Golfdom's PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

TURFGRASS TRENDS

FERTILIZATION

Nitrogen Uptake and Leaching on Greens

What are the implications for superintendents?

By Karine Paré and William J. Johnston

Superintendents know that management of putting greens is an art. Greens are often made of high-porosity sand that does not retain water or nutrients very effectively. Also, putting green grasses are cut extremely short, which does not allow a deep root system to develop and take up nutrients from deep in the soil profile. Therefore, putting greens require frequent irrigation and fertilizer applications to maintain high turfgrass quality.

Superintendents need to be aware that such management increases the potential of fertilizer leaching into ground water. Nitrogen (N) leaching can occur on putting greens, but the intensity is highly variable (Brown, 1982; Mancino and Troll, 1990; Shuman 2001).

In order to prevent the escape of N fertilizer applications into the environment, it is important to understand how N cycles in the turfgrass environment (Figure 1).

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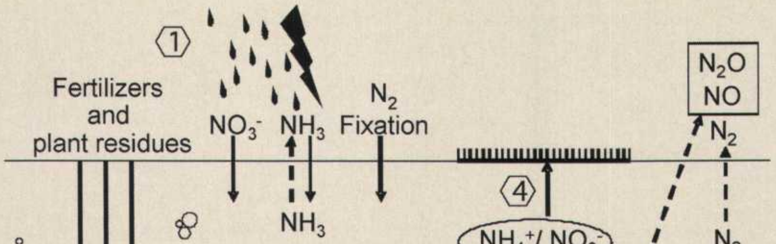
FIGURE 1



Nitrogen cycle (modified from Havlin et al., 1999).

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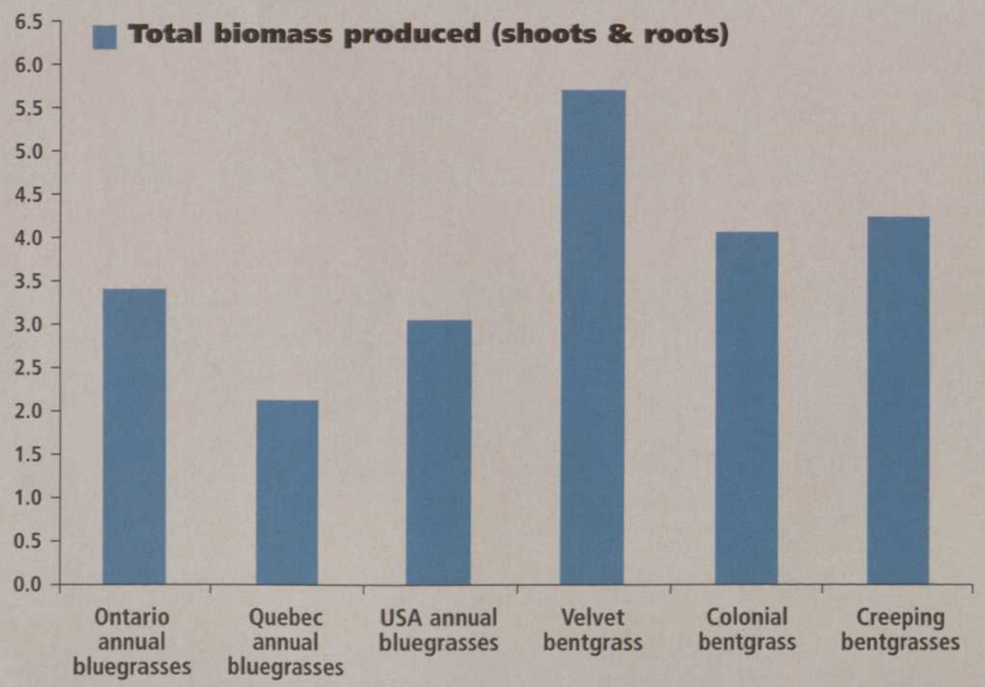
FIGURE 2



Total biomass produced (shoots plus roots) from various annual bluegrass ecotypes and bentgrass species in a greenhouse, University of Guelph.

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Nitrogen inputs are primarily from fertilizers and plant residues (clippings, if not removed) and to a lesser extent from N in rainfall and irrigation water (Petrovic, 1990) (Figure 1, step 1).

Soil microorganisms mineralize organic N from plant residues and fertilizers to ammoniacal N (NH_4^+) (Figure 1, step 2). Much of the NH_4^+ is converted to nitrate (NO_3^-) by nitrifying bacteria during nitrification (Figure 1, step 3). Turfgrass roots can take up either NH_4^+ or NO_3^- , but there is a preference determined by plant age and species, and the environment (Figure 1, step 4) (Havlin et al., 1999). NO_3^- is mobile in the soil solution and can be readily lost to groundwater or the drainage system by leaching (Figure 1, step 5), or can be converted to N_2, NO, or N_2O by bacteria or chemical reactions (Figure 1, step 6). N_2, NO and N_2O can then return to the atmosphere, thereby completing the N cycle. NH_4^+ is dissolved in the soil solution and is in equilibrium with gaseous NH_3.

If soil pH increases, NH_3 increases at the expense of NH_4^+ and is lost to the atmosphere by volatilization (Figure 1, step 7). Therefore, in turfgrass systems N fertilizers can be up taken by the plant (5-74 percent), stored in the soil plus thatch (15-21 percent, 21-26 percent when clippings are returned), lost to the atmosphere through volatilization (<36 percent) or denitrification (0-93 percent) or leached out of the soil profile (0-53 percent) (Petrovic, 1990).

Little runoff of nutrients from a fairway turf was found to occur in a two-year project at Pennsylvania State University (Linde et al., 1995). On putting greens with a sandy and porous rootzone, anaerobic conditions needed for denitrification are not present. This greatly decreases the risk for N loss.

Volatilization of N from N-containing fertilizers can be decreased with a light irrigation after fertilizer application. However, N leaching is a process that is highly variable and depends on numerous factors that include fertilizer source and rate, timing of fertilizer application and irrigation volume (Petrovic, 1990).

Ways to decrease N leaching

Certain measures can be taken to decrease the risk of N leaching. Although sufficient N fertilizer must be applied throughout the growing

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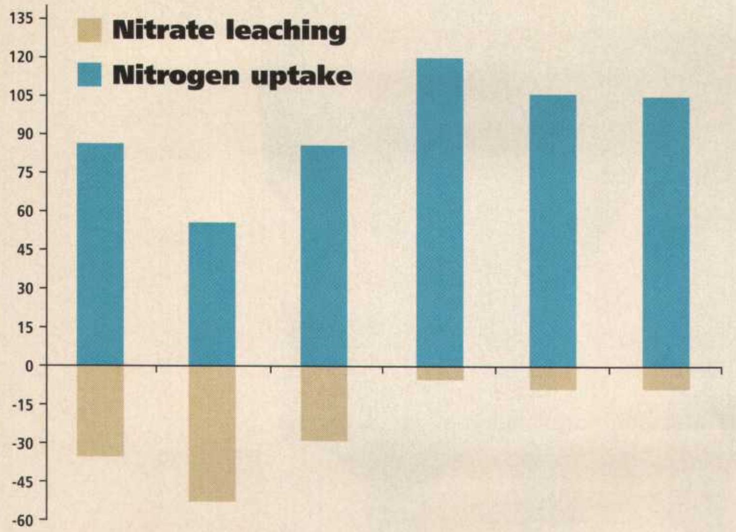
FIGURE 3



N uptake and nitrate leaching from various annual bluegrass ecotypes and bentgrass species in a greenhouse, University of Guelph.

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season to maintain an acceptable level of turf quality, the amount can often be decreased. The amount of N applied on golf greens was once much higher than today.

In Canada the yearly application of N to greens is 4.7 pounds per 1,000 square feet (Royal Canadian Golf Association, 2003). James Beard (2002) recommends 0.3 to 0.7 pounds of N per growing month for bentgrass (*Agrostis* L.) and annual bluegrass (*Poa annua* L.) putting greens.

Two types of N fertilizer are used on putting greens: quick-release (water-soluble) and controlled-release (slow-release). Water-soluble sources include ammonium nitrate (34-0-0), ammonium sulfate (21-0-0), potassium nitrate (13-0-44) and urea (46-0-0). Slow-release sources include sewage-based and other waste-based organic materials, ureaformaldehyde (UF), isobutylidene diurea (IBDU), sulphur-coated urea (SCU) and polymer-coated urea. Water-soluble N must be applied more frequently, in small quantities (spoon-feeding), followed by an adequate irrigation to avoid physiological burning of the leaves.

Controlled-released N fertilizers are generally more expensive but have the advantages of less leaching potential and rarely causing leaf burn. Carrow et al. (2001) indicated that the best plant response to N was obtained by light, frequent applications of water-soluble N sources.

It is important to irrigate according to the evapotranspiration of the turf. Weather stations and irrigation softwares now offer a precise mean of evaluating turfgrass water needs. Nitrogen will be absorbed by the root system if it stays in the root profile. If leached deeper by excessive irrigation, roots do not have access to it.

Another way to decrease N leaching is to increase uptake. Optimizing the amount of N taken up by turfgrass is an environmentally sound management practice. Nitrogen recovery in turfgrass plants (clippings, shoots and roots) can range from 5-74 percent of the N applied as fertilizer (Petrovic, 1990). The amount of N assimilated by the plant depends on N fertilizer management (N source, application rate and timing), grass species and site-specific environmental conditions. Specifically, plant N uptake depends on factors affecting grass growth rate, such as temperature, moisture, availability of soil N and the genetic potential of grass species and cultivars to absorb and metabolize N.

N uptake differences in turfgrasses

Morphological and physiological variations affecting N uptake are reported to exist among different turfgrass genotypes.

Liu et al. (1997) compared NO_3^- concentration in soil water and cumulative NO_3^- leaching for 30 cultivars of Kentucky bluegrass (*Poa pratensis* L.), perennial ryegrass (*Lolium perenne* L.) and tall fescue (*Festuca arundinacea* Schreb.). They found that NO_3^- utilization differed among species as well as within the same species.

Bowman et al. (1998, 2002) reported that the root distribution of bentgrass and six warm-season grasses affected NO_3^- leaching potential; a deep-rooted turf absorbed N more efficiently.

At the University of Guelph, Ontario, Canada, Paré et al. (2004) conducted a greenhouse experiment to compare N uptake and leaching potential under various annual bluegrass ecotypes and bentgrass species. Differences in growth characteristics were observed. Annual bluegrasses, especially Quebec ecotypes, had smaller total biomass production when compared with the bentgrasses (Figure 2).

The greatest total biomass was produced by

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velvet bentgrass. The aboveground biomass production represented 50-60 percent of total plant biomass production for all grasses tested and was greater for the bentgrasses than the annual bluegrasses. In addition, the root biomass was greater for the bentgasses and developed deeper in the soil. It is logical to assume that a plant with a larger root system exploits a larger soil volume and has a greater potential to absorb nutrients.

Bentgrasses had a greater N uptake than annual bluegrasses (Figure 3) (Paré et al., 2004). Most of the variability found in total N uptake was attributable to the greater above-ground biomass of bentgrasses compared to annual bluegrasses. In addition, differences occurred among annual bluegrass ecotypes, with Quebec ecotypes having the least N uptake. A positive correlation was observed between total biomass produced and total N uptake; bentgrasses had a greater N uptake than annual bluegrasses.

A negative correlation was noted between total N uptake and total NO_3-N leached during the study. Since the annual bluegrass ecotypes had a shallower and smaller root system, they took up less N and demonstrated a greater N leaching potential than the bentgrasses (Figure 3).

Conclusions

To prevent N leaching, superintendents need to carry out environmentally sound practices such as reducing the amounts and rates of N applied, spoon-feeding, using slow-release N fertilizers and irrigating according to evapotranspiration.

In addition to these practices, choosing a grass species or cultivar with a low N requirement, a well-developed root system and a high overall biomass production could help decrease N leaching. During the growing season it is essential to fertilize according to the state of the root system. In case of cool-season grasses, practices increasing rooting density and depth during the summer must also be considered. For instance, raising the mowing height, if possible, can help promote deeper roots.

Finally, Kerek et al. (2003) found that organic matter, which accumulates over years, can supply a large amount of N to the turfgrass. Therefore, as the putting green gets older and microorganisms recycle N from the organic matter, less external N may be required.

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