Transport of Runoff and Nutrients from Fairway Turfs

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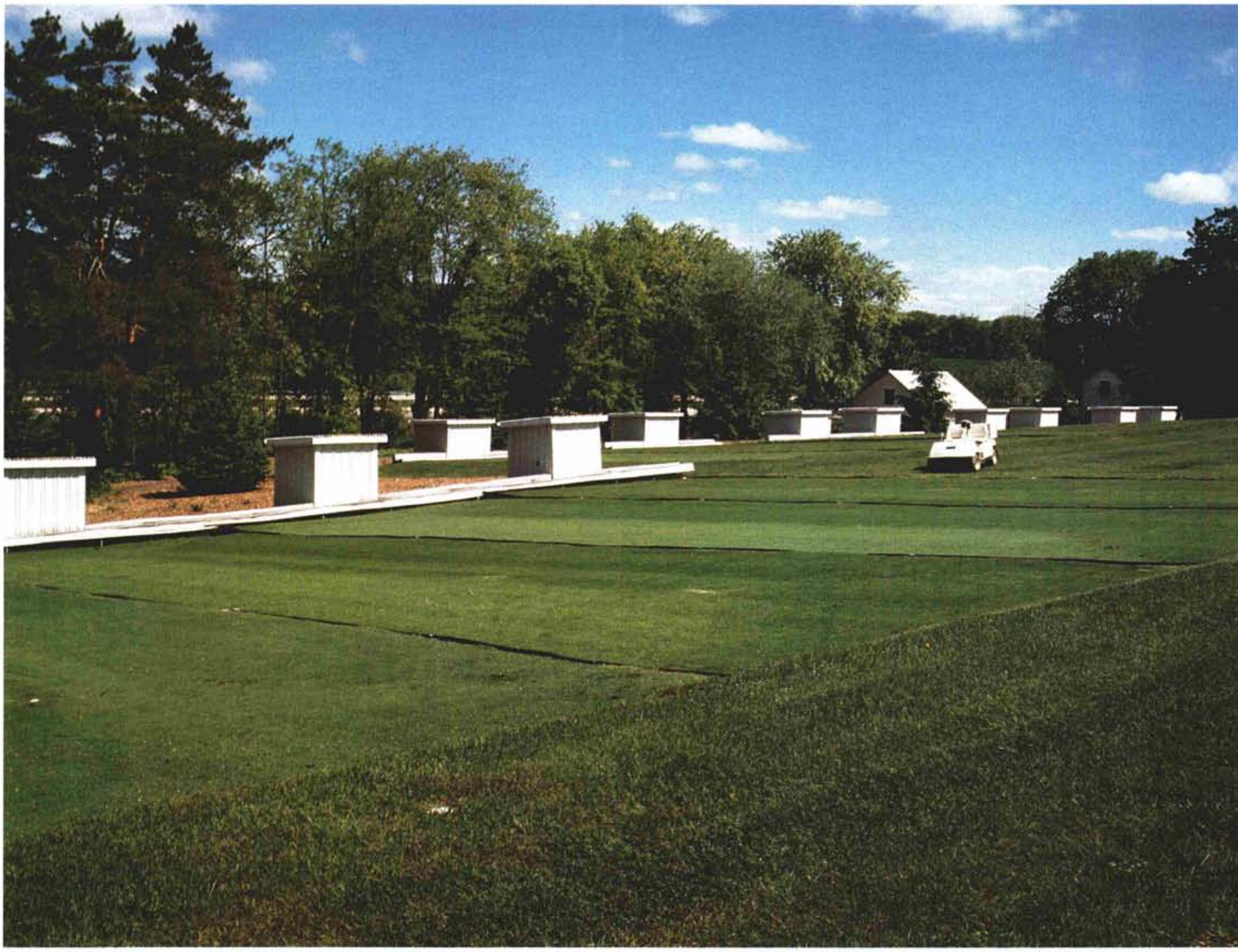


Creeping bentgrass and perennial ryegrass runoff plots.

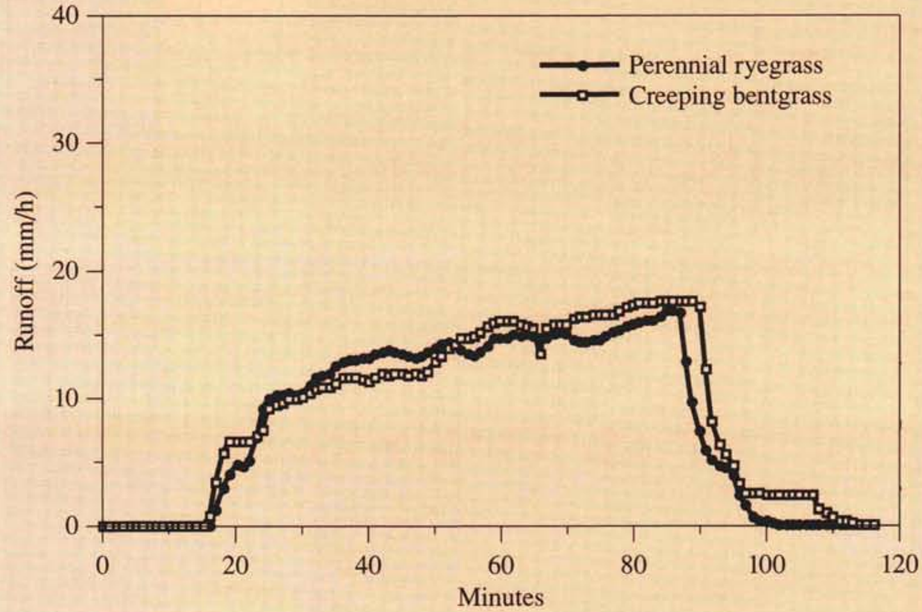
GOLF COURSES have some potential for offsite movement of nutrients in runoff water because of large, intensely maintained turfgrass areas. A better understanding of this potential would help turf managers as they use management techniques to reduce the possible movement of nutrients from golf courses.

In the limited publications concerning runoff from turfgrass, runoff, sediment, and nutrient transport were significantly reduced by turfgrass systems (Bennett, 1979; Gross et al., 1990, 1991; Harrison et al., 1993; Morton et al., 1988; Watson, 1985). These studies did not include information concerning runoff or nutrient transport from immature turfs or turfs maintained as a golf fairway. Therefore, a study was conducted that assessed runoff and nutrient transport from two commonly used fairway turfs, creeping bentgrass and perennial ryegrass, from seedling stage through maturity.

The growth habit of these two turf species is quite different. Creeping bentgrass is a fine-textured, stoloniferous (produces aboveground stems called stolons) species. It forms a turf with superior shoot density (>200 tillers/dm^2) when closely mowed and develops a definite thatch layer (Turgeon, 1985). Perennial ryegrass is a medium-textured, bunch-type (non-creeping tufts) species. It forms a turf with a good shoot density (100 to 200 tillers/dm^2) when closely mowed and develops no definite thatch layer (Turgeon, 1985).

The objectives of this study were to determine the amount of nitrate-nitrogen and phosphate in runoff and leachate samples and to compare runoff volumes from the two turf species.

Figure 1
Average Hydrographs for October 4, 1991, 6"/h Irrigation Event



Methods and Materials

The study was conducted on plots at the turfgrass runoff facility located at the Pennsylvania State University's Landscape Management Research Center on the University Park campus. The site has a variable slope (9% to 11%), and the surface soil is a severely eroded clay.

In July 1991, three runoff plots, each 1300 sq ft, were seeded with Penneagle creeping bentgrass, and three plots were seeded with a perennial ryegrass blend (Citation II, Commander, Omega II). Only triple-superphosphate was applied prior to seeding.

Plots were mowed with a reel mower at a height of 0.75" with clippings remaining. Cultivation practices such as core cultivation, verticutting, and spiking were not used during the study. Irrigation, other than that scheduled to provide adequate runoff and leachate samples, was conducted only when the turf was under moisture stress and for durations that would not produce runoff or leachate samples. Tiller density and thatch thickness were determined monthly to help characterize the surface vegetation of the two turfs.

The fertilizer used in the study was a 32-3-10 (N-P_2O_5-K_2O) fertilizer (O. M. Scott & Sons, Marysville), with 0.5% NH_4-N, 24.8% urea and methylene urea-N, P derived from monoammonium phosphate, and K from K_2SO_4. The turfs were fertilized on eight dates from October 1991 to October 1993 at a rate that applied 1 lb N/1000 sq ft. The turfs also were fertilized on one date with urea (46-0-0) at 1 lb N/1000 sq ft.

Water samples were collected from runoff events forced with irrigation and on occasion from rainstorms. Approximately 24 hours following a fertilizer application and on other selected dates, runoff was forced with irrigation at an average rate of 6" per hour to provide runoff and leachate samples for nutrient concentration analyses. A runoff hydrograph and volume were recorded for each plot. Irrigation duration varied from 7 to 35 minutes, depending on the turf species and soil moisture content.

Runoff was sampled at the rate of 16 ml/min throughout an event's duration to form a composite sample. A composite leachate sample was made from four subsurface samples per plot, leached 6" below the soil surface. Nutrient concentration analyses were based on samples collected from a total of 22 irrigated and rainstorm runoff events that occurred between August 1991 and October 1993.

Due to major differences in environmental and hydrologic conditions for each runoff event, comparisons were limited to individual dates. Also, runoff events from rainstorms often did not provide a full data set because runoff did not occur on all plots. In these cases, averages were based on the number of plots that provided data and were not included in any statistical analysis.

Results and Discussion

During the experimental period (August 1991 to October 1993), detectable levels of runoff (>0.6 mm/h) occurred due to rainfall on 5 dates. These runoff events occurred in response to intense rainstorms, usually containing short-term heavy downpours typical of thunderstorms.

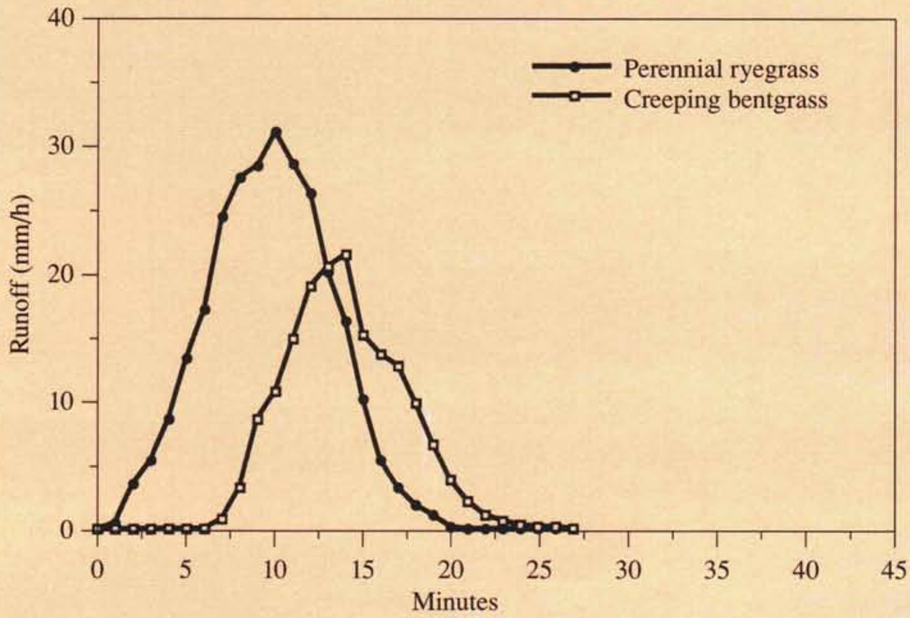
Average runoff volumes for all rainstorm events were lower for bentgrass than ryegrass plots. In addition, runoff volumes were consistently smaller, and the magnitude of the species differences was larger for the rainstorm events than the irrigation events. For example, on June 26, 1992, rainfall caused an average of 22 gallons of runoff from bentgrass and 109 gallons from ryegrass.

As the turfs matured, some interesting observations were made. On October 4, 1991, average runoff from the two turfs was similar (Figure 1). On this date (about 3 months after seeding), the turfs were immature and the bentgrass had not produced stolons or thatch. By the May 6, 1992, event (Figure 2), bentgrass had a significantly higher tiller density (860 tillers/dm^2) than the ryegrass (106 tillers/dm^2), and had begun to produce stolons. For the first time, runoff was found to be significantly different between the turfs. From then to the end of the study, runoff differences between the bentgrass and ryegrass plots were consistent. Runoff from the ryegrass plots occurred more quickly and at greater volumes than from the bentgrass plots. By July 1992, a measurable thatch layer had developed for bentgrass. No thatch was present in the ryegrass plots throughout the study.

When runoff was forced with irrigation in 1992, mean runoff values from bentgrass and ryegrass plots ranged from 1.8% to 22.5% of the total water applied. Values were always lower for the bentgrass plots that year, with 5 of the 7 events having a statistically significant species difference. Values determined by Harrison et al. (1993) for home lawn turfs ranged from 0% to 49%, but rarely exceeded 20% of total applied water.

Four additional experiments (Linde et al, 1994a) were conducted to provide some explanation of the runoff differences that developed between creeping bentgrass and perennial ryegrass. In one experiment, the average infiltration rates for the bentgrass

Figure 2
Average Hydrographs for May 6, 1992, 6"/h Irrigation Event



(2.5"/hr) and ryegrass (1.4"/hr) plots were not significantly different because of high sampling variation, which is typical for such measurements. In a greenhouse experiment that used 2.7 sq ft sloped trays of turf, we found that creeping bentgrass retarded the flow of surface runoff through its vegetation significantly more than perennial ryegrass. We also found that the leaves and stems of mature bentgrass intercepted 113% more water than the leaves and stems of mature ryegrass, and that bentgrass thatch slowed the initiation of runoff because of its high water-holding capacity and increased resistance to water flow.

From those four additional experiments, we determined that the high-density, thatch-forming bentgrass provided a more tortuous (winding) pathway for water movement. This increased the resistance to overland flow, which in turn increased the time that water spent on the turf, therefore allowing for greater overall infiltration on the bentgrass plots. As a result, for intensely maintained turf areas, selecting creeping bentgrass rather than perennial ryegrass would provide greater protection from surface runoff.

Nitrogen (NO_3-N) concentration in runoff and leachate were consistently lower than the 10 ppm drinking water standard set by the USEPA and rarely exceeded 7 ppm. Phosphate concentrations were also low and rarely exceeded 5 ppm.

Total Kjeldahl-N analyses were conducted on 1992 samples to determine the amount of fertilizer N that may not have yet been converted to the NO_3-N form. Because total Kjeldahl-N concentrations were low (rarely exceeding 2 ppm), it was assumed that most of the fertilizer N applied was in the soil above the subsurface sampler and/or did not become soluble and remained on the soil surface. To a lesser extent, the fertilizer could possibly have been converted to NO_3-N, absorbed by foliage and roots, utilized by the plants, and/or lost due to denitrification. As Harrison et al. (1993) had found, there was little indication in the runoff and leachate samples that fertilizer was ever applied.

Nutrient concentration and runoff volume per unit area were used to calculate nutrient loading rates in runoff and leachate for each turf. Loading rates of NO_3-N, phosophate, and total Kjeldahl-N were consistently lower than fertilizer and irrigation inputs of the nutrients.

Conclusions

Although creeping bentgrass reduced runoff more than perennial ryegrass, appreciable transport of NO_3-N, phosphate, and total Kjeldahl-N did not occur from either turf. Concentrations of NO_3-N, phosphate, and total Kjeldahl-N rarely exceeded 7, 5, and 2 ppm, respectively. In fact, nutrient concentrations and loading rates generally reflected those found in the irrigation water. Clearly, the nutrients in the fertilizer used in this study did not move in runoff or into subsurface samplers in amounts greater than found in the irrigation water. Under similar conditions on a golf course fairway, it would be reasonable to assume that little off-site movement of nutrients from the fairway would occur as a result of fertilization.

For golf courses that have potential runoff concerns, the selection of creeping bentgrass, which has more surface vegetation than perennial ryegrass, could reduce the amount of runoff from golf fairways, thereby reducing the potential off-site movement of nutrients and pesticides in runoff water.

The information from this study will be useful in the development of environmental models designed to determine the potential non-point impacts of nutrient applications on water quality. Current models and simulation software are not specifically modified for turfgrass conditions. In addition, the information from this study increases the database that a superintendent may refer to when communicating to others about the influence that golf courses have on the environment. Finally, this and other types of environmental research related to golf courses will be used to develop and refine management practices that the golf course superintendent can implement to protect the environment.

Further information regarding this research may be found in Linde (1993) and Linde et al. (1994a and 1994b).

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