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tors also contribute to the lower nitrogen-use efficiency of cereals compared to turfgrasses. The perennial root systems of a grass sod contribute substantial amounts of organic matter throughout the soil profile as roots continuously die and are replaced. This organic matter supply encourages a complex microbial population that converts dead roots into organic soil colloids that in turn provide cation exchange sites that bind ammonium ions (NH4+). Being in equilibrium with ammonium ions in the soil solution, this colloid-bound reservoir of ammonium maintains a low but stable concentration of ammonium in the soil solution replacing that absorbed by roots or oxidized by microbes. The presence of both ionic nitrogen species in the root environment favors root absorption by helping to maintain ionic balance between root cells and soil solution (Garnett et al. 2009).

Colloidal organic matter also sequesters organic nitrogen within its chemical structure and serves as a slowly available stockpile of soil nitrogen. Soil organic matter accretion can accumulate carbon and nitrogen within the turf-soil ecosystem for about 45 years when it may exceed 4.5 percent of soil dry weight (Qian et al. 2003). From then on, the turnover of soil organic nitrogen is sufficient to support turf growth with little if any fertilizer nitrogen being added. Such a mature turfgrass sod will leach virtually no nitrate to groundwater unless it continues to be fertilized in excess of 25 pounds nitrogen per acre per year.

Accumulation of ammonium and/or amino acids (glutamine) within root cells will suppress nitrate and ammonium uptake by down-regulating the genes that encode for transport protein (Garnett et al. 2009). If this occurs, nitrate can accumulate within the soil solution and become vulnerable to leaching in the event of excess rain or irrigation. Excess nitrate in roots can and likely will be transported to the shoots, especially to the leaves. There, nitrate sends a signal to the roots, probably in the form of glutamine, to suppress further nitrate absorption and root growth.

Excess nitrogen in the leaves also diverts photosynthetic energy (sugars) toward greater shoot growth leaving less available for translocation to the roots, further depressing root growth. In cool-season turf, root deterioration can occur during periods of elevated soil temperatures. However, soil microbial activity will be stimulated under higher temperatures, increasing the oxidation of organic matter and the ultimate release of nitrate. Soil nitrate levels will increase and be subject to leaching if root absorption is inhibited. Warm-season turfgrasses are much less vulnerable to high temperature growth inhibition; in fact elevated temperatures stimulate them. All this results in a summer decline in nitrogen-use efficiency, especially in cool-season turf.

Because of their annual lifecycle, cereal grasses are unable to establish the complex association with soil microbes and organic matter metabolism that is characteristic of perennial grasses. Consequently, dramatic increases in their nitrogen-use efficiency may be difficult to achieve. At 33 percent nitrogen-use efficiency, there's room for improvement but Garnett et al. (2009) admit that a clear path to achieving improvement is not evident.

Thus, it appears that turfgrasses inherently pose less of a problem for nutrient loss than do most crop plantings. Grasses have been used for more than a century to stabilize soils and prevent nutrient losses. It seems only reasonable and research clearly confirms that no landscape component offers less threat to the environment than well-managed turf.

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