Winter/Spring Nutrient Use
By Cool- and Warm-Season Turf

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As the grip of winter begins to relax, thoughts of spring and your turf nutrient management program slowly invade your consciousness. The subject of turf nutrition is not as simple as it was a few years ago. Many conflicting priorities linked with minimizing water pollution, practicing sustainable turf management, integrating with turf IPM programs and maintaining good public relations all confuse the issue. Basic questions of how much fertilizer to apply, when to apply it, in what form and in what ratio no longer depend solely on your level of understanding of turfgrass nutrient requirements.

Now might be a good time to review some of the basics on how grasses utilize nutrients during this critical late winter/early spring season. It just might be that our older ideas of nutrient management were not so great and some rethinking is in order.

In decades past, most nutrients were applied at greater rates than are currently recommended, which means that, historically, nutrient use was not very efficient. Now we know a good deal more about seasonal nutrient use and this has allowed application rates to be lowered markedly. There may still be room for additional reductions.

Annual Growth Cycle of Turfgrass Roots

Cool-season turfgrasses exhibit a distinct bimodal pattern of root. During the heat of summer, root growth is very slow, often nonexistent. As the temperatures cool during September, root growth resumes, mostly from basal crowns and nodes on rhizomes or stolons. This fall flush of root growth gradually increases until cold soil temperatures slow it again. However, even during the heart of winter, root growth continues as long as the root zone is not actually frozen.

In areas where a substantial snow pack is retained throughout the winter, the soil is rarely frozen to any depth and root growth continues, if slowly, all winter. In southern New England, we have observed greater translocation of photosynthetic products to roots during mild days in winter than at any other time of the year.

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As the soil warms slightly during early spring, light levels increase and more photosynthesis occurs, providing a strong surge of root growth. This continues through the time when temperatures increase enough to stimulate shoot growth, about April or early May, depending on latitude and seasonal variation. Spring root growth continues until June when soil temperatures increase to levels that become inhibitory. Beard (1966) found temperature to be the single most important environmental factor controlling root growth and their physiological condition in cool-season grasses.

Warm-season turfgrasses exhibit a very different root growth cycle. Unlike cool-season grasses, where root growth is inhibited by temperature increases that stimulate shoot growth, warm-season grasses exhibit greatest root growth when shoot growth is also maximal. This means roots grow very slowly, if at all during late fall, winter and early spring, but resume growth at about the same time that shoot green-up occurs. Root growth increases as tempera-

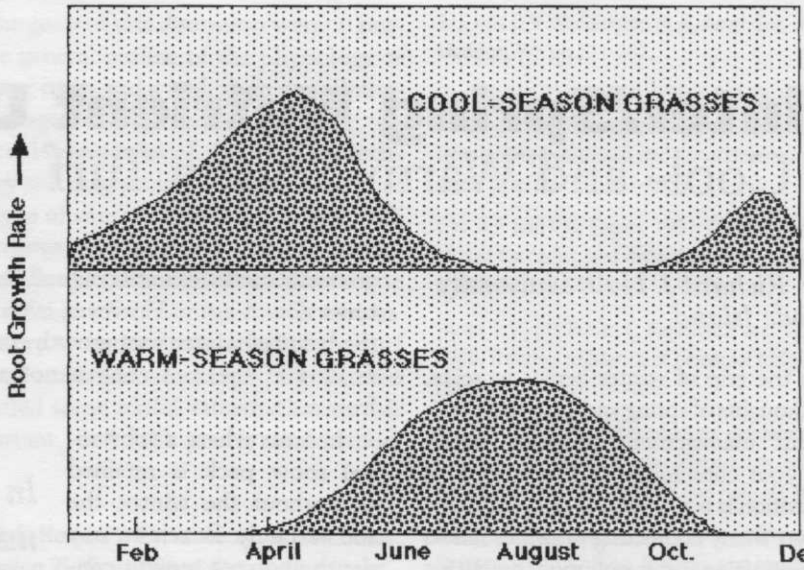

Figure 1. The annual root growth pattern of cool-season and warm-season turfgrasses.

ture and light increases, reaching a peak during mid- to late-summer. As temperatures decline during the fall, root growth slows and, following the first frost, all but stops. Thus, while cool-season grasses experience a marked mid-summer decline in root growth that recovers during the cold seasons, warm-season grasses grow roots primarily during the warm seasons when shoot growth also is greatest.

Resource allocation in cool- and warm-season turf

The integration of root growth and shoot growth activities is different between cool-season and warm-season grasses.

Because root growth in cool-season grasses is stimulated by lower temperatures than the temperatures that promote rapid shoot growth, there appears to be a seasonal division in resource allocation within the plant. When conditions are cold, all photosynthetic energy is diverted to root growth, while during the warm season, shoot growth is favored at the expense of roots. In warm-season grasses, there is sufficient photosynthetic energy to power both shoot and root growth simultaneously.

The reason for this difference is the draining effect of photorespiration on net photosynthesis in cool-season grasses during hot weather. Because mid-summer photosynthesis in cool-season grasses is not very efficient, there is normally not enough energy available to promote both shoot and root growth. During very hot weather, even shoot growth is seriously inhibited and cool-season grasses enter summer "dormancy." Because warm-season grasses lack photorespiration, their photosynthetic output increases with light and temperature, providing sufficient energy for both root and shoot growth.

Factors controlling nutrient uptake by roots

Root growth requires energy and carbon compounds — both of which are derived from sugars that are translocated to roots from leaf photosynthetic production. The energy is expended, generating electrochemical gradients across cell membranes that enable root cells to absorb nutrient ions from the dilute soil solution. This energy must be available for roots to function even if roots are not growing. Normally, root function takes priority over root growth when energy supplies are low but nutrient uptake still requires the expenditure of energy. If energy supplies are extremely low, roots will fail to absorb nutrients in amounts sufficient to support shoot growth and the plant begins to shut down or exhibit deficiency symptoms.

In cool-season grasses, roots have adequate energy to function and grow during times when soil temperatures are cool. The optimum temperature for root growth of Kentucky bluegrass is 10° to 15°F, which is considerably lower than the optimum for shoot growth. Consequently, roots will grow and function at near optimum rates when shoot growth is limited by suboptimum temperatures. Conversely, when shoots are experiencing optimum temperatures, root growth may be inhibited by temperatures that are supraoptimal for them.

However, there is a normal delay in soil warming, and roots frequently experience cooler temperatures than shoots during daylight hours. Because of this, field grown turf can, and often does, experience temperatures near optimal for both roots and shoots during spring and fall. Thus, temperature is the primary condition explaining the bimodal growth curve of roots in cool-season turfgrasses.

In warm-season grasses, the temperature effect is more direct and there is less difference in optimum temperatures for roots and shoots. Because shoots lose most of their photosynthetic tissues during the winter, both root and shoot regrowth in the spring depends upon energy (carbohydrates) stored in crown tissues and stolons from the previous summer and fall. This can present a problem for the grass if rapid spring warming stimulates growth of roots and shoots simultaneously.

The demand for energy may be greater than the rate that stored reserves can be mobilized and delivered to existing roots, and their rapid death may result. This spring root decline destroys over-wintering roots, so a new root system must be regenerated from grass crowns and stolon nodes. The result is a delay in green-up and resumption of shoot growth.

Nutrient availability

Nutrient availability in soils is also influenced by the seasonal cycle. Those nutrients which exist in soil primarily as organic residues and are not readily available in an ionic form, until they are released by microbial action, are most subject to seasonal availability. This primarily involves nitrogen and sulfur and, to a much lesser extent, phosphorus and iron. The availability of nutrients retained mostly on soil cation exchange sites (potassium, calcium and magnesium) is least affected by temperature.

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Nitrogen is clearly the most important nutrient with respect to seasonal limitations on turf growth. During the late summer and early fall, while the soil is warm, available nitrogen is released into the soil solution due to rapid microbial oxidation of organic matter. Because cool-season grasses lose most of their root system during the hot summer months, soluble nitrogen, mostly in the form of nitrate, accumulates within the soil solution to concentrations approaching 10 ppm nitrate-N. Warm-season grasses do not experience this summer root loss, so nitrogen is absorbed by roots just about as rapidly as it is mobilized from soil organic matter.

In cool-season grasses, roots regenerate during the fall into a soil enriched with available nitrate. Throughout the winter, this nitrate is gradually absorbed by the developing root system, although some may be leached from the root zone. The available nitrogen level declines until it reaches a very low concentration during April, just about the time when plant demand is greatest. Soils are still cold, so nitrogen mobilization by microbial action is slow and will not increase much for several weeks. It is for this reason that nitrogen deficiency symptoms are most often evident during the spring months. By late May and early June, soils have warmed enough that soluble nitrogen is being released from soil reserves and plant needs begin to be met.

Because warm-season grasses resume spring growth after soils have warmed substantially, this imbalance between plant needs and the rate of nitrogen release is much less dramatic. Consequently, spring nitrogen deficiencies are less likely to be obvious in warm-season turf, provided the soil contains sufficient organic matter through which microbial oxidation can release enough nitrogen to meet plant needs. In some sandy soils of southern regions, low soil organic reserves will not supply all the nitrogen required by a rapidly growing turf, and fertilizer nitrogen must be added if chlorotic turf is to be avoided. Other nutrients that are released to plant roots from decomposing soil organic matter show a similar pattern of availability but the impact of transient deficiencies is less dramatic on plant growth.

A late fall application of nitrogen will support winter and early spring root growth.

Nutrient management strategies to use

Based on the above discussion, we can consider how best to meet the nutrient needs of turf in the most efficient way possible.

Cool-season grasses: Nitrogen poses the greatest problem for cool-season grasses during the spring, when soil availability and plant growth rate are not well coordinated. Consequently, a modest nitrogen application during early spring will avoid deficiency conditions without excessively stimulating shoot growth. Once the soil warms, a mature turf will probably receive all the nitrogen it needs from microbial oxidation of soil organic matter.

A young turf or one growing on very sandy soils with limited organic matter will benefit from a light mid-June nitrogen application. Summer nitrogen applications are a waste, since soils are normally more than adequate and turf roots are declining, with limited capacity for nutrient uptake.

A light nitrogen application during early fall may be helpful in getting a root system to regenerate. Even though there may be adequate available nitrogen in the soil, emerging roots may not be able to reach it. A light application of a soluble nitrogen source at that time will give root regeneration a boost and promote fall recovery from summer injury. This may be especially important for athletic field turf.

Mid-fall fertilization is also not often helpful and may promote nitrate leaching. However, a late fall application of nitrogen, especially a mix of soluble and slow-release materials, will insure available nitrogen to support winter and early spring root growth. The quantity applied at this time need not be great. I personally question the wisdom of applying two-thirds of your total annual nitrogen allotment during late fall.

Phosphorous, however, is best applied during late fall. It will stimulate root growth and will have a chance to move into the root zone during the freeze-thaw cycles of winter. Phosphorous may not be needed at all in a mature turf that has been well fertilized for years. A similar case can be made for potassium, especially if clippings are normally retained on the turf. It is less likely to leach than nitrate and can also accumulate in medium texture soils.

Warm-season grasses: For warm-season grasses, nitrogen should be applied in small amounts, but as frequently as the turf needs it. A little nitrogen in the spring may get roots off to a good start but the grass demands may exceed soil supplies during the summer period of rapid growth. Consequently, several small applications should keep the grass going and well ahead of weeds and disease.

Fall nitrogen applications are of little value because the roots have or soon will decline and nutrient uptake will be limited. Nutrients such as phosphorus and potassium can be applied in the fall and will be well positioned in the soil during the following spring to meet turf needs.

In managing both cool- and warm-season grasses, calcium and magnesium are best applied in the fall or winter, so long as there is no snow cover. These nutrients do not move easily into the soil profile and will benefit from winter conditions to increase incorporation. Applying these elements just before aerification will also speed infiltration into the soil.

Conclusions

Fertilizing established turf is best when based on a sound knowledge of the annual cycle of turf needs and the availability of nutrients in the soil.

Cool- and warm-season turfgrasses differ in their root growth cycles and consequently require different strategies for applying nutrients.

The amount of fertilizer required by turf can often be reduced substantially if its application is properly coordinated with turf needs and soil nutrient availability.

No general suggestions should be taken without fully considering your situation and recognizing how it might differ from the so-called "typical" turf condition. In short, turf fertilization in the spring and at any time is largely a matter of common sense.

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