Turfgrass Fertilization

[Turfgrass Extension & Outreach](#)

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The major goal of turfgrass management programs should be to produce turf that is attractive, healthy, and able to withstand the rigors of its intended use. Fertilization is one of the most basic and important components of a turfgrass management program. Turf fertilization contributes greatly to turf color, density, uniformity, and growth rate. In addition, properly fertilized turf is better able to compete with weed invasions and is able to recover from damage caused by environmental and biotic stresses more readily than turf that is improperly fertilized. When developing a turf fertilization program, a number of factors need to be considered.

These factors include the:

- minerals required for turf growth and development;
- natural soil fertility;
- fertilizer selection;
- turfgrass species, desired quality, and use;
- environmental and management conditions; and
- application schedule.

Minerals Required for Turfgrass Growth and Development

Turfgrasses require 16 chemical elements for growth and development. These elements can be divided into two main groups based on where they are obtained by turf plants. The first group, carbon (C), hydrogen (H), and oxygen (O), are obtained from atmospheric carbon dioxide and water and comprise most of the turfgrass body.

The second group are minerals derived from soil or fertilizer application. This group can further be divided into three groups based on the quantities in which they are used by turf plants. The macronutrients, nitrogen (N), phosphorus (P), and potassium (K) are used in relatively large quantities by turfgrasses. The secondary nutrients, sulfur (S), calcium (Ca), and magnesium (Mg), are used in somewhat smaller amounts by turf plants, and micronutrients, iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), boron (B), and chlorine (Cl) are used in the smallest amounts by the plants.

Table 1 presents the mineral composition range normally occurring in turf plants as determined by tissue analysis. Trying to maintain turfgrasses in these ranges through proper fertilization allows turf to be maintained in a healthy, dense, and vigorous condition.

Table 1. Turfgrass mineral composition

Mineral	Percent dry weight
nitrogen (N)	3 to 6
phosphorus (P)	0.4 to 0.8
potassium (K)	2 to 4
sulfur (S)	0.3 to 0.7
calcium (Ca)	0.3 to 0.6
magnesium (Mg)	0.1 to 0.2
iron (Fe)	0.1 to 0.3
manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), boron (B), chlorine (Cl)	trace

Of these mineral elements, nitrogen, potassium, phosphorus, sulfur, and iron are most commonly applied to turf. For the most part, Illinois soils supply adequate quantities of most other secondary nutrients and micronutrients. The application of nitrogen, potassium, phosphorus, sulfur, and iron elicit certain growth responses in turfgrasses. Table 2 lists some of these responses.

Table 2. Growth responses of major minerals used by turf

Mineral	Response
nitrogen (N)	green color; shoot growth and density; root growth; carbohydrate reserves; recuperative potential; heat, cold, drought hardiness; wear tolerance; disease susceptibility
phosphorus (P)	establishment rate; maturation; root growth; seed production
potassium (K)	root growth; heat, cold, and drought hardiness; wear tolerance; disease susceptibility
sulfur (S)	green color; shoot growth and density; root growth; carbohydrate reserves; disease susceptibility
iron (Fe)	green color; shoot growth and density; root growth; carbohydrate reserves; heat, cold, drought hardiness; wear tolerance

Soil Fertility and Soil Testing

Determining the natural fertility of the growing site by making a soil test is the first step in developing a turfgrass fertility program. A basic soil test usually includes analysis of soil pH, phosphorus, and potassium levels. Knowing these conditions allows the manager to make informed decisions regarding other aspects of turf fertilization such as fertilizer

application rates and frequencies.
Soil samples for testing should be taken in areas of similar soil type and fertilization history, making a composite sample from each area. Collect samples for testing during the growing season when soil temperatures are above 50·F. Samples should be 2 to 4 inches deep and the same size in diameter. Combine several (at least eight) samples collected from all similar areas in a clean bucket. For instance, in a yard having both high, dry areas and low, wet areas, two composite samples, one from each unique area, are required. Remove any plants or plant parts present in the sample and submit about a cup of each sample for analysis.
Soil testing prior to turfgrass establishment is extremely useful. It is easier to change soil before planting than after the grass is established. When preparing a new seedbed, extract samples to the depth of soil cultivation, or about 6 inches.

pH adjustment

Soil pH is the measure of acidity or alkalinity and is measured on a 0 to 14 scale. When the pH is below 7.0, the soil is acidic, and when it is greater than 7.0, it is alkaline. A pH of 7.0 is considered to be neutral, neither acidic or alkaline. The optimum soil pH level for turfgrass growth is 6.0 to 7.0, indicating soil conditions that are slightly acidic. Slightly acidic soil reaction is desirable because it is at this pH that most soil nutrients are most available to growing plants.
Over time, the leaching of acidic materials in the soil and the use of acidifying fertilizers tend to gradually reduce the pH. Conversely, irrigation water tends to add bases (calcium, magnesium, potassium, and sodium) that gradually increase the pH level. Periodic soil tests are the only way to monitor changes.
Alkaline soils (when pH is above 7.0) are not desirable for turfgrass growth because of the reduced availability of plant nutrients. An alkaline soil problem can often be corrected by applying elemental sulfur according to the guidelines presented in Table 3. Individual applications of elemental sulfur on established turf should not exceed 5 pounds per 1,000 square feet. The best time for such applications is in the spring or fall, preferably in conjunction with core cultivation. Sulfur reacts slowly, so retest soil pH after 6 to 12 months to measure changes. Unfortunately, the addition of sulfur may not lower the pH in all soils; some soils are highly buffered and resist attempts to lower the pH.

Table 3. Recommended sulfur applications to lower the soil pH to 6.5

		Soil texture	
	Sandy		**Clayey**
Original soil pH		**pounds sulfur/1,000 square feet**	
7.5	10-15		20-25
8.0	25-35		35-40
8.5	35-40		40-50

NOTE: Individual applications of elemental sulfur should not exceed 5 pounds per 1,000 square feet.

Endeavoring to lower the pH rapidly with acidulating materials on established turf can cause a deterioration of the soil tilt and an excess buildup of soluble salts at levels harmful to turfgrass. Hard water used for irrigation purposes may neutralize or partially reduce the acidifying effect of sulfur applications. Acidifying fertilizers such as ammonium sulfate can be used in fertilization programs to offset the alkalinity of irrigation water.
Excessively acidic soils (when pH is below 6.0) may be ameliorated by adding agricultural limestone. The amounts are given in Table 4. Like sulfur, the amount to add depends on soil type and the desired change. To be effective, sulfur or limestone should be incorporated thoroughly into the soil by tilling. Avoid using slaked lime and burned lime because they are dangerous to handle. The recommendations are based on soil tests of samples taken to a depth of 3 inches in established turf. For a new seedbed, apply limestone at double the rates shown and incorporate it into the soil to a depth of 6 inches.

Table 4. Recommended limestone applications for turf

		Soil texture **a**	
	Sandy	**Loamy**	**Clayey**
Soil pH		**pounds agricultural limestone/1,000 square feet**	
6.0-5.5	25 **b**	35	45
5.5-5.0	40	55	70
5.0-4.5	55	75	105

NOTE: Individual applications on established turf should not exceed 25 to 50 pounds per 1,000 square feet.

a) An additional factor affecting the lime requirement is the organic-matter content of the soil. The recommendations given are based on soils containing 4 to 5 percent organic matter, approximately. With higher percentages, increase the limestone rates by 25 to 50 percent; when the organic-matter content is lower, reduce the rates by 25 to 50 percent.

b) Agricultural ground limestone has a total neutralizing power of 90. If another limestone material is used, adjust the indicated rates accordingly.

As mentioned, basic soil test results also include phosphorus and potassium levels. The desired levels for each of these minerals appears in the section below on fertilizer selection.

Fertilizer Selection

Nitrogen

Nitrogen is the most important element in turfgrass culture because it is present in larger percentages than other minerals in turf tissues (Table 2). This large quantity of nitrogen is used by turf for the formation of chlorophyll, a substance necessary for photosynthesis. Nitrogen also comprises portions of plant proteins, amino acids, enzymes, and vitamins. Obviously nitrogen is important for turf development and health. Nitrogen is absorbed by turf plants primarily in the nitrate ($NO3^-$) form, although the ammonia form ($NH4^+$) can also be taken in by the plants.

Nitrogen fertilization is also important for turfgrasses because it elicits the strongest growth response of any mineral element. Nitrogen mineral fertilization is often used to enhance green color and increase or maintain high density, both of which improve turf appearance. Response to nitrogen fertilization can be quick; under good growing conditions it can be translocated into leaf tissue within 15 to 24 hours following application. A turf that receives proper nitrogen fertilization generally has good color and density.

Although the nitrogen status of the soil may be determined by soil tests, it is difficult to conduct a nitrogen fertility program based on test results. Hence, the guides given in Tables 8 and 9 are preferred to using soil test results. Application rates are indicated within a range because of variations in climate, soil texture, cultural practices, and quality desired.

Very often nitrogen applications are made in excessive amounts or at times when they are not beneficial to the plant. Obvious results of excessive or improper timing of nitrogen applications are turf that is prone to Pythium blight, some patch diseases, and leaf spot diseases; thatch production; increased water usage; and the need for increased mowing. In addition, overfertilization, especially with water-soluble forms of nitrogen, can burn turf. Some problems that are not so obvious include reduced root, rhizome, tiller, and stolon growth, as well as reduced heat and drought tolerance.

Turfs deficient in nitrogen also exhibit characteristic symptoms. Older leaves at first become light green as nitrogen in these leaves moves into younger foliage. If nitrogen deficiency is allowed to continue, older leaves will turn yellow, becoming darker yellow-brown until they die. Pale green turf is not the only symptom of a lack of nitrogen. Nitrogen-deficient turf usually becomes less dense, encouraging weed encroachment. Also several diseases, e. g., dollar spot or red thread, commonly occur in turf that is nitrogen deficient. Finally, nitrogen-deficient turf grows slowly, producing fewer leaves and tillers. Observing turf color, density, diseases, and growth rate can help when determining the need for nitrogen application.

Nitrogen forms

Turf nitrogen fertilizers are usually classified as quick release or slow release (Table 5). Quick-release sources are water-soluble (e. g., ammonium nitrate, urea, ammonium sulfate); they will release nitrogen into the soil solution rapidly with rainfall or irrigation. They produce a relatively short-lived flush of growth and can burn the grass leaves if applied incorrectly. However, in most cases, they are cheaper per pound of actual nitrogen than slow-release forms.

Slow-release forms of nitrogen include natural organic materials such as activated sewage sludge and animal by-products, synthetic organic materials such as IBDU and ureaform, and coated materials such as sulfur-coated urea. These materials release nitrogen over a period of time. Natural organic materials and ureaform are broken down slowly by soil microorganisms. The activity of these microorganisms and, in turn, the rate of nitrogen release is affected by the temperature, moisture, and pH levels. Nitrogen release is limited during cool seasons, and it may be necessary to use water-soluble nitrogen carriers for spring and fall applications.

IBDU has a slow release by virtue of its low water solubility. The release rate increases as the temperature rises, but low temperature does not affect IBDU as much as the sources that depend on microbial activity for release.

As the names indicates, sulfur-coated urea (SCU) and resin-coated urea are forms in which urea is encapsulated with sulfur or resin to slow nitrogen release. The release rate increases as the coating thickness decreases and the temperature rises. Since urea particles are not coated evenly, SCU is approximately one-third quick release and two-thirds slow release. This gives the advantage of initial response to application combined with additional long-term benefits.

The slow-release forms are more expensive per pound of nitrogen than the water-soluble forms, but do provide a greater margin of safety and may be preferred during summer periods. These materials can be useful for extending the response to nitrogen fertilization and are also useful during periods of dry weather. The characteristics of gradual availability and safety to plants make slow-release nitrogen carriers desirable for certain fertilization programs.

Nitrogen fertilizer sources can be combined over an annual fertility program. For example, an early September and late fall application may be made using a quick-release nitrogen source, and the early May and late June applications may be made using slow-release forms.

When selecting nitrogen fertilizers for a specific application, consider the budget, how quickly and how long a response is desired, the amount of mowing and irrigation required, and the nitrogen form that will best fit into the application program.

Table 5. Some nitrogen carriers and relative characteristics

Carrier	% Nitrogen	Analysis	Residual response	Low temp. effects	Burn potential	Leaching potential
Quick release						
urea	45 - 46	45 or 46-0-0	short	rapid	high	moderate
ammonium nitrate	33 - 34	33 or 34-0-0	short	rapid	high	high
ammonium sulfate	21	21-0-0	short	rapid	high	high
potassium nitrate	13	13-0-44	short	rapid	high	high
monoammonium phosphate	11	11-50-0	short	rapid	moderate	moderate

diammonium phosphate	20	20-50-0	short	rapid	moderate	moderate
Slow release						
IBDU	31	31-0-0	moderate	moderate	mod. low	low
SCU	22 - 38	22 to 38-0-0	moderate	moderate	low	low
resin-coated urea	24 - 35	24 to 35-0-0	moderate to long	moderate	low	low
methylene ureas & ureaformaldehyde	38	38-0-0	moderate to long	very low	low	low
activated sewage sludge	4 - 6	4 to 6-4-0	long	very low	very low	very low
manures	1.5 - 3	variable	long	very low	very low	very low
dried blood	3 - 14	variable	short	moderate	very low	very low

Additional considerations include the source's burn and leaching potential. Burn potential is essentially an indication of the fertilizer's potential to pull water out of the turf plant by creating a high salt concentration in the soil. Quick-release nitrogen forms are prone to causing fertilizer burn because the minerals are already in a salt form. Certain environmental conditions, such as high temperatures and low humidity can increase a fertilizer's burn potential. By applying no more than 1 pound of actual nitrogen per 1,000 square feet per application, the burn potential is reduced dramatically.

Most quick release nitrogen sources are in a soluble form that enables them to leach readily. Nitrate leaching can be an environmental problem due to ground water contamination. In many turf situations, this is not a great problem. A potential problem can occur, however, when turf is grown on sandy soils, the water table is very close to the ground's surface, or excessive amounts of soluble forms of nitrogen have been applied.

Phosphorus

Physiologically, phosphorus is involved with holding and transferring energy required by turfgrass plants for metabolic processes. It does, however, make up only a small portion of dried turf tissues (Table 2), and the greatest growth response to phosphorus is usually observed with new turfgrass seedlings. Phosphorus deficiencies are rarely observed in established turf, unless the phosphorus level in the soil is extremely low or an unfavorable soil pH exists. Where a deficiency does occur, turf plants may suffer from reduced growth, dark or reddish leaf color, or narrow leaf blades. Phosphorus is absorbed in the H 2 PO 4 - and the HPO 42 - forms.

Base phosphorus applications on soil tests; Table 6 shows a guide for determining desired application rates for buildup to a desirable soil test level. Soil tests should be made before new turf is seeded, and every few years on established turf, to make sure the available soil phosphorus is present in adequate amounts. Be aware that high phosphorus soil levels increase the potential for annual bluegrass infestation on highly maintained turf.

Fertilizer phosphorus is obtained primarily from rock phosphate ores that are crushed and then treated with acids or heat to clean the material and make the phosphorus to be more soluble. It is most commonly applied to turf as triple super phosphate (0-46-0, or 46% phosphate), monoammonium phosphate (11-50-0, or 11% nitrogen and 50% phosphate), or diammonium phosphate (20-50-0, or 20% nitrogen and 50% phosphate).

Table 6. Recommended P_2O_5 applications, based on soil tests (Bray P1 Extractable Phosphorus [a])

P1 soil test (lbs./acre [b])	P2O5 (lbs./1,000 sq. ft)
Less than 25	4
26 to 50	2
51 to 75	1
More than 75	0

a) Usually, one application of a complete fertilizer (12-12-12, 10-6-4, etc.) per year is enough to maintain a sufficient level of phosphorus in the soil for turfgrass growth.

b) If the recommendation exceeds 2 pounds of P2O5 per 1,000 square feet, split the applications between spring and fall-except when the fertilizer is to be incorporated into the soil.

Potassium

Potassium plays a vital role in healthy turfgrass growth and development and is second to nitrogen in the amounts required for turf growth (Table 2). Physiologically, potassium is involved in cellular metabolism, environmental stress resistance, disease incidence, internal water management, and wear tolerance. Potassium is absorbed in the K+ form. As with phosphorus, potassium applications should be based on soil tests. The principal factors affecting the potassium requirement for turf are clipping removal, irrigation, and soil texture. If the clippings are removed, larger and more frequent applications of potassium are generally required to maintain satisfactory growth. The specific requirement is usually about half the rate at which nitrogen is applied. Where clippings are not removed, the potassium requirement is 2 to 2.5 pounds less per 1,000 square feet per year. Very sandy soils tend to lose potassium more rapidly than finer textured soils through leaching. Potassium reserves are more difficult to build up in sandy soils than in those having a greater storage capacity for this element. Thus, smaller and more frequent applications of potassium would be in order on coarse-textured soils. Table 7 provides a guide for determining the desired rates of application to build up potassium to a more desirable soil-test level.

High-potash fertilizers are available and are often called *winterizers*. Manufacturers generally call for these fertilizers to be used in autumn so that turf can derive the benefits of potash during the winter months. Potash certainly plays a role in turfgrass cold tolerance, but it is important at other times of the year also. Thus, our recommendation is to maintain continuously adequate potash levels so that turf can derive all potash benefits

throughout the entire growing season.
Fertilizer potassium is derived from potassium mines as the salt potassium chloride (KCl), also called muriate of potash or just potash. Muriate of potash, when used as a fertilizer, has an analysis of 0-0-60 (60% K 2 0). Potassium nitrate (13-0-44, 13% nitrogen and 44% K 2 0)) and potassium sulfate (0-0-50, 44% K 2 O and 18% sulfur) are also K sources.

Table 7. Recommended potash applications based on soil tests a

K soil test (lbs./acre)	Potash b (lbs./1,000 sq. ft)
Less than 50	6
51 to 100	4
101 to 150	2
151 to 200	1
More than 200	0

a Potash may be applied as 0-0-60 (muriate of potash) or as a complete fertilizer.

b Applications should be split into 1.5-pound increments applied through the growing season since rates of more than 1.5 pounds per 1,000 square feet may cause burning. Apply to dry turf and water immediately if possible.

Secondary nutrients and micronutrients

Although the quantities of secondary nutrients and micronutrients required for turf growth are quite small (Table 2), they are all necessary to maintain quality turf growth. Fortunately, the quantity of these mineral nutrients in most Illinois soils is usually adequate.
Sulfur is a constituent of some proteins and is the secondary nutrient occasionally found to be deficient in turfgrasses, especially in sandy soils or soils void of organic matter. This is especially true in sulfur-deficient turfgrasses where symptoms include yellowing older leaves, slowed growth, and delayed maturity. Sulfur is commonly supplied to turf during the breakdown of soil organic matter and during precipitation in areas where sulfur-containing coal is burned. When sulfur is thought to be deficient, apply 4 ounces of elemental sulfur (99% sulfur) to 1,000 square feet as a test area to evaluate results. Should deficiency symptoms be eliminated, apply 4 ounces of sulfur per 1,000 square feet over the remaining turf area. Sulfur can also be supplied to turf as gypsum (18.6% sulfur), ferrous sulfate (18.8% sulfur), potassium sulfate (17.6% sulfur), and ammonium sulfate (24% sulfur).
Micronutrients are required in very small quantities and are often supplied as impurities in commonly used fertilizers and in clippings, liming materials, topdressing, certain pesticides, and irrigation water. Sandiness increases the possibility for micronutrient deficiencies; however, most sands used for soil modification are not pure and are usually modified some with soil and organic matter.
Iron is the micronutrient most often found to be deficient in turf. Iron deficiency is

characterized by an interveinal chlorosis (yellowing) of turfgrass leaves and an eventual thinning of the turf. Deficiencies of iron are a more serious problem under conditions of high pH (above 7.5) and high soil phosphorus. The problem can be corrected by spraying every 2 weeks with 1 to 2 ounces of ferrous sulfate per 1,000 square feet of turf. Deficiencies of other micronutrients are not common in field turf, but high pH is also known to induce deficiencies of manganese, zinc, or copper in other crops. High soil phosphorus in conjunction with high pH further aggravates a zinc deficiency.

Turfgrass Species, Desired Quality, and Use

Turfgrass species Turfgrass species have evolved, and also been selected, to perform well under different nitrogen fertility regimes. For instance, improved Kentucky bluegrasses require more nitrogen than red fescue. See Table 8 for nitrogen requirements of different turfgrass species.

Table 8. Pounds of actual nitrogen per 1,000 square feet per year required by different turf species

Cool season grasses	**Pounds N / 1,000 sq. ft/year**
sheep and hard fescue	0 - 3
red fescue	1 - 3
tall fescue	2 - 4
perennial ryegrass	2 - 4
improved Kentucky bluegrass **a**	2 - 4
common Kentucky bluegrass **b**	1 - 2
creeping bentgrasses	3 - 8
Warm season grasses	
improved bermudagrass	4 - 8
buffalograss	0 - 2
St. Augustinegrass	2 - 4
zoysiagrass	2 - 4

a. includes A-34, Adelphi, Baron, Glade, Sydsport, Touchdown, Victa

b. includes Kenblue, Park, and South Dakota Certified

Desired quality and use

The desired turf quality and use should also be considered when planning a turf fertilization program. In general, if a high-quality turf is desired, greater amounts of mineral nutrients are required than for low-quality turf. Be aware that the intensity of other management practices (mowing, irrigating, cultivating) also needs to reflect the desired quality level. Rarely will turf quality improve solely by increasing fertilizer

applications.
Generally, one or two fertilizer applications per year will maintain turf in an acceptable condition. Three or more applications are usually necessary to produce turf of high quality (Table 9).
In addition, turf use should be considered in planning a fertility program. Intensely used turf generally requires higher fertility inputs to encourage turf growth and recovery from the trafficking. Little-used turf does not receive the wear and tear of high-use areas; thus turf growth will not need to be pushed and fertility can be reduced.

Environmental and Management Conditions

Astute turf managers realize that each growing season is different from those preceding it. Fertilization practices need to be altered in response to environmental changes. Certain conditions, such as excessively cool and wet or hot and dry weather, require different fertilization practices than more normal conditions. Cool, wet conditions favorable for cool season turfgrass growth and nitrogen leaching may require additional fertilization as compared to more normal growing conditions. Hot, dry weather that is unfavorable for cool season turf growth usually requires less fertilizer inputs than normal conditions.
In addition, differences in soil or in amount of light and shade can dictate different fertility regimes. Nitrogen applications to turf growing on sandy soils are usually greater than on more finely textured soils or highly organic soils. Nitrogen leaching is more likely to occur on sandy soils than on these other types. Under shady conditions, the low end of the fertility range should be used since the nitrogen requirement of the grasses is lower in shade than in full sunlight.
Mowing and irrigating practices should also be considered when developing a fertility program. Where clippings are returned to turf, apply 1/4 less actual mineral nutrients than when clippings are not returned. Clipping breakdown can supply the additional minerals to the turf. Heavily irrigated turfgrasses will generally require additional fertilizer due to leaching and increased turf growth rate. Evaluate turf fertilization after making changes in other management practices so that turf quality can be maintained.

Fertilizer Application

Turfgrass fertility programs often revolve around the quantity and timing of nitrogen applications. Nitrogen is used by turf plants in large quantities, and because it is mobile in the soil, it should be applied to most turfs one to four times per year. Most turf fertility recommendations will indicate the pounds of actual nitrogen to be applied per 1,000 square feet of turf per year.
For cool season turfgrasses (e. g., Kentucky bluegrasses, perennial ryegrasses, creeping bentgrass, and the fescues), active growth occurs in mid-spring to early summer and again in late summer through mid-fall. The cool, moist weather during those periods favors tillering and rhizome development.
By following the application schedule in Table 9 for three or four applications per year, turf of moderate to high quality can be maintained. Supply low- to medium-quality lawns with mineral nutrients in one or two applications per year. Regardless of the fertilization schedule used, make sure that an application occurs to cool season turf in late summer or

early fall. This fertilization helps turf recover from summer stresses and prepare for winter.

Water-soluble nitrogen sources can be used in moderate amounts during the mid-spring period after the early flush of growth and during the late summer or early fall. As a general rule, never apply more than 1 pound of actual nitrogen per 1,000 square feet from a quick-release nitrogen source during any one application. Following this recommendation will reduce the possibility of fertilizer burn. For an early summer application, a supplemental application can be made at 1/2 to 1 pound per 1,000 square feet. This early summer application might consist of a combination of nitrogen sources: half as soluble nitrogen to provide a readily available source of nitrogen and half as slowly soluble nitrogen to provide a nitrogen carryover through the summer months.

A late season fertilization can supply adequate fertility for early spring growth. Fertilizer applied at this time can enhance turf root growth, provide early spring green-up without a large flush of growth, and supply enhanced winter color. This fertilization should be applied when vertical shoot growth has stopped, but the turf is still green and photosynthesizing. This occurs approximately 1 week after the final mowing of the season when daytime air temperatures are cool. Use quick-release fertilizers (urea, ammonium nitrate, ammonium sulfate, ammonium phosphates) or slow-release nitrogen sources (IBDU, SCU, or RCU). Avoid using fertilizers that are dependent on warm soil temperatures and microbial activity for release.

Studies at the University of Illinois indicate a higher incidence of leafspot disease on susceptible cultivars when high rates of nitrogen are applied in the early spring. If enhanced color is desired during early spring, a quarter to half pound nitrogen per 1,000 square feet can be applied at that time.

Slow-release sources of nitrogen can be used at higher rates (2 to 3 pounds of actual nitrogen per 1,000 square feet) on a less frequent basis. Two applications of such materials per year will generally be adequate to sustain healthy, vigorous turf.

In most cases, turf fertilization should not consist solely of nitrogen applications. Soil tests can determine the need for additional mineral applications, especially potassium, and phosphorus. In lieu of soil testing, select turf fertilizers with analysis ratios of 3-1-2, 4-1-2, or 5-1-2.

Table 9. Cool season turfgrass fertilization schedule

No. nitrogen application(s) per year **a**	Early May	Mid- to late-June	Early Sept.	Late season
1			X	.
2	X		X	
3	X		X	X
4 (with summer irrigation)	X	X	X	X

a Split the annual number of pounds of nitrogen to be applied equally into each application. Do not exceed one pound of nitrogen in a quick-release form at any one application.

b Late season application should be applied approximately 1 week following the final mowing of the season.

Warm season turfgrasses (e. g., zoysiagrass, bermudagrass, St. Augustinegrass) grow actively when temperatures are warmer, usually from mid-spring through mid-fall depending on latitude. Warm season grasses are usually fertilized at least once per year in the spring at the initiation of growth. Successive applications can be made monthly during active growth.

Summary

Developing a successful turfgrass fertilization program entails more than an annual early-April application of a high-nitrogen fertilizer. It requires both technical knowledge and turf management experience. To develop a total fertilization program, the turfgrass species and growth cycles, the turf's use, the minerals required for growth and development, the soil fertility, fertilizer characteristics, the environmental and management conditions, and the application schedule need to be considered. Successful turf managers, whether they realize it or not, consider these factors in total when making the decision on how to fertilize, when to fertilize, and how much to fertilize.