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Turf Grass TRENDS

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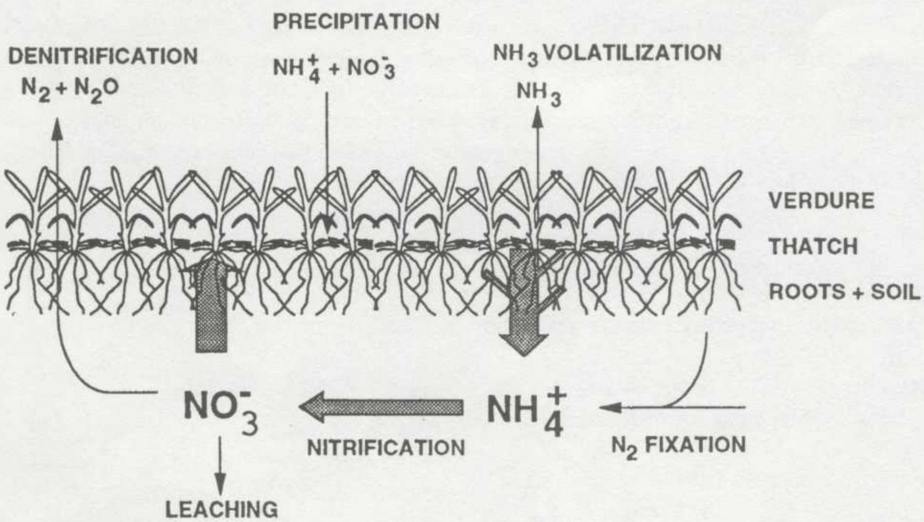
Nitrogen fate

What happens to it and where does it go?

by Dr. Richard Hull

The appetite of turfgrasses for nitrogen seems to be insatiable. It does not matter how old or how young the turf stand may be or what type of nitrogen source is applied to it; turfgrasses love nitrogen. So much so that, given the opportunity, they will take in more nitrogen than they can use, often to their own detriment. Yet, if a nitrogen fertilizer application is missed, the turfgrass will often go off color. In fact, only about 80% of the fertilizer that is applied

Nitrogen cycle in the turf-soil ecosystem



All natural inputs and losses of nitrogen are identified as well as chemical transformations. Mineralization of soil organic nitrogen is not shown nor is fertilizer input.

Figure from Hull, Alm and Jackson, 1994. Toward Sustainable Lawn Turf. p. 3-15. In A.R. Leslie (ed.) Handbook of Integrated Pest Management for Turf and Ornamentals, Lewis Pub. Boca Raton, FL.

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by turfgrass managers to turf stands can actually be accounted for in the turfgrass environment. This means that about 20% of the applied nitrogen is lost by some mechanisms other than plant use.

Where does the majority of the nitrogen go?

I and many of my fellow researchers, who are studying the fate of applied nitrogen in the turfgrass environment, have been trying to identify all of the mechanisms by which these losses take place. Certainly removal of clippings, which can contain the nitrogen equivalent of 75% of that applied as fertilizer, from the turfgrass canopy can explain the major portion of the nitrogen use. However, when the clippings are not removed and remain in the turfgrass environment, research has only been able to explain the aforementioned 20% loss.

This fact implies that as much as 80% of the fertilizer that is applied each year should still be there at the end of the year and that this accumulated nitrogen could eventually lead to a substantial reduction in the annual amount of nitrogen that is applied to a site. Although researchers are beginning to gather data that suggest that nitrogen may be accumulating in the turfgrass environment, as of this writing there has been little evidence that would lead to such reduced application recommendations forthcoming.

This mystery of the unaccounted for nitrogen is becoming the subject of much active research by many turfgrass nutritionists and turf management specialists. The research has not progressed to the point where definite answers to this question will soon be developed, but it is providing enough data that we are beginning to understand the scope of the question. In other words, we think that we now know enough to ask the right questions.

Since the results of this research may well change the way turfgrass managers use nitrogen fertility in the near future, it might be useful to examine what we do know about the fate of nitrogen in the turfgrass environment.

Turf can accumulate nitrogen

by Dr. Richard Hull

If clippings are retained and all other mechanisms of loss can account for only 15% to 20% of nitrogen applied as fertilizer to the turfgrass environment, the question remains: Where does the remaining 80% to 85% of the nitrogen accumulate?

To answer that question, we conducted a study where we collected six-inch cores of turf and separated them into their component fractions — shoots, roots, thatch, and soil. Each fraction was analyzed for total nitrogen. The table below contains the results of that analysis.

The turf used in this analysis had received 3.5 pounds nitrogen per 1000 square feet per year for three years prior to the core samples being taken. Before initiating high management practices at this site, it had been in turf for more than 25 years under varying fertility levels.

Our research into the organic nitrogen dynamics of the turf-soil ecosystem is on going, with an emphasis on determining the rate at which nitrogen accumulates in the soil fraction and what part the rate of mineralization of soil organic nitrogen plays in that accumulation. These values must be known before turfgrass managers will be able to capitalize on accumulated soil nitrogen and subsequently reduce the amount of applied fertilizer.

Nitrogen distribution within the turf-soil ecosystem

Intensively managed turf (3.5 pounds nitrogen per 1000 square feet per year)*

Turf fraction	**Total nitrogen**		**Percent of total**
	pounds per acre	pounds per 1000 square feet	%
Soil	1811	41.2	83.2
Thatch	257	5.8	11.8
Shoots	94	2.1	4.3
Roots	15	0.3	0.7
Total	2177	49.4	100.0

* Turf sampled April, 1993

It all comes down to nitrates

From a turfgrass plant's point of view, it makes little difference what source or form of nitrogen a turfgrass manager may apply, be it inorganic nitrogen salt, a coated product, or natural organic. Before the plant can benefit from the fertilizer, the nitrogen must be in a form that the plant can utilize, often the nitrate form. The nitrate and ammonium forms of nitrogen are the only two forms that the turfgrass root system can use.

If a "fast-release" inorganic nitrogen salt, such as ammonium sulfate, is applied as a fertilizer source, the salt's components dissociate in the soil water, directly releasing ammonium and sulfate into the soil solution, where they are immediately available for plant use.

If a "slow-release" nitrogen source is applied, it is often in an organic form, either synthetic or natural organic. Organic nitrogen sources are forms of nitrogen that have been "built" into complex chemical structures along with carbon, hydrogen, and oxygen. These organics range in complexity from the relatively simple water-soluble synthetic organics, such as urea and methylene urea, to the much more complex water-insoluble synthetic urea formaldehyde and the naturally-occurring organics, such as those derived from composted sources. Whether they are relatively simple organics or highly complex, they are basically similar in chemical form and are subject to the same processes.

Mineralization and nitrification

Once applied, organic nitrogen fertilizers are subject to two basic processes, mineralization and nitrification.

Mineralization: Organic nitrogen sources are utilized by microorganisms as a food source. In the process of digesting the organic nitrogen compounds much of the

Gaseous nitrogen losses

by Dr. Richard Hull

In our search for routes of nitrogen loss from the turfgrass environment, we measured loss by nitrate leaching and clipping removal. In addition, we monitored gaseous losses which can occur under very specific conditions.

Gaseous ammonia losses

Within the first 48 to 72 hours after an application of fertilizer, some nitrogen can escape as gaseous ammonia. This can occur when urea, the nitrogen source most closely identified with this phenomenon, experiences rapid mineralization either within the thatch layer or on leaf surfaces. If the ammonia that is produced is not quickly dissolved in water, producing ammonium ions, ammonia will be lost into the atmosphere.

Depending on the nitrogen source applied and the application technique used to apply the fertilizer, losses by ammonia volatilization can be substantial. These losses can reach 25% to 30% of the amount of nitrogen applied, with some researchers reporting losses that approach 50%.

Losses of gaseous ammonia into the atmosphere can be minimized by applying water immediately after an application of fertilizer. In our studies, when we did that, we observed very little ammonia volatilization: only about 1% of the nitrogen applied.

Mineralization of nitrogen within the soil profile is not subject to ammonia volatilization, because with sufficient soil water available and under the slightly acidic conditions of soil, the ammonia is rapidly trapped as ammonium ions.

Other gaseous losses

In addition to nitrogen losses as ammonia gas, saturated soil can lose nitrogen by a different process. When normally well aerated soils are waterlogged, the nitrate present can become chemically reduced by the activity of microorganisms to form elemental nitrogen and nitrous oxide. Both of these compounds are gaseous and are rapidly lost into the atmosphere. The gaseous loss occurs when the soil is saturated for several hours, soil temperatures are warm and nitrate is present.

We have measured the potential for denitrification in saturated turf soils and found that it occurs at reasonable rates. When we calculated the total nitrogen losses that can occur during times when soil is saturated, usually the 24 hours following a heavy rainfall, we found that about 5% of the nitrogen applied was lost over the course of a year.

nitrogen is released as an ammonium ion (NH_4^+) as in the following chemical reaction:

$$2CO(NH_4)_2 + O_2 + 4H^+ \longrightarrow 2CO_2 + 2NH_4^+$$

This reaction represents the oxidation of an organic nitrogen source, urea, into carbon dioxide and ammonium. This conversion of an organic nitrogen source into an inorganic ammonium-nitrogen source is an example of the process of mineralization. All organic sources, whether they are synthetic or natural, undergo this mineralization either by action of soil microbes or by chemical hydrolysis to release ammonium into the soil solution. In addition to applied nitrogen sources, naturally occurring soil organic matter also is subject to this process, liberating additional ammonium into the turfgrass environment.

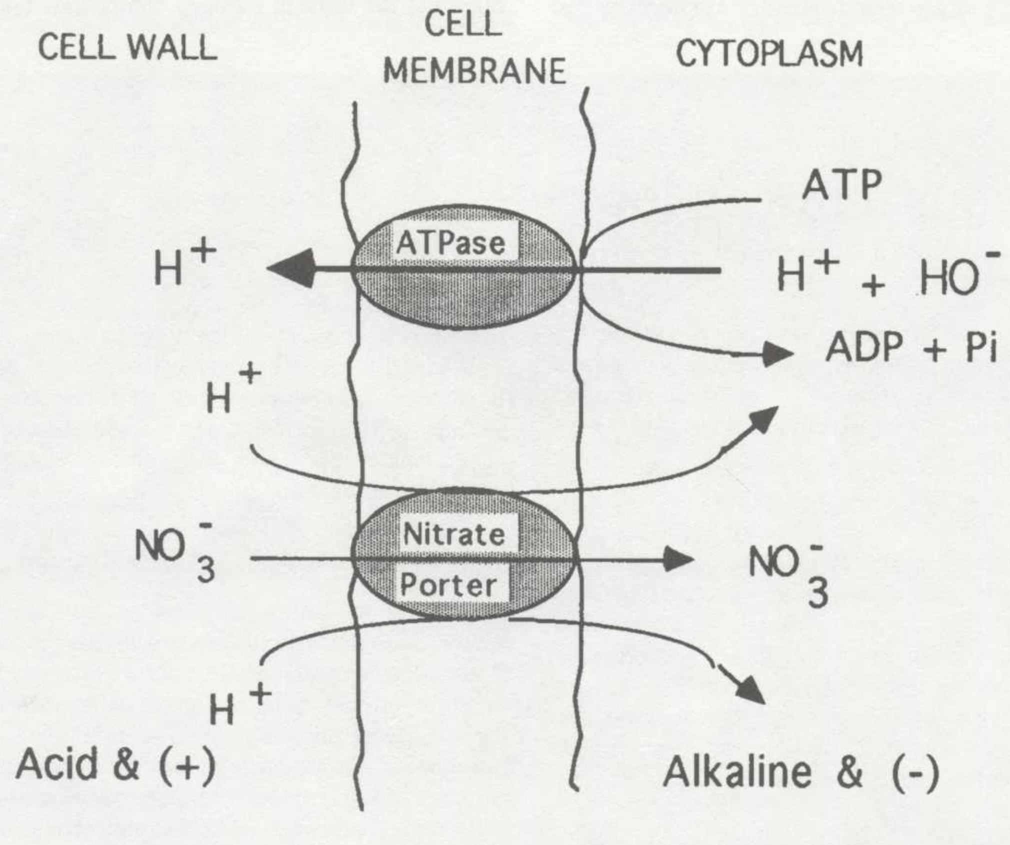
Nitrification: Ammonium is available for use by both plants and soil bacteria. When ammonium is absorbed by plant roots it is incorporated into the plant in the form of important nitrogen compounds such as amino acids, proteins, and nucleic acids.

However, ammonium can also be utilized as an energy source by specialized soil bacteria in a process known as nitrification, as in the following chemical reaction:

$$2NH_4^+ + 5O_2 \longrightarrow 2NO_3^- + 4H_2O$$

This reaction represents the oxidation of ammonium into nitrate ions (NO_3^-) and water. The nitrifying bacteria intercept the majority of the ammonium liberated by the mineralization process, before it can be absorbed by the turfgrass roots. As a result, the nitrate form of nitrogen is left by default as the primary form of nitrogen that is available to be absorbed and utilized by the plants.

Model of nitrate absorption



A model of nitrate uptake by root cells. The H^+ gradient across the cell membrane produced by ATPase is used by the nitrate porter to carry NO_3^- into the cell along with 2 H^+.

Figure provided by Dr. Richard Hull, Rhode Island University

Why does nitrogen leach from soils?

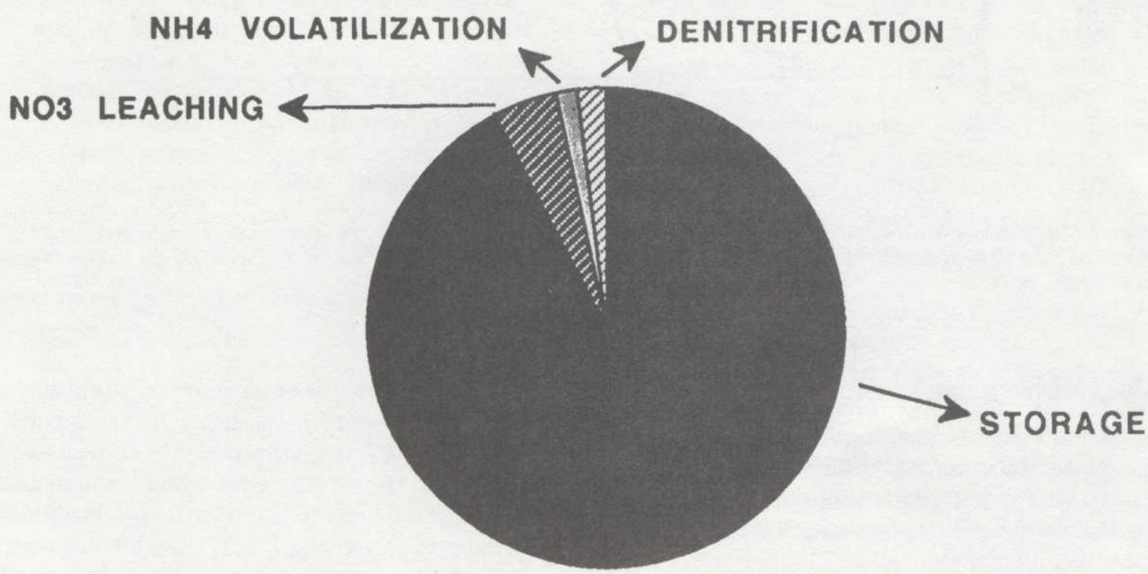
Nitrate ions (NO_3^-), relatively small and having a negative charge, are not electrically attracted to the fixed, negatively charged soil particles that normally bind many other of the positively charged plant nutrients, such as calcium, to the soil colloids in a process called cation exchange. As a result of this failure to bind to these sites (note: like negative charges repel), the nitrate is free within the soil solution and susceptible to leaching down through the soil profile below the root zone and into the ground water. This makes nitrates a potential ground water pollutant that can contaminate wells and drinking water supplies.

The major process by which nitrates are removed from the soil solution is by root absorption. Consequently, the amount of nitrates in the soil solution at any given moment is the difference between that which is released through fertilization and decomposition of naturally occurring organic matter and the amount of nitrates that are being absorbed by plant root structures.

This soil-water concentration of nitrates is an excellent measure of the balance between production and removal, and is a measure of the potential for nitrogen leaching. Low soil-water nitrate levels indicate that the nitrate produced is being absorbed by the turfgrass root system and that the potential for leaching is low. High soil-water nitrate levels indicate that production exceeds the turfgrass root system's ability to absorb the nitrogen and that the potential for leaching is high.

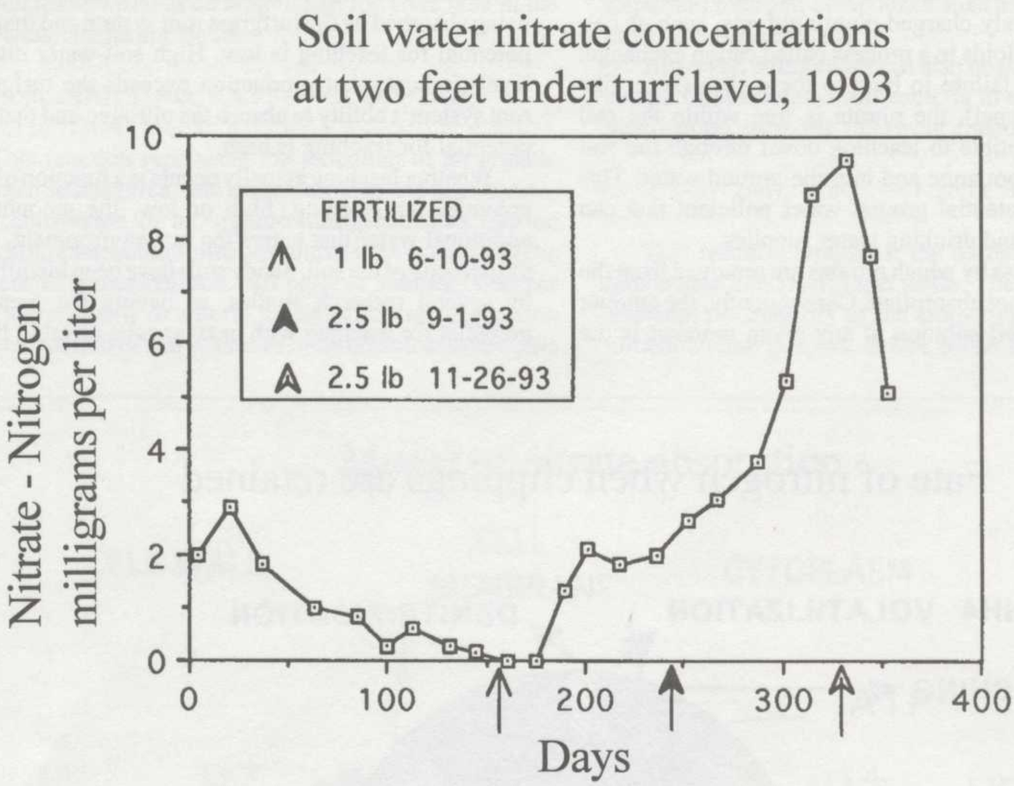
Whether leaching actually occurs is a function of the potential for leaching, high or low, the amount of additional water that enters the turf environment, and the porosity of the soil. Sandy soils have been identified, by several research studies, as having the greatest potential for leaching with heavier soils offering little potential. Most leaching will occur from sandy soil sites that have high soil water nitrate levels and get sufficient rainfall or irrigation water to percolate down through the soil profile, carrying the excess nitrates. These sites may have little or no leaching if excess water is delayed until the production and absorption of nitrates achieves a better balance.

Fate of nitrogen when clippings are retained



More than 80% of the nitrogen is retained in the turf-soil system as plant tissues, thatch, and soil organic matter. This nitrogen can be viewed as in storage because it will eventually become available to turfgrass plants.

Figure provided by Dr. Richard Hull, Rhode Island University



The yearly profile of soil water nitrate concentrations two feet under established turf. All plots received one pound nitrogen per 1000 square feet on June 10 and half of the plots received 2.5 pounds nitrogen on September 1. The other half received 2.5 pounds nitrogen on November 26, 1993.

Figure provided by Dr. Richard Hull, Rhode Island University

How does nitrogen uptake occur?

Despite the turfgrass plant's propensity for excess nitrogen uptake, the process by which the plants absorb nitrogen is anything but simple. Considering all of the obstacles that the absorption process must overcome, it is remarkable that it takes place at all.

Nitrate absorption occurs at the outermost layer of root cells, the epidermis. Despite the fact that turfgrass roots can be up to a foot in length, only the first one to two inches of the root tip efficiently absorb nutrients. If the root tips are damaged, diseased, or missing, the amount of nitrate absorption can be severely restricted.

Once at the root tip, the nitrate must overcome two important conditions to be absorbed by the root: an unfavorable nitrate ion concentration gradient and an electrical gradient. The nitrate ion concentration gradient occurs, because the nitrate concentration within the cells of the root tip is normally higher than the concentration of nitrates in the soil-water. Ions do not freely travel across a membrane, from an area of low concentration to an area of high concentration. Normally, they travel from high to low to achieve a balance. The electrical gradient occurs when the normal functioning of the roots causes hydrogen ions (H^+) to be pumped into the outer cell walls of the epidermis and the surrounding soil-water. This process occurs through the controlled hydrolysis of adenosine triphosphate (ATP) (See Figure 1 on page 4.). This leaves high concentrations of positively charged hydrogen in the cell wall and soil-water. And it leaves a higher concentration of negatively charged hydroxide ions (OH^-) within the cell in addition the existing negatively charged nitrate and organic ions.

In order for nitrate absorption to succeed against these two formidable forces working against the absorption, a third process must be at work. That is exactly what happens.

A protein imbedded in the cell membrane allows two hydrogen ions to return to the cell cytoplasm, if they are accompanied by a single nitrate ion (See Figure on page 4.). This cotransporting protein uses the energy represented by the hydrogen ion gradient across the cell membrane to drive the nitrate ion into the cell against both the ion concentration and the electrical gradient. This cotransport will succeed as long as the energy propelling the two hydrogen ions into the cell is greater than the energy keeping the single nitrate ion out.

How important are functioning roots?

How does all this chemistry relate to nitrate use by turfgrasses? For nitrate uptake to occur in turfgrass roots, metabolic energy, in the form of ATP, must be expended.

In other words, nitrate absorption can only occur in the presence of metabolically active and growing roots. ATP, in the roots, comes from the respiratory metabolism of sugars, which have been transported from the leaves to the roots. Thus for roots to be metabolically active and create the ATP that allows for the absorption of nitrates by the roots, they must be receiving sugars from the photosynthetic activity of healthy functioning leaves.

Dormant, damaged, or stressed turf leaves cannot support actively growing roots and in turn support the least amount of nitrate absorption. While robust, healthy leaves support the greatest amount of nitrate uptake. This is supported by the fact that nitrate uptake has been measured to be the highest in the spring and the lowest in the late summer.

This relationship between leaf activity and root activity would imply that rapid shoot growth and rapid root growth should go hand in hand with high nitrate uptake. Although some times true, periods of rapid leaf growth often sup-

Field tips

Steps to reduce nitrogen leaching

by Dr. Richard Hull

The experimental results suggest several nitrogen conservation practices that can be used by turfgrass managers to reduce the potential for nitrate leaching into ground water at their managed sites.

Although much research remains to be done, turfgrass managers should be able to combine these proposals with site specific information on soils, grade, etc., with current cultural practices on mowing and irrigation to significantly reduce nitrate leaching.

The over-riding principle of reducing nitrate leaching is to make fertilizer applications when the turfgrass roots can absorb it and when mineralization of naturally occurring organic matter is inadequate to meet plant needs. In cool-season turfgrass species, this can be accomplished by:

- Applying nitrogen in the early and late spring, when turfgrass roots can best use the nutrients and soil nitrate levels are likely to be low.

- Use moderately available nitrogen sources, such as urea, polymerized polycoated urea with 50% water soluble nitrogen, short-chain methylene urea or urea formaldehyde, or fortified composted materials (5-8% nitrogen). Avoid nitrogen salts, as they may release nitrates faster than root structures can absorb them or straight composts as they usually do not contain sufficient nitrogen and the mineralization can be inconsistent. Some of the organic extracts which are sold to promote root growth due to their hormonal properties may deliver sufficient nitrogen but rarely are cost effective.

- Do not apply more than 1/2 pound nitrogen per 1000 square feet at a time. That should boost the soil water nitrate level enough to supplement what the soil is delivering, but not provide much opportunity for leaching. Early spring applications may be as high as one pound nitrogen per 1000 square feet, if soil nitrate levels are low and grass is showing signs of nitrogen deficiency.

- Late summer may be a good time to apply 1/2 pound nitrogen per 1000 square feet or less if grass looks bad due to excessive loss of roots during the summer. Since the root system must regenerate from the crowns and rhizomes contained within the top 1/2 inch of soil or thatch, the plants' ability to use the abundant soil nitrate may be limited. Light applications at this time may be helpful.

- Late fall applications of nitrogen should not exceed 1/2 pound nitrogen per 1000 square feet, if the grass appears to be nitrogen deficient. If no nitrogen shortage appears to be evident, delay adding fertilizer until the spring. Fall soil nitrate levels are usually high as is the potential for leaching. Late fall applications of fertilizer may accomplish little.

- Our recommendations total only 1.5 to 2.0 pounds nitrogen per 1000 square feet per year. We believe that this amount of applied nitrogen is sufficient to maintain quality turf if it is applied when it can do the most good. We currently have research underway to test this belief.

presses root growth. In some woody ornamentals, root growth stops when the spring flush of leaf growth is occurring. This takes place because of limitations of available energy. If available energy is being spent on rapid growth of leaves and stems, less energy is available to support growth and nutrient absorption in the roots.

To be specific, nitrate uptake will occur as long as the leaves are functioning photosynthetically and the environment surrounding the roots allows for metabolic activity. This explains why our findings show that nitrate concentrations in soil-water under turfgrasses are very low during the spring and early summer.

Nitrate levels begin to drop early in spring (March and April) when, under Rhode Island conditions, grass growth is slow. During that time of modest shoot growth, as the plants green up, photosynthetic activity increases producing sugars that are translocated to the roots, because demand for sugars by the shoots is limited. Our research has found that during warm days in the early winter-early spring period up to 25% of the sugars produced in the leaves are transported to the roots. Soil-water nitrate levels are usually decreasing during this period.

During the summer, soil-water nitrate levels increase rapidly and continue to do so during much of the fall. Certainly increasing nitrate levels are partly the results of increased fertilization and decomposition of soil organic matter during this period, but a substantial portion is due to the fact that late summer conditions are not conducive to root growth. Summer's stress from high soil temperatures, the depressive effects of weed growth, and roots being damaged by both insect and disease activity normally lead to a substantial loss of turfgrass root mass, even when a summer is conducive to maintaining good quality turf.

During this time, root absorption is not able to keep pace with nitrate production, making summer one of the periods with the highest potential for nitrate leaching. Fortunately, summer rainfall is normally not excessive and actual leaching is usually not a consistent problem.

During the late fall and early winter, turf root growth increases; often much of the root system is regenerated during this period. It has been estimated that as much as 80% of the root system of turfgrass is lost and regenerated

German study

Nitrate leaching into ground water shows low risk from golf course greens

A German study on nitrate leaching from a predominantly sand-based golf course green has found that, at reasonable levels of fertility, the actual amount of nitrate leaching is very low.

The Stuttgart study covered leaching from a green, constructed of 75% sand, 15% topsoil, and 10% peat moss, over a two year period. The year old, predominantly fine fescue green was subjected to three different nitrogen application loads (4, 8, 16 pounds per 1000 square feet per year) using four different nitrogen sources (Ureaform, IBDU, Corn meal, Ammonium sulfate) with the leachate collected 14 inches below the surface.

The annual collected leachate data in the first year for all the fertilizer sources produced the figures that are represented in the table, right. Only the data from the first year is shown, as the data from the second year are very similar to that of the first.

TGT's view: None of the fertilizer sources (Ureaform, a complex, synthetic organic; IBDU, a special polymer form of urea; Corn meal, a natural organic; or Ammonium sulfate, a fast-release mineral source) when applied at the reasonable four pound nitorgen rate and even the higher 8 pound nitrogen rate, produced nitrate leaching greater than 1% of the total nitrogen applied. Only when the nitorgen rate was pushed to the excessive rate of 16 pounds, did nitrate leach rates become excessive.

This study, although it was designed to produce statistically significant data, does not represent current nitrogen usage.

Most golf course superintendents do not exceed 3.5 to 4.0 pounds of nitrogen per 1000 square feet per year on sand based greens and tees, while many do not exceed 2.0 pounds on the slower leaching native soil greens and tees that make up the great majority of the golf course greens and tees in this country. Current nitrogen fertility practices probably do not contribute any more nitrate to ground water pollution than the 0.17% (4 pound average) shown in the table for applied nitrogen, and probably contribute considerably less. -CS each year. The rate at which this root regeneration occurs depends on the favorable cool and wet conditions of this period and the extent of the damage that had occurred during the summer months. Often many cool-season turfgrass species will not have fully functioning root systems until late November.

The graph on page 6 is a visual representation of the nitrate concentrations two feet under turf during the calendar year 1993. It illustrates the seasonal variations of that concentration in relation to days of the year and fertilizer applications made.

The cyclical nature of root growth is less of a problem on warm-season turfgrass species. These grasses grow best under warm temperatures and their root growth is not depressed during the summer. Because these species are less stressed during high temperatures, any root damage that may occur from insects or diseases is often regenerated more rapidly than their northern cousins. Consequently soil nitrate levels are usually low during the summer months on turf of warm-season species. However, as soils cool down during the fall and winter, these grasses often suffer a substantial loss in root mass, making the period from winter to early spring exhibit the highest potential for nitrate leaching.

How much nitrate can leach from turf?

After discussing the soil-turfgrass system with respect to nitrogen use and the opportunities for nitrate leaching, two questions arise: How much nitrogen can turfgrass plants actually utilize? And, how much nitrate can actually leach out of the turfgrass environment?

As to how much nitrogen can be utilized, the work of Dr. Dan Bowman at the University of California at Davis best answers this question. He found that when nitrate or ammonium was applied at the rate of one pound per thousand square feet (45 pounds per acre) to Kentucky bluegrass, 70% to 80% was removed in the first day and that virtually all was gone within 48 hours. The bluegrass plots that were used were modestly nitrogen deficient, but no more so than turf in the early spring. His work determined that of the nitrogen removed from the soil, 75% was absorbed by the turf and the remaining 25% was

Table

Collected leachate, first year

Pounds of nitrogen applied per 1000 square feet per year

Source	**4pounds/year (64oz.)**	**8pounds/year (128oz.)**	**16pounds/year (256oz.)**
Ureaform	0.23%* (0.15oz.)**	0.15%* (0.19oz.)**	0.69%* (1.77oz.)**
IBDU	0.15% (0.10oz.)	0.125% (0.16oz.)	5.00% (12.8oz.)
Corn Meal	0.15% (0.10oz.)	0.125% (0.16oz.)	11.2% (28.8oz.)
Amm. Sulfate	0.15% (0.10oz.)	0.70% (0.90oz.)	9.98% (25.6oz.)
Average	0.17% (0.11oz.)	0.28% (0.35oz.)	5.80% (17.2oz.)

* percent of total applied   ** equivalent amount

probably absorbed by microorganisms. This same rapid absorption of nitrogen was observed on perennial ryegrass, tall fescue, and creeping bentgrass stands.

In a companion study Dr. Bowman calculated that nitrogen deficient turfgrasses can absorb nitrogen at a rate of almost two pounds per 1000 square feet per 24 hours (90 pounds nitrogen per acre). It is little wonder that, when grass in vigorously growing in the spring, soil-water nitrate concentrations are reduced to very low levels. In fact, microbial mineralization of soil organic matter or slow-release fertilizers probably cannot satisfy the turfgrass needs at that time.

As to questions about how much nitrate can leach, our studies over ten years have found that total nitrogen leaching from applied fertilizer is never more than 15% of the total nitrogen applied. Also, we have found that nitrate leaching from naturally occurring organic matter in thin unfertilized turf may actually exceed that from healthy, dense well-fertilized turf. When total nitrogen applications are kept in the two to three pound range and organic nitrogen sources are used, annual leaching losses are more likely to be less than 5% of that applied or about five pounds per acre. By comparison, this loss is two to three times that which would leach from native forest and about 25% of that released by a single family septic system.

Bottom line

The bottom line appears to be: well-managed turf contributes very little nitrate to ground water and turf is one of the most environmentally sound ground covers available for both suburban and rural landscapes. ■

Lancaster County, PA, study

Farm nitrogen loading: a major cause of pollution

A three year study of nitrogen loads entering and leaving a 55 acre, organically managed farm in the Amish area of Lancaster County, PA, illustrates the large part that such agricultural practices can play in the nitrate contamination of ground water resources.

Before nutrient management practices were put into place, the annual total applied nitrogen from manure and commercial fertilizer averaged 480 pounds per acre (10.9 pounds per 1000 square feet) with nitrogen discharge rates that averaged 292 pounds per million gallons of ground water (36.5 parts per million). After applied nitrogen rates were reduced 33% to 320 pounds per acre (7.3 pounds per 1000 square feet), discharged nitrogen rates averaged 203 pounds per million gallons of ground water (25.4 parts per million), a 30% reduction.

The study estimated that 25% of the applied nitrogen was lost through volatilization as various gaseous forms of nitrogen and that 38% of the applied nitrogen was discharged into the ground water. The nitrogen losses averaged 100 pounds per acre per year (2.25 pounds per 1000 square feet per year) for both management practices due to volatilization and 152 pounds per acre per year (3.45 pounds per 1000 square feet per year) due to ground water loading. Including loss by surface runoff, less than 1%, the total nitrogen loss averaged 64% of applied nitrogen or 260 pounds per acre per year (5.91 pounds per 1000 square feet per year) out of a total average application of 400 pounds per acre per year (9.09 pounds per 1000 square feet per year).

TGT's view: The loss of applied nitrogen at this site into the air, surface water, and ground water was a staggering 64%, with 38% lost to ground water alone. If anyone had any questions concerning the relative contributions to nitrate pollution by agriculture and turfgrass management, this study and the German study, page 8, should answer them completely. In these two studies, on average, current "organically" oriented agriculture management practices were much more likely to contribute to nitrate pollution of ground water than current turfgrass management practices. Previously reported analysis of nitrate loading of ground water by septic systems, and Dr. Hull's identification of nitrate leaching from naturally occurring organic matter in the soil profile, clearly identify agriculture, septic systems, and organic matter as the three major contributors to nitrate loading of ground water resources. -CS

EPA rules to establish pesticide management zones

In an effort to strike a balance between the conflicting forces of human health and the agricultural and ornamental use of ground water polluting pesticides, the Environmental Protection Agency (EPA) will soon promulgate new regulations that have the potential of causing a considerable impact on the way turfgrass managers operate.

The new regulations, coming some time this fall, will require all states to follow the lead of California and compile a list of those agriculture and turf pesticides that are believed to be contributing to the contamination of its ground water and well water drinking water supplies. Also, the states will be required to designate pesticide management zones (PMZ) or areas within each state that have been identified as the sources of their drinking water supplies.

Once the lists have been compiled, the pesticides on that list will be considered to have been designated as having a "special prescription status". Pesticide applicators will be allowed to use these prescription status pesticides in the PMZ areas, if they first obtain written permission to use the listed pesticide from a state certified chemical advisor and they agree to the pesticide's use under strict new government regulation. The state certified chemical advisor will be required to clear all of the approvals for prescription status pesticides with that state's Department of Agriculture.

Once these new regulations become effective at the state level, probably no sooner than 1996, the states will be required to monitor their drinking water supplies for the presents of the listed pesticides. If this new level of regulation does not limit the amount of detected pesticide in tests and it reaches the level which is considered to be hazardous to human health, the state will have no choice but to ban the use of that pesticide in all PMZ areas.

TGT's view: Turfgrass managers can expect that previously identified ground water contaminating chemicals, such as Atrazine, Simazine, and Bromacil, to be placed on the prescription status lists. In general, any highly soluble chemical that has the potential to pollute drinking water supplies will eventually find their way onto many of the new prescription status lists. Designation to this list would be up to the determination of each state, which the EPA thinks are better prepared to accurately identify offending materials under varying local conditions.

Turfgrass managers may well opt not to use prescription listed pesticides in their local PMZ's, as long as there are adequate alternative products. If adequate alternative products or control strategies are not available, then each turfgrass manager should carefully consider time lag to get approvals, added costs of administration, and added levels of regulation before making the decision to use these products. -CS

Oklahoma and Illinois study

Clippings increase turf canopy temperatures

Joint research done by Oklahoma State University and the University of Illinois indicate that canopy temperatures increase when clippings are returned to the turfgrass canopy.

The research found that canopy temperatures increased by an average of 1.32 C or 4.5% the day following clipping return and by .36 C or 1.2% on the second day. The mechanism for this increase in canopy temperature was not identified, although it could have been caused either by metabolic activity of microbes decomposing the clippings or by a reduction in the leaf surface area involved in evapotranspiration.

TGT's view: Turfgrass managers monitoring air and canopy temperatures for peak disease activity may want to add this effect into their calculations. -CS

Over $12.5 billion spent on America's lawns

In a recent Gallup survey, 17 million U.S. households spent $12.5 billion on professional landscaping and lawn care services in 1993. The study revealed that the number of homeowners using landscape professionals was up 29% over 1992, and is expected to grow by 6% in 1994.

The average 1993 household spending on landscape services was $721 with the cumulative breakdown being $6.4 billion for homeowner landscaping, $5.6 billion for landscape installation or construction, and $381 million for landscape design. The improved national economy, the upturn in homebuilding, and the growing awareness of landscaping's environmental and economic benefits are believed to be key factors contributing to the growth in homeowner spending on professional landscape services.

The survey was commissioned by seven associations, including the Professional Lawn Care Association of America and the American Association of Nurserymen.

Tolerance of grasses studied by Japanese

Ryegrass and tall fescue can tolerate flooding

Research recently conducted in Japan has found that both ryegrasses and tall fescues tolerate prolonged flooding better than bluegrasses.

The research found that the majority of the varieties of the three species tested tolerated prolonged field saturated conditions during the coolest six months of the year, but once temperatures rose the tall fescues showed the least damage when compared to ryegrasses and bluegrasses.

TGT's view: Turfgrass managers should consider converting saturated areas over to stands of tall fescue, if correcting drainage or percolation problems is not possible. This research also indicates why tall fescue varieties do well in wet, shaded areas. It is clearly the species that tolerates wet feet better than the other two. -CS

Bluegrass best tolerates heat

Research conducted in Japan has identified bluegrasses as tolerating one-day exposure to high day/night temperatures better than either tall fescue or ryegrass.

The experiment subjected six well-watered varieties of each species to the conditioning of moderately high temperatures and high humidity of a growth chamber for three weeks and then exposed them to 24 hours of high heat. The ryegrasses only averaged 67% survival at 36/31 C (97/88 F) and only 4% at 48/43 C (116/106 F) after a day of high temperatures. The tall fescue and bluegrasses tolerated temperatures of 44/39 C (108/98 F) with 90% average survival rates, with bluegrasses showing 23% average survival rates at 50/45 C (120/110 F) and tall fescue only 8%. When 96% of the ryegrasses were dead at 48/43 C (116/106 F), 51% of the bluegrasses and 39% of the tall fescues still survived.

TGT's view: In regions where very high heat conditions may spike up for a day or two, turfgrass managers may want to stay away from ryegrasses in critical areas, opting for bluegrasses where possible or tall fescue, where bluegrass management requires too much input. -CS

Nine states to give pesticide recertification credits for home study

Nine states — Delaware, Florida, Georgia, Maine, Nebraska, Pennsylvania, Rhode Island, West Virginia and Wyoming — have recognized the home study correspondence course, entitled "The Principles of Turfgrass Management", as having met their recertification training standards. The course was produced through the cooperative efforts of the University of Georgia and the Professional Lawn Care Association of America.

Each state will assign credits to participants as determined by that state's standards. Six additional states — Colorado, Connecticut, Indiana, North Carolina, Oregon, and South Dakota — are reviewing the course to see if it meets their standards.

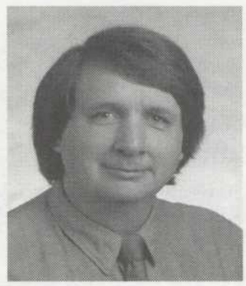
Studds' bill

Would tax pesticide, fertilizer makers

Rep. Gary Studds (D-MA) has introduced a bill, H.R. 2199, as part of the Clean Water Act reauthorization, called the Polluter Pays Bill. The new law would tax pesticide and fertilizer manufacturers to provide revenues for the cleanup of contaminated surface and ground water supplies. Hearings were held before the full Committee on Merchant Marine and Fisheries in March and the Environmental Protection Agency (EPA) has said it may study this bill as way to deal with the existing problem of water pollution. According to committee sources, further legislative action on the Clean Water Act, including the Polluter Pays amendment, is not expected until the 1995 session of Congress.

What we don't know may hurt us

by Christopher Sann



In conversations that I had with Dr. Richard Hull, while planning and discussing his excellent article on nitrogen fate in turfgrass, I have once again been struck by the lack of precise information about basic turfgrass biology and the workings of the turf-soil ecosystem currently available to our industry. Indeed, there are a multitude of potential problems facing turfgrass managers in the very near future as a direct result of this knowledge gap.

Minimum turfgrass nitrogen requirements have yet to be established

Dr. Hull told me that his research is directed toward finally establishing the minimum annual amount of nitrogen that is required to maintain healthy turf. I was shocked when he told me this, as I have always thought that such basic information was readily available. According to Dr. Hull, however, the minimum amount of supplemental nitrogen needed to be applied to maintain healthy turf, while taking in to account the seasonal fluctuations in soil nitrate levels, has yet to be established.

Dr. Hull's work has the potential of offering turfgrass managers a set of protocols that could be used to precisely apply just the exact amount of fertilizer needed, and to make those applications at times when the turfgrass can best use the applied nitrogen. By following these protocols, once developed, it may be possible to reduce the total annual fertilizer inputs at turf sites by as much as 25% to 50%, depending on the desired level of fertility.

All very promising, but ...

This work has enormous potential, but it is still a work in progress and the industry may need this specific information without delay to combat the developing pressures to restrict fertilizer use sooner than generally expected.

Recently two bills have been introduced in Congress to do just that. The first bill restricts fertilizer applications to no more than that recommended by a soil test, and the second bill would heavily tax the nutrient content of fertilizers to pay for the cleanup of nutrient-polluted waterways and ground water. Both of these bills offer politically popular solutions to questions that have yet to be fully understood and represent yet another attempt by Congress to create scientific "conclusions" by legislative process.

Dr. Hull's work bears directly on both of these pieces of legislation. The bill to restrict fertilizer applications to soil test recommendations assumes that the precise nitrogen requirements for turfgrasses are known, but they are not. Until Dr. Hull's research, as well as the work of other scientists, is completed, there will be no scientific basis for a nitrogen level standard. The second bill, which creates a fertilizer tax to pay for the problem of nutrient pollution, assumes that only applied fertilizers add to the environmental nitrate load. Dr. Hull's research already indicates that mineralization of naturally occurring organic matter is a major contributor to nutrient pollution and in many cases is the primary or sole contributor.

Unfortunately, both of these pieces of legislation, in one form or another, may well become law with substantial negative effects on the turfgrass management industry before the scientific questions that surround them are answered. In fact, the February warning by Mr. Victor Kimm, deputy director of the Environmental Protection Agency, about adverse legislation being promulgated without sound scientific foundation, has alarmingly come true.

As an industry, we are eager to participate with the EPA or anyone in authority in any changes that can help reduce the unintended environmental consequences of our actions. But the minimum requirement, for our wholehearted cooperation, ought to be that the new legislation or regulation be grounded in scientific fact, not political expediency. ■

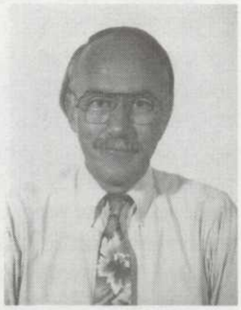
Transgenic plants field tested

In a major international research move, the Bt Management Working Group (BtMWG), a group of 15 international companies involved in *Bacillus thuringienis (Bt)* research and development, has funded several research projects to test transgenic corn and cotton in the field. Two universities were awarded funds for studying Bt transgenic corn and a third was funded for studying Bt transgenic cotton. This marks the first movement of these genetically engineered plant species from the laboratory into the field.

Progress report

New editor takes the helm

by Juergen Haber



If you've read the box on the back page next to your mailing label — it's what in the publishing trade is called the masthead — you'll notice that *Turf Grass Trends* has a new editor.

After an exhaustive search, we've finally succeeded in landing a man with many talents, Todd Natkin. Todd's qualifications are top-notch: he earned his blue pencil after more than seven years on the TIME Magazine copy desk in New York.

Not content with being at one of the top news magazines in the country, Todd went on to earn his law degree at Hofstra University. That would seem to have his feet planted firmly on the ground, but, no, instead he went on to earn several pilot's licenses: single and multi-engine and that for free balloons.

Todd Natkin

After his TIME Magazine work, Todd practiced law in both New York and Washington including work before the Supreme Court of the United States.

During the course of his law practice he's appeared on national television several times: on The Oprah Winfrey Show, on Cable News Network, and on Black Entertainment Television.

Todd has already been hard at work talking to new contributors for future issues.

Dr. Hull's ground-breaking research

As long as I'm on that subject, I'd like to introduce Dr. Richard Hull. Dr. Hull is professor of plant sciences at the University of Rhode Island. His ground-breaking research on nitrogen fate is part of a quarter-century career in applied plant physiology and much of his effort has been devoted to solving turfgrass problems.

Dr. Hull writes, "I have worked in the general areas of plant nutrition with emphasis on energy partitioning and nutrient use efficiency."

He also says, "In recent years, I have concentrated on nitrogen use by lawn turf featuring studies on the efficiency on nitrate absorption and the potential for nitrate leaching from turf."

This work is of the utmost importance, as Field Editor Chris Sann notes in his column in this issue, because two bills in Congress "may well become law with substantial negative effects on the turfgrass management industry before the scientific questions that surround them are answered."

Dr. Hull's current work is "investigating the impacts of various nitrogen fertilization strategies on nitrogen losses and pool sizes."

Speaking of strategies, we've always tried at *Turf Grass Trends* to provide ways for turfgrass managers to apply the theory we preach. One of the accompanying stories, Steps to reduce nitrogen leaching, on page 7, gives turfgrass managers strategies and tactics to combat the problem of nitrogen leaching.

Strategies for the future

Strategies are important in all phases of business including publishing. Here at *Turf Grass Trends* we've just finished the analysis of our first six months in business. With this issue, we'll be coming closer to the eve of a one-year anniversary.

We're still on a big march to growth. After a several months' hiatus, we'll be sending out more sales promotions. It is possible that our current subscribers may get one of these sales promotions. If you're already a subscriber, we hope that you'll pass the sales promotion along to a friend or colleague. Right now we're not equipped to eliminate current subscribers from the mailing lists for the sales promotions.

Other things we're doing soon will be to send out a survey for our readers to fill out. Although I talk to subscribers regularly, I just can't call everyone, so we hope we can find out what you expect, what you like — and dislike — every month in *Turf Grass Trends*.

See you at the Green Industry Expo

We're looking for feedback from our readers and we'll be sure to get it at the 1994 Green Industry Expo to be held Nov. 14-17 at the America's Center, St. Louis, MO. We'll be there with a booth just as we were last year at the 1993 Green Industry Expo in Baltimore, MD. We hope to see a great many of you there. If you're a member of the Associated Landscape Contractors of America, the Professional Grounds Management Society or the Professional Lawn Care Association of America you will no doubt have heard about their annual meetings and the Green Industry Expo.

If you haven't heard about it, you should plan to come. The Expo has its office at: 1000 Johnson Ferry Rd. NE, #C-135, Marietta, GA 30068-2112, phone: (404) 973-2019, fax: (404) 578-6071. We hope to see you there!

New products at *Turf Grass Trends*

We're also working on an index; actually, we're working on two kinds: a conventional index and an articles index. Many readers have written and called about ordering back issues of *Turf Grass Trends*.

But without an articles index, it's difficult for us — and them — to know which issues to send. The index of the 1992 issues will be ready shortly. The index of the 1993 issues and of the issues of the first half of 1994 will follow. Watch these pages for an announcement.

We've learned to take on one new project at a time here at *Turf Grass Trends*.

As soon as the index is ready for the printer, we'll consider taking on other new ideas. One of the first we'll take on is a binder to hold copies of *Turf Grass Trends*.

I'm confident that the binder will be out before the end of the year.

In the press there's been much discussion of multimedia and computers. We've been evaluating offerings in video format. We're not proposing to put *Turf Grass Trends* on video — though some might welcome the idea! We're looking at instructional videos. Training and education after one's formal schooling is finished is becoming more important than ever (see News Brief on page 12 about pesticide recertification). Not all videos are equal, however. They can range from bad home productions to professional studio ones. We'll be gathering videos together, evaluating them and making recommendations to our readers.

Speaking of computers, the magazines are full of ads for computer hardware and software that claim to solve turfgrass managers' problems. Editor Todd Natkin is beginning to gather turfgrass-specific software together for evaluation as well. In addition to Todd's other talents and credentials, he knows a thing or two about computers. Our vertical-market software article will come some time this winter. Many of us are using computers to manage bits and pieces of our businesses. We should be able to get the most out of those machines and the software.

Those are some of the things we've been preparing. The last year has been an exciting one here. We've made a great many changes: increased the size of *Turf Grass Trends* from 12 to 16 pages; moved production from Wilmington, DE, to Washington, DC; doubled the circulation and brought new writers on board.

We appreciate our readers' loyalty

As we approach the one-year anniversary under the new publishing regime, we'd like to salute the readers that stuck with us through trying times and welcome the new readers aboard. Thank you all for your loyalty!

ASK THE EXPERT

Have a question on any aspect of turf management?

Contact:

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Fax: (202) 483-5797

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Coming attractions

October Issue

Snow molds and other cold-season diseases

by Christopher Sann

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