Fertilization/Nutrient Management BMPs

Turfgrass fertilization is one of the most important cultural practices needed to maintain a healthy, dense stand of grass. Fertilization supplies supplemental nutrients to keep turfgrass healthy. The practice is especially important given the amount of traffic and intensity of use of many sports fields. However, as with any practice, there are limits to how much fertilization is required, and excessive fertilizer applications can be detrimental to the turfgrass and environment.

Regulations

Each state has specific laws and/or regulations in place for fertilizer application. The following resources can be used to identify what is legal for your state.

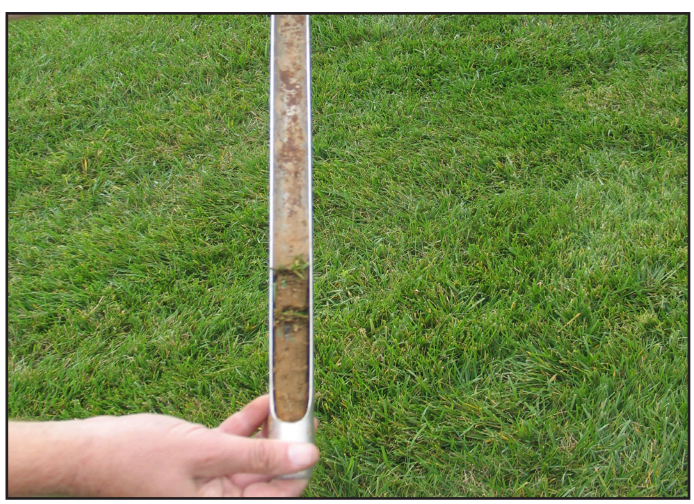
Environmental Regulations that Affect Sports Fields (by State)

Association of American Plant Food Control Officials

Soil Testing

A standard soil test provides information on soil pH and the levels of the macronutrients phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) and typical micronutrients iron (Fe), zinc (Zn), copper (Cu), and boron (B). Soil test results do not provide nitrogen (N) levels because N constantly fluctuates between plant available and unavailable forms. However, soil test results typically provide a recommendation for N levels and timing of applications. Soil tests should be conducted on an annual or more frequent basis to help prevent over-application of nutrients to turfgrass and landscaped areas.

- Test native soils once every three years and sand-based soils annually.
- Soil samples can be taken at any time of year; however, do not perform sampling for at least 2 months following liming or fertilization.
- To provide a representative, uniform soil sample for the field being tested, use a soil probe to take 10-15 random samples from a 4-inch depth and blend together in a plastic bucket/container.
- Work with a single accredited laboratory for consistent results over time. Different laboratories may vary in their testing techniques, which may impact results.
- Base all fertilization and liming practices on the soil test results except for nitrogen. Test results recommend nutrient and lime application levels and frequency of application. The results form the basis for nutrient management planning for selection of nutrient sources, rates of application, and appropriate timing to meet site specific needs.
- Check state and local laws on your ability to apply phosphorus.
- Keep records of soil test results from previous years to observe changes in the soil over time.
- Supplement soil tests with plant tissue tests when necessary.



Soil sample – Photo courtesy of Michael Goatley, Jr., Ph.D.

Fertilization/Nutrient Management BMPs

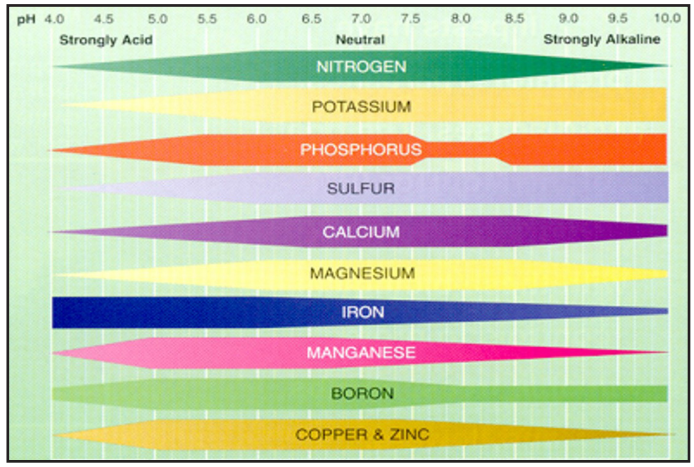
Plant Tissue Tests

Tissue testing can help to adjust nutrient management programs to confirm a suspected nutrient element deficiency when visual symptoms are present. Tissue tests can also be used to monitor plant nutrient element status to determine when each tested nutrient is in sufficient concentration for optimum performance.

- Consider supplementing a soil test with a tissue test. While a soil test indicates the level of available essential nutrients in the soil, the tissue test indicates the macro and micronutrients within the plant.
- When collecting samples, take only the leaf blades. Clip by hand to avoid contamination with soil or other material. Collect about a ½ pint of material during the normal growing season.
- Use tissue tests as a secondary tool to soil testing to determine the ranges of possible nutrient excesses or deficiencies. Low tissue levels of a given plant nutrient may not indicate a lack of nutrient availability, but rather an abiotic problem, such as stress, or a biotic problem, such as a root pathogen, that reduces or inhibits nutrient uptake. The data from a tissue test will not explain the cause of the nutrient deficiency (such as unsuitable pH or excessive nutrient application), but when used with a soil test, it certainly can improve the chances to understand what is wrong.

Soil pH

Soil pH levels may be the most important data in soil test results. Nutrients may be present in the soil but not available to plants because nutrient availability to plants is governed primarily by pH. Turfgrasses can withstand a broad range of soil pH, but 6.2-6.8 is generally considered ideal because it provides the greatest probability of micronutrient availability. Extremes in soil pH result in nutrient deficiency or toxicity, both of which can cause suboptimal growth conditions and ultimately lead to turfgrass loss. In addition, soil pH between 6 and 7 is important for encouraging microbial activity. Microbes are important for the soil environment to breakdown fertilizers. Depending on the turfgrass species, problems may start to occur at a pH above 7.8 and below 5.4. Soil pH adjustments may occur slowly and are temporary and should always be based off the soil test results.



pH Influence on Nutrient Availability

- Monitor soil pH by conducting soil tests on native soils once every three years and sand-based soils annually. Test results will provide the recommendations for which turfgrass managers can base their lime and fertilizer applications.
- If soil test results indicate low pH, apply a quality liming material readily available to your area (sources vary depending on location) and be sure to consider the product's Calcium Carbonate Equivalency (CCE) value; it is a % value you will find on its label. Similar to a fertilizer grade, the value compares the liming ability of your source to a pure calcium carbonate standard. Simply put, to meet the recommended liming rate for a source that has a CCE value less than 100%, you will need to increase the level of your particular lime source. For example, if a recommendation is to apply 20 pounds of lime per 1000 square feet and your source has a CCE value of 85%, you need to apply 20 ÷ 0.85 = 23.5 pounds of material per 1000 square feet. If the CCE value is higher than 100% (possible because some lime sources can have acid neutralizing abilities that exceed pure calcium carbonate), you would need less than the recommended level. Most land grant universities have extension publications devoted to the selection, use and expectations of liming materials.
- No more than 50 pounds of lime per 1000 square feet should be applied in a single application on established

turfgrass. If the soil test suggests more, split the application into incremental amounts and apply on monthly intervals.

- Apply lime in conjunction with hollow tine aeration or during periods of freezing and thawing so it can be incorporated into the soil profile. Winter months can be a great time to make supplemental lime applications due to lower burn potential to the turfgrass and the extended time required for the chemical reactions to occur.
- When possible, soil pH should be adjusted prior to establishment. Incorporating lime prior to planting greatly accelerates the neutralization of acidity throughout the rootzone.
- If soil test results indicate a high pH, apply a product containing elemental sulfur, aluminum sulfate, or an acid forming N fertilizer. Depending on the source used, maximum application levels may be restricted due to burn potential. One of the most important reasons to use a soil test to determine lime levels is to avoid raising pH too high; it is much easier to raise pH than it is to lower pH.

Understand Your Fertilizer

The goal of nutrient application is to maximize plant uptake while minimizing nutrient losses. Understanding processes and nutrients will increase ability to make sound management decisions and ultimately leads to a reduction in environmental risk. Rate, application date, location, and turfgrass species should all factor into nutrient application decisions.

The laws governing the labeling of fertilizer vary greatly among states. Consult your land-grant university or the appropriate state agency regarding the laws in your location. Check your state and local laws regarding phosphorus applications before making an application to turfgrass areas. Even if the soil test results indicate low phosphorus levels, some state and local laws override soil-test phosphorus recommendations.

- Apply nutrients based on soil test recommendations.
- Know your fertilizer label. The label must include the following information:

  – Brand

  – Grade or analysis – the percentages by weight of nitrogen, phosphate, and potash that is guaranteed to be in the fertilizer

  – Guaranteed analysis – lists all nutrients in the product on a percent by weight basis

  – Net weight

  – Name and address of the registrant and licensee

- Know the type of fertilizer you're using

  – Organic fertilizer – contains carbon and sources are naturally occurring animal or plant byproducts

  – Inorganic fertilizer – does not contain carbon, source is a synthetic product

- Understand the roles of the primary and secondary macronutrients (see Table 1 on page 7 for more information on essential nutrients, their function, sufficiency range in shoot tissue, and potential deficiency/excessive occurrence to plants).

  – Nitrogen is essential for plant growth. It influences color, shoot growth, shoot density, root growth, rhizome and stolon growth, carbohydrate reserves, high temperature stress, cold tolerance, drought resistance, wear tolerance, thatch accumulation, disease susceptibility, and recuperative potential.

  – Phosphorus is involved in the transfer and storage of energy for metabolic processes. It affects seedling development, maturation, root growth and seed production. Phosphorus enhances turfgrass establishment. Phosphorus CAN contribute to impaired water when it is mis- or over-applied, but it is absolutely essential for healthy turfgrass growth and development.

  – Potassium is involved in photosynthesis and is important in the regulation of stomates and internal water management. Potassium also affects root growth, heat, cold and drought tolerance, wear tolerance, disease susceptibility, and environmental stress resistance.

– Calcium aids in cell wall structure and new cell formation. It also stimulates root and leaf development.

– Magnesium is a central ion in the chlorophyll molecule and chlorophyll synthesis.

– Sulfur is involved with the formation of proteins. It helps with turfgrass growth, green color, shoot growth and density, root growth, carbohydrate reserves, and disease susceptibility.

- Understand the role of the micronutrients iron, manganese, boron, copper, zinc, molybdenum, and chlorine. Micronutrients are required in very small quantities but are just as important to plant health as macronutrients. Deficiencies are rare in heavy textured soil (clay or silt-based), but deficiencies can occur periodically in sandy soils. Maintaining an appropriate pH is the most important factor in ensuring sufficient availability of micronutrients.

- Understand the nitrogen sources in the fertilizer.

– Water soluble N (WSN) provides rapid turfgrass growth and color responses and is more prone to leaching, particularly in sand-based soil. Types:

o Urea
o Ammonium sulfate
o Diammonium phosphate
o Monoammonium phosphate
o Calcium nitrate
o Potassium nitrate

– Slowly available N (SAN) / water insoluble N (WIN) / controlled release N (CRN) are highly variable in N content and release characteristics. These are N-containing fertilizers where release of N into soil is delayed either by requiring microbial degradation of the N source, by coating the N substrate which delays the dissolution of N, or by reducing the water solubility of the N source. Types:

o Sulfur-coated urea
o Polymer/resin-coated
o Isobutylidene diurea
o Urea-formaldehyde/urea-formaldehyde reaction products
o Natural organic

– Enhanced efficiency (EE) fertilizer products minimize the potential of nutrient losses to the environment. Types:

o Slow release fertilizer sources release or convert nutrients to a plant available form at a slower rate relative to 'reference soluble' products. Release is governed by either some coating or occluded materials.

o 'Stabilized' N sources – amended with an additive that reduces the rate of transformation of fertilizer compounds, resulting in extended time of availability in the soil.

- Understand the phosphorus sources in a fertilizer.

– Diammonium phosphate
– Concentrated superphosphate
– Monoammonium phosphate
– Natural organics

- Understand the potassium sources in a fertilizer.

– Potassium sulfate
– Potassium chloride
– Potassium nitrate

Fertilizer Application – Photo courtesy of Gregg Munshaw, Ph.D.

Nutrient Application

A site-specific nutrient management plan provides the basis for developing a nutrient management strategy that optimizes plant health in an environmentally responsible manner. It is difficult to provide one plan that meets the needs of all turfgrass areas due to variables such as grass, grass use, soil, climate, budget, equipment, etc.

- Calibrate your fertilizer spreader accurately to reduce environmental risk. STMA has calibration worksheets available for **backpack and hand-held sprayers**, **boom sprayers**, **drop spreaders** and **rotary spreaders**.
- Choose the appropriate spreader based on the fertilizer material: walk-behind rotary, drop spreader, bulk rotary, or spray. Not all fertilizers can be spread with every spreader.
- Follow N application rate recommendations from soil tests or your local land-grant university. Typically, recommended application rates are no more than 1 pound of N per 1000 square feet applied per active growing month (Active growing months for cool-season grasses are typically late summer through mid-fall and warmer periods in the spring. Active growing months for warm-season grasses are typically mid-spring through mid-summer.) Applying excessive nutrients or high quantities of fertilizer increases the likelihood that nutrients will end up in local waterways due to stormwater runoff from excessive rain or irrigation. Excessive N can also increase pressures from pests, environmental extremes and reduce traffic tolerance. Sports fields require more aggressive N fertility programs than other managed turfgrass to optimize playability and safety, but these programs still must match site-specific needs for grasses, budgets etc.
- Apply nitrogen during periods of optimal turfgrass growth to reduce water quality impacts. For cool-season grasses, 2/3-3/4 of seasonal N applications occur in the fall with 1/3-1/4 occurring mid spring. For warm-season grasses, N application occurs from mid-spring through late summer.
- Use slow release or enhanced efficiency nitrogen sources to optimize nutrient use efficiency and reduce leaching potential.
- Apply slow release N fertilizers at the appropriate time of year to maximize release characteristics. For example, an application of slow release N in the fall to warm season grasses is not as effective as an application in early summer due to the prolonged release time. Slow release fertilizers minimize environmental impacts and are less likely to enter storm water systems.
- Percentages of readily- and slowly-available N in products should be used to determine application rates.
- Apply phosphorus based on soil test results and local or state laws. Phosphorus leaching is a concern on sand-based soils and where it is overapplied on established turfgrass.
- When budget and labor permit, foliar fertilization programs that apply light and frequent applications of required nutrients can improve nutrient use efficiency compared to granular fertilizers.
- Apply the appropriate amount of fertilizer to each specific turfgrass area to maintain it to acceptable conditions for both safety and playability. The amount of fertilizer applied should be specific to that particular use. For example, nutrients would be applied differently to a heavily-used soccer field versus the surrounding utility turfgrass areas.
- Apply granular fertilizers at lower rates on a more frequent schedule.
- For best results, apply half rates of fertilizer in two directions for better distribution.
- Establish minimal maintenance buffer zones around stream and lake boundaries to protect water sources.
- Do not use water soluble N on sites conducive to leaching and/or runoff, such as on sandy soils or sloped areas where turfgrass is not actively growing.
- Fill spreaders and sprayers in designated areas for such purpose and have a response plan in case spills occur. Safety Data Sheets for chemicals should always be close at hand to correctly address the procedures to follow in case of any spills.
- If applying granular/soluble fertilizer to bare soil, incorporate the fertilizer into the soil to reduce exposure of nutrients to stormwater runoff.
- Irrigate turfgrass following fertilization to bring fertilizer into contact with the soil and move soluble N into the soil. Irrigation intensity should be low enough that water infiltrates the soil and does not runoff.

Fertilizer removal from hardscapes – Photo courtesy of Michael Goatley, Jr., Ph.D.

- Do not apply fertilizers near hardscapes that move stormwater as this contributes to water quality concerns if runoff should occur. Immediately remove fertilizer from hardscapes by blowing, brushing etc. the product into a grassed area.
- Check past and future weather before applying fertilizer. Avoid applying fertilizer to soils that are at or near field capacity or following rain events that leave soils wet. Avoid applying fertilizer on windy days. Do not apply fertilizer when the National Weather Service has issued flood, tropical storm, hurricane, or heavy rain warnings.

Fertilizer Storage and Disposal

Sometimes more fertilizer is prepared than is used, and it will need to be disposed of in a way that does not impact the environment.

- Ensure you are in compliance with state regulations pertaining to fertilizer disposal.
- Dispose of excess fertilizer safely by spreading it at a secondary area that can use fertilization.
- Store excess fertilizer for future use.
- Open bags of granular fertilizers should be stored in a dry place (low humidity). If unable to, be sure bags are closed tightly to keep moisture out.
- Follow storage instructions of liquid fertilizers. Many require storage above freezing and out of direct sunlight.

Table 1. Essential nutrients, their function, sufficiency range in shoot tissue, and potential deficiency/excessive occurrence to plants

Essential Nutrient	Chemical Symbol	Available Form	Primary Role	Mobility	Tissue Sufficiency Range	Frequency of Deficiency In Turfgrasses	Deficiency Occurrence	Excessive Occurrence
Carbon	C	CO_2	Many	---	---	Sometimes	Drought Stress	---
Hydrogen	H	H_2O	Many	---	---	Sometimes	Drought Stress	---
Oxygen	O	CO_2 O_2	Many	---	---	Sometimes	Compaction, water-logged	---
Nitrogen	N	NO_3^- NH_4^+	Amino Acids Nucleic acids Proteins Enzymes	Mobile	% 2.8-3.5	Common	Sandy soils; high leaching conditions from high rainfall or irrigation; clipping removal; denitrification; low pH (<4.8)	Direct toxicity as a salt; excessive growth and tissue succulence
Phosphorus	P	$H_2PO_4^-$ HPO_4^{-2}	Sugar phosphates Phospholipids Nucleic acids Enzymes ATP	Mobile	% 0.20-0.55	Sometimes	Sandy, low CEC, irrigated soils; under low pH(<5.5) or high pH (>7.5-8.5); reduced uptake in cold soils with high clay content	May induce Fe deficiency under some conditions
Potassium	K	K^+	Enzymes Stomata function	Mobile	% 1.5-3.0	Sometimes	Sandy or low CEC soils; low pH (<5.5); clipping removal; soils receiving high Ca & Mg additions	Contributes to salinity stress; cause fertilizer burn; suppresses Mg, Ca, or Mn uptake
Calcium	Ca	Ca^{+2}	Cell walls Enzymes	Immobile	% 0.50-1.25	Rare	Low pH (<5.5) on low CEC, high leaching soils; soils receiving high levels of Na, Al, Mn or H	Can induce deficiencies of Mg, K, Mn, or Fe
Magnesium	Mg	Mg^{+2}	Chlorophyll	Mobile	% 0.15-0.50	Sometimes	Low pH (<5.5) on low CEC, high leaching soils; under high Na, Ca, or K additions	Can induce deficiencies of K, Mn, and Ca
Sulfur	S	SO_4^{-2}	Proteins	Somewhat Mobile	% 0.20-0.50	Sometimes	Low organic matter; sandy, low CEC soils; under high N with clipping removal	Cause foliar burn; induce soil acidity; contribute to black layer under anaerobic conditions
Iron	Fe	Fe^{+2}, Fe^{+3} Fe Chelates	Chlorophyll pigment Proteins	Immobile	ppm 50-100	Common	High pH(>7.5); excessive thatch; cold and wet soils; low organic matter soils; irrigation water high in HCO_3^-, Ca, Mn, Zn, or Cu	Acidic, poorly drained soils can produce toxic levels; can induce Mn deficiencies; blackened leaves and injury
Manganese	Mn	Mn^{+2} Mn Chelates	Enzymes Photosynthetic evolution of O_2	Immobile	ppm 20-100	Sometimes	High pH(>7.0); calcareous soils; warm weather reduces availability; high levels of Cu, Zn, Fe, and Na on leached low CEC soils	Low pH(<4.8); anaerobic soils; high Mn can induce Ca, Fe, and Mg deficiencies
Zinc	Zn	Zn^{+2} $ZnOH^+$	Enzymes	Somewhat Mobile	ppm 20-55	Rare	High pH (>7.0); high levels of Fe, Cu, Mn, P, or N; high soil moisture; cool wet weather and low light intensity	Municipal waste; high levels may induce Fe or Mg deficiencies
Copper	Cu	Cu^{+2} $Cu(OH)^+$ Cu Chelates	Enzymes	Somewhat Mobile	ppm 5-20	Rare	High pH; organic soils; heavily leached sandy soils; high levels of Fe, Mn, Zn, and N	Use of sewage sludge; pig/poultry manures; over-application of micros
Molybdenum	Mo	MoO_4^{-2} $HMoO_4^-$	Nitrate reduction for N_2 fixation	Somewhat Mobile	ppm 1-4	Rare	Low pH, sandy soils; soils high in Fe and Al oxides; high levels of Cu, Mn, Fe, and S suppress uptake	High pH, wet soils
Boron	B	H_3BO_3 BO_3^{-3}	Cell wall and plasma membrane integrity	Somewhat Mobile	ppm 5-60	Rare	High pH induces deficiencies on leached calcareous soils; high Ca; dry soils; high K may increase deficiency	High B in irrigation water; over-application of micros; compost amendments
Chlorine	Cl	Cl^-	Photosynthetic evolution of O_2	Mobile	ppm 200-400	Never	Uptake suppressed by high NO_3^- and SO_4^{2-}	Component of many salts enhancing soil salinity reducing water availability
Nickel	Ni	Ni^{+2}	Urease enzyme to transform urea to NH_3	---	ppm < 1.0	Never	Conditions unclear; rare occurrence of deficiency	Use of sewage sludge

Table developed from: Carrow, R.N, D.V. Waddington, and P.E. Rieke. Turfgrass Soil Fertility and Chemical Problems. 2001. Ann Arbor Press. Chelsea, Michigan.