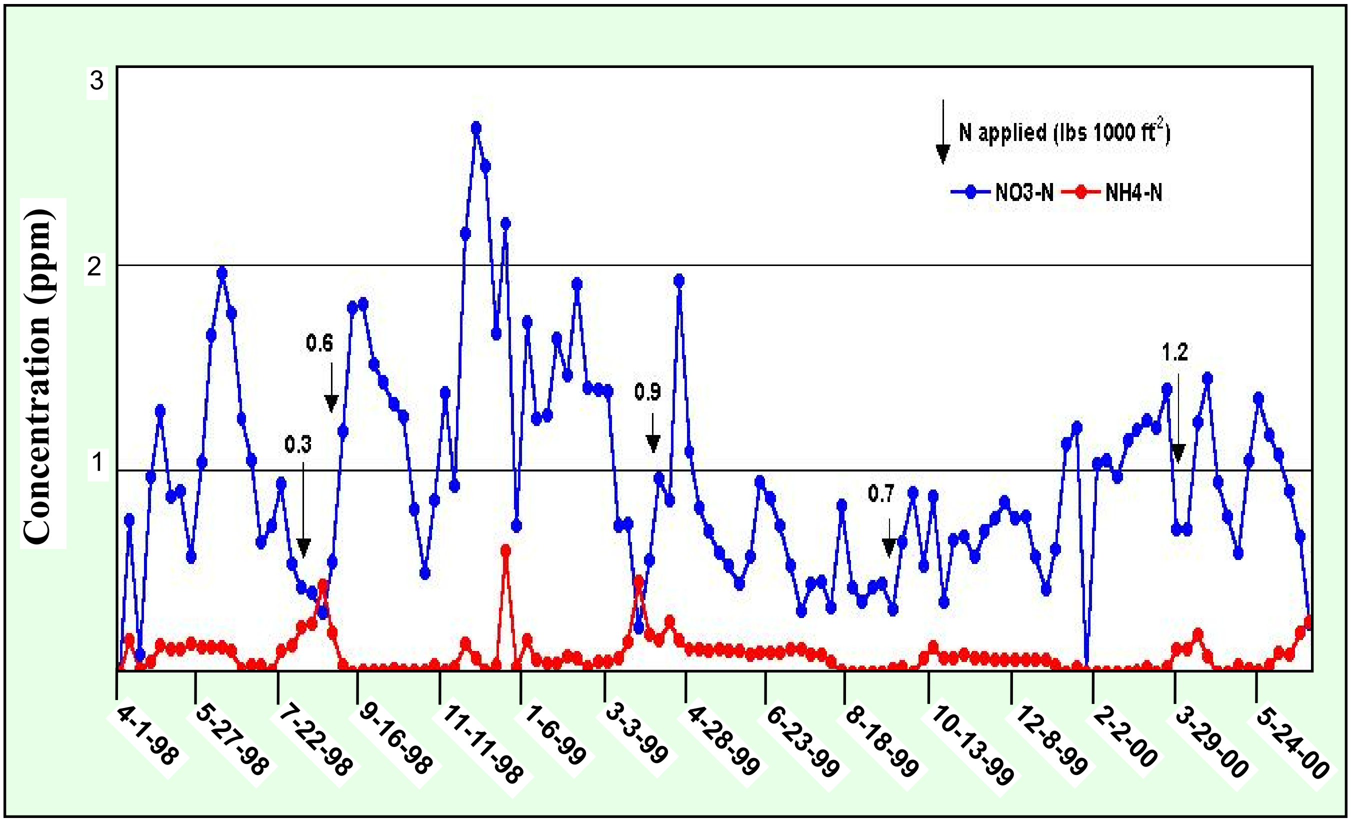

Figure 5. Leachate nitrogen concentrations from a golf green at Coeur d'Alene, ID, 1998-2000. Arrows indicate timing of nitrogen applications (lbs of N per 1000 square feet).

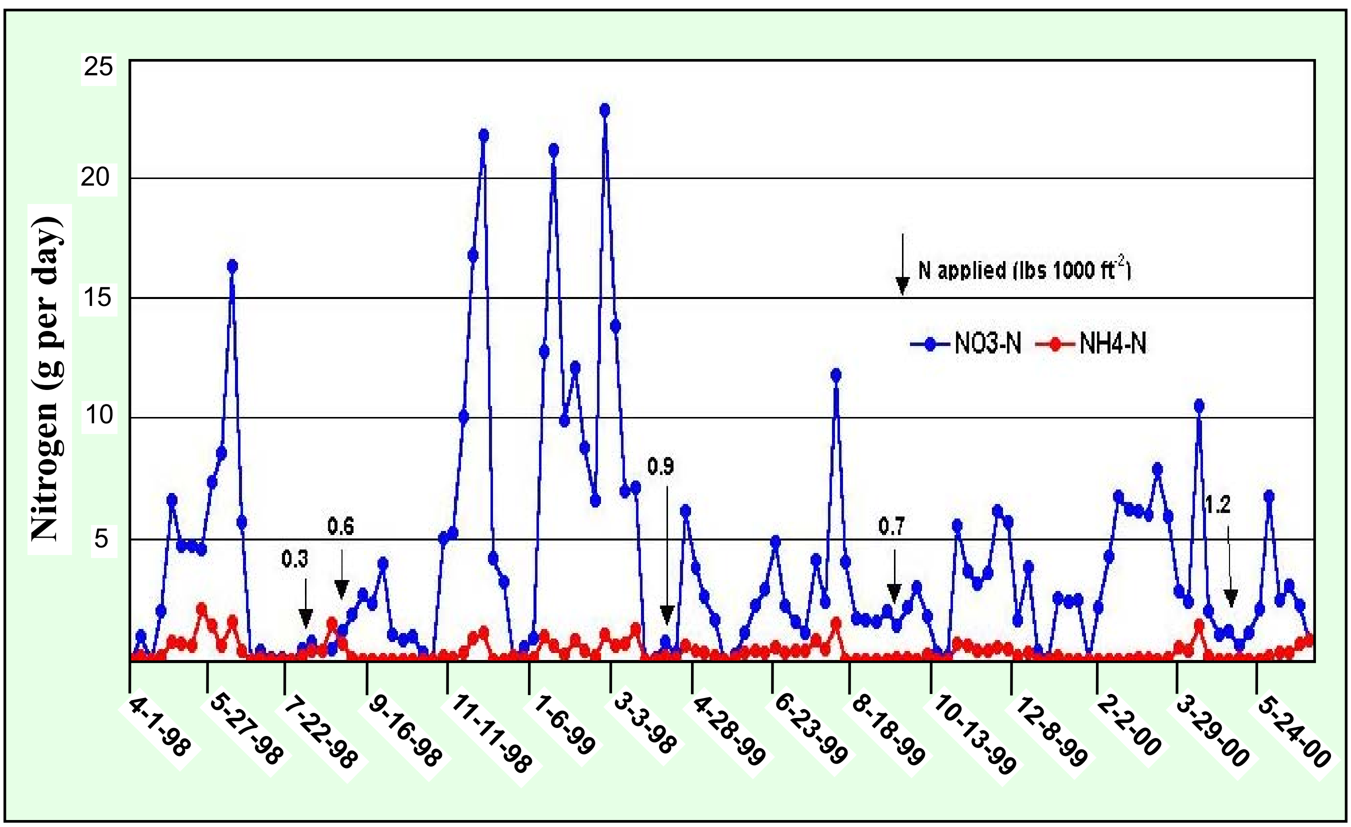

Figure 6. Nitrogen quantity (grams per day) in leachate from a 7,000 ft^2 golf green in Coeur d'Alene, ID, 1998-2000. Arrows indicate timing of nitrogen applications (lbs of N per 1000 square feet).

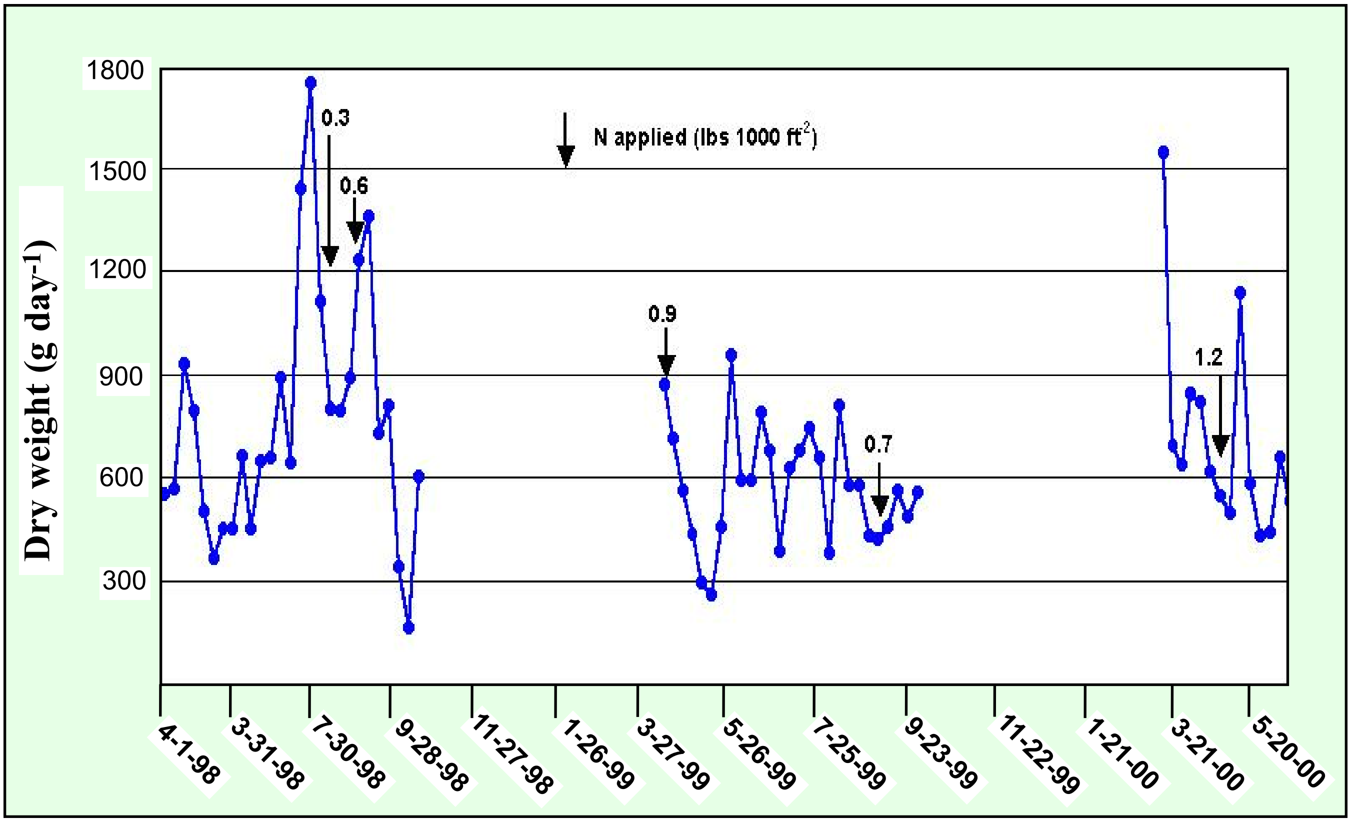

Figure 7. Clippings removed (grams per day, dry weight) from a 7,000 ft^2 golf green at Coeur d'Alene, ID, 1998-2000. Arrows indicate timing of nitrogen applications (lbs of N per 1000 square feet).

course superintendent, weighed, sub-sampled, and frozen. The clippings samples were later dried in a 60°C oven for 3 days and weighed. Clippings were separated from topdressing sand and analyzed for N using a LECO combustion auto-analyzer.

Flow (leaching) through the green

Annual precipitation during the study was 25 inches with more than two-thirds occurring from late October to early March, a period when the golf course was generally closed (golf course was open April 1 to October 31). Precipitation and flow through the green were related, i.e., as precipitation increased the flow through the green increased (Fig. 4). Low flow during winter occurred when the soil profile was frozen. When soil temperatures increased and snow melt occurred there was a notable increase in flow. Mean flow rate through the green over the 3-year study was 1151 gal per day. Peak flow rates can be attributed to rainfall events, e.g., during the week of August 4, 1999, when a 2-inch rainfall occurred during a 24-hour period (Fig. 4).

N concentration in leachate

Analysis for NO_3-N and NH_4-N indicated low levels of N in the leachate. NO_3-N ranged from 0 to 3.1 ppm, well below the US Environmental Protection Agency limit of 10 ppm, and NH_4-N levels ranged from 0 to 0.6 ppm (Fig. 5). There is no EPA standard for NH_4-N in ground water. Low concentrations of NO_3-N in the leachate may be attributed in part to light, frequent foliar N applications, periods of high leachate flow, and rapid turfgrass growth with high nitrogen uptake.

Increased nitrogen fertilizer rates increased leachate NO_3-N concentration during the 7- to 21-day period following application (Fig. 5). Others (2, 4) have reported higher NO_3-N leaching as N fertilization rated increased. However, at no time during an 8-week post-application period were NO_3-N concentrations

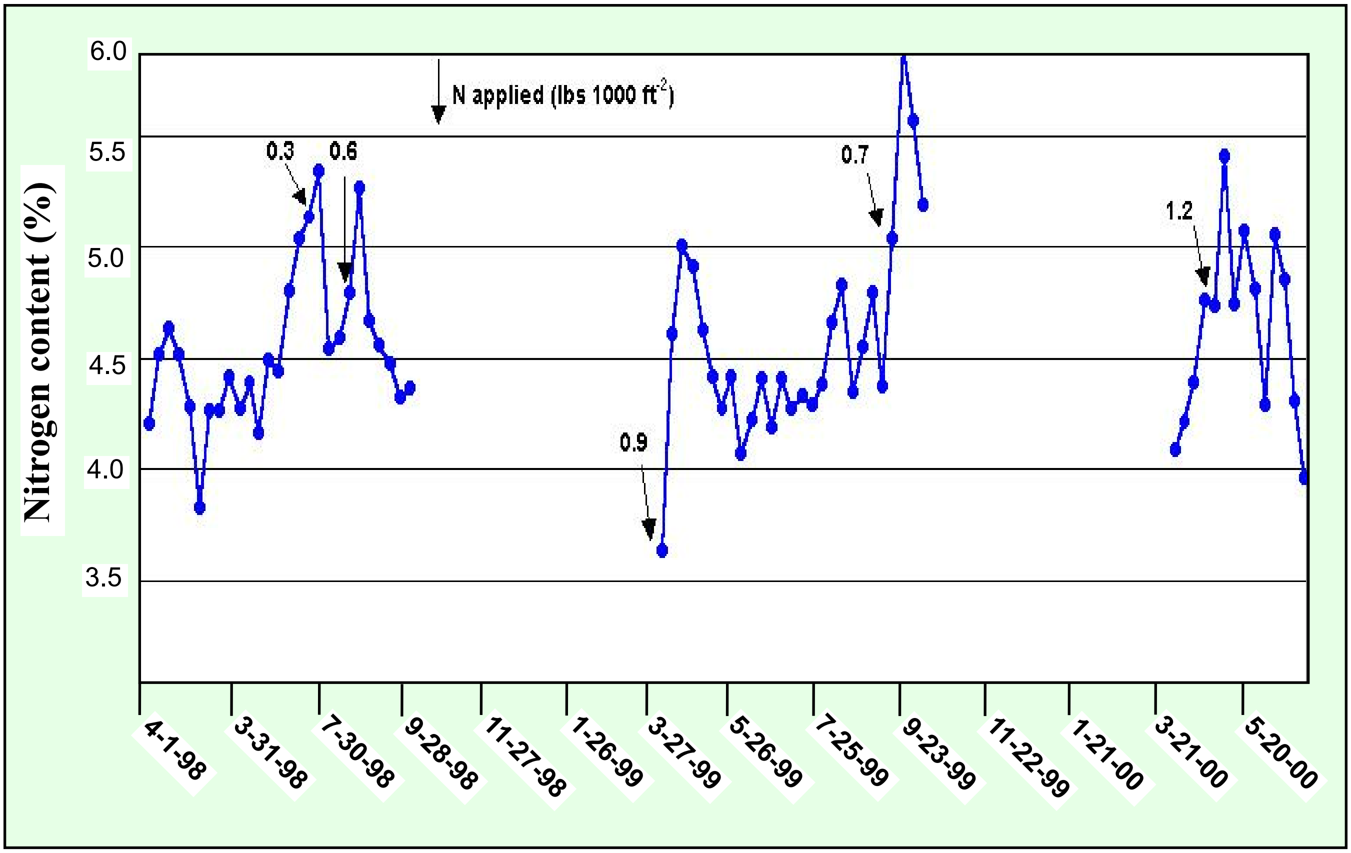

Figure 8. Nitrogen content (%) of clippings from a golf green at Coeur d'Alene, ID, 1998-2000. Arrows indicate timing of nitrogen applications (lbs of N per 1000 square feet).

excessive (i.e., greater than 1.9 ppm).

N quantity in leachate

The highest quantity of N leached during late fall and late winter/early spring when water flow and N leachate concentrations were high and grass growth was minimal (Fig. 6). An increase in the amount of N leached occurred 7 to 14 days following fertilizer applications, but results were confounded by increased flow that also occurred during this period. Since, in general, concentration decreases as flow increases, which as noted above did not occur, there was an increase in the amount of N leaching following fertilizer applications.

Clipping dry wt. and %N

Clipping dry weight variation can be attributed to mowing height variation, periodic mowing of cleanup lap, and environmental factors (Fig. 7). The daily bentgrass clipping N ranged from 2.4 to 7.3% and reflected increased N applications (Fig. 8). Mean N in the clippings was 4.6%. This is within the range of 3 to 6% N on a dry weight basis reported for turfgrass (1). The amount of bentgrass clippings removed from the green (Fig. 7) was a less accurate predictor of when N was applied than %N in the clippings (Fig. 8). Low leachate concentrations combined with high leaf tissue (clippings) N suggests efficient N uptake by the grass.

% N recovered

Over the three years of this study, total recovered N was 59% (11% in leachate; 48% in clippings). Non-recovered N could be present in non-available forms in both the soil and thatch with some potential loss due to volatilization (13, 14); but is believed not to be an environmental concern (6, 12).

Acknowledgements

This research was supported in part by

grants from the United States Golf Association, Northwest Turfgrass Association, Western Canada Turfgrass Association, and Inland Empire Golf Course Superintendents' Association. The authors would like to recognize the on-site assistance of John Anderson, Golf Course Superintendent at the Coeur d'Alene Resort Golf Course, and the labor and technical assistance of WSU turfgrass students Jeff Schnurr and Chris Kleene and WSU faculty Dr. Bill Pan and Dr. Eric Miltner.

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