

- E. Stormwater Runoff. All concentrated runoff will be captured with proposed water quality ponds in conformance with County stormwater regulations. See attached stormwater plan exhibit.

Nutrient Management for Golf Courses

James H. May, Research Associate, Crop and Soil Environmental Sciences

John R. Hall, Professor and Extension Specialist, Turfgrass Management

David R. Chalmers, Associate Professor and Extension Agronomist, Turfgrass Management

Patricia R. Carry, Extension Technician, Crop and Soil Environmental Sciences, Virginia Tech

Golf courses have traditionally been thought of as environmentally sound landscapes, preserving green spaces that otherwise could have been developed and providing a recreational opportunity for nearby residents. In recent years, however as the public has become increasingly alarmed and concerned with chemical use and groundwater quality, the idea of a golf course being a chemically pristine expanse has been challenged.

Nitrate is a ubiquitous contaminant of groundwater. Nitrogenous fertilizers applied to turfgrass can pose a threat to groundwater if not applied correctly. There are a number of factors, environmental and otherwise, involved in a proper management program that must be considered in order to minimize runoff and erosion, and fertilizer and pesticide leaching. Good management can help to reduce the risk of contamination of our water resources.

Public Perceptions

To the public, expansive areas of turf such as golf courses seem to receive an unusually large amount of fertilizers and pesticides. Tees and greens are often highly modified, sandy soils that drain very easily, are highly irrigated and do not retain nutrients. With today's trend toward lower nitrogen use rates and the use of slow-release fertilizers, these areas, when properly managed, can be no more prone to leaching and runoff than any other turf, according to research information.

Tees and greens make up only a small percentage of the land area in a golf course. If you think of a typical 18 hole golf course that encompasses between 100 to 150 acres, tees and greens cover an area of 2 to 4 acres, which is less than 5 percent of the golf course

acreage.

Golf course superintendents managing these areas must be extra careful in selecting management methods that have a minimal environmental impact while still providing the turf with the needed nutrients. Much of the public's perception of nutrients and pesticides is brought about by negative stories in the news and by lack of education. Many people think that whatever the plant doesn't use has to leach into the groundwater. Concepts of complex, related factors such as solubility, volatility, persistence or adsorption, and environmental factors such as root density, soil temperature, soil organic matter precipitation and evapotranspiration are often overlooked.

Management to Minimize Nitrate Leaching

There are several related factors that the manager has control over that are important in determining the leaching potential of a fertilizer applied to turf. Leaching can be kept to a minimum while supplying the turf with the optimum amount of nutrients.

Source of nitrogen. A water-soluble source of nitrogen has a higher leaching potential than a slow-release source, especially when its application is followed by a large amount of water, either from rainfall or irrigation. If, however, water-soluble sources are applied in several split applications, rather than all at once, their pollution potential is reduced.

Use of a slow-release nitrogen source is a good practice whenever possible. It offers the advantages of reducing labor costs, since the number of applications is reduced, as well as reducing the risk of foliar burn, providing a more even supply of nitrogen, and reducing nitrogen

www.ext.vt.edu



Produced by Communications and Marketing, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University, 2009

Virginia Cooperative Extension programs and employment are open to all, regardless of race, color, national origin, sex, religion, age, disability, political beliefs, sexual orientation, or marital or family status. An equal opportunity/affirmative action employer. Issued in furtherance of Cooperative Extension work, Virginia Polytechnic Institute and State University, Virginia State University, and the U.S. Department of Agriculture cooperating. Rick D. Rudd, Interim Director, Virginia Cooperative Extension, Virginia Tech, Blacksburg; Alma C. Hobbs, Administrator, 1890 Extension Program, Virginia State, Petersburg.



VIRGINIA STATE UNIVERSITY

leaching. However, there are several minor problems with the use of slow-release sources. Some slow-release sources, especially ureaformaldehyde (UF) and natural organics, such as Milorganite, give only poor to moderate response in cool weather. The reason for this is that the water-insoluble-nitrogen (WIN) in these sources becomes available to the plant as a function of soil microbial activity. Other slow-release sources, such as isobutylidene diurea (IBDU) and sulfur coated urea (SCU), are not as dependent on soil microbial action; therefore, release rates are not significantly decreased in cold temperatures. These sources can be more expensive than water-soluble sources and they are frequently applied in a dry form, which at times is inconvenient. There are, however, slow-release fertilizers in fine granular form and in a sprayable micro-pelletized form. It is recommended that slow-release fertilizers be used on sand-amended areas of the golf course, such as greens and tees, that have higher leaching potential.

Nitrogen applied as a fertilizer to turfgrass can be lost to the atmosphere as either ammonia (NH_3 volatilization) or as one of several nitrous oxide compounds (denitrification). Increases in soil temperature tend to increase the rates of volatilization of ammonia and the rate of denitrification of the nitrogen source. Urea is most prone to volatilization. In situations where urea is used it should be watered in to minimize the potential for volatilization.

Denitrification is a microbial process whereby NO_3^- is converted to a volatile gas due to environmental influences such as high soil temperature, limited oxygen supply, microbial population, and excessive moisture. While neither volatilization or denitrification has a direct effect on water contamination, they both are related to increases in atmospheric nitrogen and reduced fertilizer efficiency. Nitrate sources of nitrogen are most prone to denitrification.

Rate of application. The rate of application is affected by the source of nitrogen, amount of traffic, time of year, nature of the soil media, and amount of sunlight. Slow-release fertilizers, high traffic, sandy media, and full sun situations are going to necessitate higher yearly rates of application. The recent trend has been to reduce the total yearly amount of nitrogen applied, especially on greens and fairways. If using a soluble source, apply it more frequently at a reduced rate, either by split surface application or fertigation. In general, slow-release fertilizers can be applied at higher rates. If soluble sources are applied to sand-modified soils, individual nitrogen applications should not exceed 0.75

lb. N/1,000 square feet. On traditional Virginia soils, nitrogen applications should not exceed 1.0 lb. N/1,000 square feet. Golf greens that have been established two or more years generally require 3 to 6 lb. N/1,000 square feet per year. Young greens in full sun with high traffic will require the higher amounts of nitrogen. Tees and fairways require from 2 to 4 and 1 to 3 lb. N/1,000 square feet per year, respectively. Bermuda grass tees and fairways on sandy soils may necessitate slightly higher total nitrogen use rates.

Time of year. The total amount of nitrogen applied to warm or cool season grasses and the timing of the application reflect differences in plant uptake and root growth. The best time to fertilize cool-season grasses is in the fall from September through November. In late fall to winter, cool-season grasses are beginning to develop their root systems and store carbohydrates. Extensive root systems will be developed in the spring along with earlier green up. On the other hand, warm-season grasses have the greatest rate of uptake in the spring after green up and throughout the summer.

Excessive nitrogen stimulation of cool season grasses in the February through April period when rapid root growth is occurring inhibits root development. It is advisable to not apply more than 0.5 lb. of soluble N/1,000 square feet to these grasses in this time frame.

On cool season grasses it is normally advisable to apply approximately 75 percent of the total nitrogen in the fall of the year and the remainder in the May to June time frame. Golf greens some times benefit from "spoon feeding applications" providing 1/8 to 1/4 lb. N/1,000 square feet during cooler periods of the summer.

Alternatives to Nitrogen. Iron applications to turfgrass have been shown to increase chlorophyll content, carbohydrates and rooting while decreasing respiration rates. Mid-summer green up can be accomplished with iron instead of nitrogen. Late fall applications of iron with nitrogen on cool-season grasses - have produced earlier spring green up and enhanced rooting.

Phosphorus and Potassium. Phosphorus is very immobile in soils, whereas potassium is moderately leachable. Turfgrass maintenance fertilizers generally provide N: P_2O_5 : K_2O ratios from 4:1:2 to 4:2:4. The higher potassium ratios are desirable on sandy media. The higher phosphorus ratios would be beneficial on new greens. Normal ratios of annual N: K_2O use on golf greens range from 2:1 to 1:1.

Biostimulants containing cytokinins and other growth promoters show promise of promoting increased root

growth and greening while reducing nitrogen requirements. Both iron and biostimulants can be used to reduce nitrogen fertilization rates.

Irrigation practices. Excessive irrigation can cause leaching of nitrates, especially from water-soluble sources, or if nitrogen is applied to turf in a dormant or semi-dormant period of limited plant uptake.

Soil type. Certain types of soils have a greater ability to hold nutrients than others. This is due to the amount of clay or organic matter in the soil, both of which have a negative charge, allowing them to hold on to, or adsorb, positively charged particles (cations), such as ammonium (NH_4^+) or potassium (K^+). Cation exchange capacity (CEC) of a soil is a measure of the ability of a soil to retain positively charged ions. Soils that are high in sand content have a low CEC and must be managed to reduce the risk of leaching.

Amending soils with clay or organic matter increases their CEC. Most greens are constructed of laboratory specified mixtures of sand, peat and clay. Having clay in a greens mixture does reduce the potential for nitrogen and potassium leaching or runoff.

Grass selection. Bermudagrass normally requires higher levels of total nitrogen application than cool season grasses. Some varieties of grass naturally require less nitrogen to maintain a good green color. Research continues on the development of these types of grasses. Select dark green varieties where possible, to minimize the use of nitrogen to create green color. Using native ornamental plants, wildflowers and ornamental grasses in non-playing areas is one way to reduce management inputs including fertilizers, pesticides and mowing. However, care must be taken to prevent erosion in the establishment phase.

Mowing height. Selection of mowing height is probably the most important decision in mowing. There is no doubt that mowing is a stress-creating management practice. Each species of turfgrass has a mowing tolerance range, under which it can exist over a broad range of climatic conditions with minimum stress and still be expected to provide a satisfactory turf. If the turf is mowed too short, it tends to become denser, but have less growth of roots and rhizomes. This also makes the turf less tolerant of environmental stresses, more disease prone, and more dependent on a carefully implemented cultural program. The smaller, shorter root system requires more water and fertilizer to compensate for its decreased ability to secure and hold moisture and nutrients from the soil.

To avoid this stress, the turf manager must provide stress-reducing inputs such as irrigation, fungicides, herbicides, and properly timed cultivation and fertilization.

Care must be taken when providing these inputs, however. If we are removing leaf area and reducing root area, while applying pesticides, fertilizers and water to reduce stress, we are increasing the risk of these inputs leaching through the soil or running off and endangering our water supply. The best approach is to use the highest mowing height acceptable for the use being made of the turf.

Mowing frequency. This can have an extreme effect upon root growth especially when more than 40 percent of the existing foliage is removed. Time of mowing, pattern of mowing and even type of mowing equipment can influence turf quality. For example, mowing turfgrass areas that are too wet or under extreme heat or moisture stress can be detrimental to the turf. Stressing the turf can lead to the need for increased inputs. If the turf is too wet, clipping discharge can be affected, leading to clumps of clippings that shade turf, and reducing quality of the playing surface. Mowing increases evapotranspiration, and when temperatures are high, water loss may be extreme, necessitating irrigation.

Returning clippings. This continues to be a controversial practice because it was thought to increase thatch buildup and possibly increase disease problems. Research has shown, however, that in turf that is otherwise properly managed, returning clippings does not greatly increase thatch buildup. Work at USDA has demonstrated that clipping removal for eight years only reduced thatch buildup 12 percent in Kentucky bluegrass turf.

Clippings do have significant nutrient value. They normally contain from 3 to 5 percent nitrogen, 0.30 to 0.5 percent phosphorus and about 2 to 3 percent potassium. Being fairly high in nitrogen, they will decompose rapidly and return nitrogen to the soil, actually reducing the need for nitrogen fertilizer.

Of course, tees and greens are areas of a golf course that will always require clipping collection. The clippings collected from these areas can be dispersed in roughs and wooded areas. If the grass clippings are mixed with a high carbon source, such as leaves, they may be composted. This is a disposal method that is gaining much well deserved attention. The finished compost can then be used as a soil amendment for renovation or other landscaping projects.

Aeration. Core aeration is extremely beneficial in increasing air exchange, water infiltration rates, water retention, nutrient penetration, root development and thatch decomposition. It also decreases runoff and therefore increases water use efficiency, reducing total irrigation requirements. Heavily trafficked cool-season

grasses should be aerified spring and fall during periods of active foliage growth. Mid-summer aeration can be beneficial if irrigation is available and temperatures are favorable. Warm-season grasses can be beneficially aerified from the time they green up until they go dormant in the fall.

Integrated Pest Management (IPM)

Integrated pest management is the use of a variety of management practices or tactics to control pests that offers the possibility of improving the efficiency of plant production while minimizing environmental impacts. Developing these concepts for turf areas is important in maintaining high quality turf while minimizing damage to our water resources.

Pesticides are valuable components of a turfgrass cultural program, but pest management includes more than simply applying the right pesticides to control specific organisms. It also includes selecting turfgrasses that are well adapted and maintaining the health of the turf through good management practices. Damage from insects and other pests is often greater in turf that is subjected to other stresses.

Many pesticides can leach through the soil or runoff into water supplies if applied incorrectly or at the wrong time. Soil characteristics also have an effect on pesticide leaching. Highly modified soils, for example, leach more easily than a soil with organic matter or a thatch layer. Thatch can tie up pesticide residues, slowing their leaching, and has also been shown to encourage the degradation of certain pesticides.

While the potential environmental hazard associated with most turfgrass pesticides appears to be minimal, it is still a good practice to employ integrated pest management in turf areas. Some of the suggested practices include: **Spot treat.** Scout for and treat specific pest problems instead of treating large areas.

Understand damage thresholds. The presence of a

few spots on leaves or a few insects in the turf does not require the use of a pesticide. It is only when the pest populations develop sufficiently to cause damage that a pesticide should be applied.

Preventive vs. Curative approach. Some pest problems, such as dollar spot and crabgrass occur so routinely and cause so much damage that a preventive approach is necessary. For most turfgrass problems, however, pesticide application should probably be withheld until scouting or monitoring indicates that unacceptable damage will occur if a pesticide is not used. This is called a curative approach.

Selecting Pesticides

In selecting pesticides, the turf manager wants products that will be effective in controlling the pest problem, while minimizing environmental impacts. Many pesticides are organic compounds that interfere with some physiological process in the pest organism. There are several compound-related factors to consider when selecting pesticides.

Mobility. In general, highly water-soluble chemical leach faster than the less soluble ones, although high solubility alone does not imply that a chemical will contaminate groundwater.

Adsorption. Depending on their composition, most compounds are more or less strongly adsorbed on soil organic matter, the thatch layer and clay. Adsorbed chemicals do not move in bulk with the water, but are retained while the water moves toward the groundwater saturated zone. Adsorbed compounds are gradually released back into the soil solution where they are broken down.

Persistence. Chemicals persist in the soil for varying amounts of time. Most modern chemicals are moderately persistent or non-persistent. Persistence is reported as half-life, that is, the time it takes for about half of a given amount to break down.

None of the above factors, taken by itself, should be used to condemn a pesticide. However, for example, a pesticide with high mobility, low adsorption and moderate to high persistence would be more prone to contaminate than one with low mobility, high adsorption and low persistence.