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Turf Fertilizers for Hawaii's Landscapes

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Fertilizer requirements of the various turfgrasses common in Hawaii differ greatly. Hybrid bermudagrasses have the highest fertilizer requirements; zoysiagrasses, St. Augustinegrass, and seashore paspalum are intermediate; centipedegrass needs the least amount of fertilizer. Fertilizer requirements for any given turf also vary greatly depending upon its intended use, the desired level of appearance, soil conditions, the amount of rainfall or irrigation, and other environmental conditions. Poor fertilizer practices including excess or insufficient application and poor fertilizer distribution are responsible for many of the common problems associated with turfgrass maintenance.

In Hawaii, where the growing season is year-long, it is necessary to apply fertilizers throughout the year. Failure to follow a regular schedule, especially with the high-demand turfgrasses, will result in uneven appearance and may increase weed, insect, and disease problems.

An important factor in developing a fertilizer application schedule is a good knowledge of the type of turfgrass you are working with. Bermudagrass requires and responds to a monthly feeding of 1 pound of nitrogen (N) per 1000 square feet (sq ft, or ft^2). Applying the same amount to a centipedegrass turf would be a waste of time and money. The main objective of a good turf fertilizer program is to promote good color and vigor of the grass without producing excessive growth. Overfertilizing with N promotes lush growth, which can lead to a number of problems including rapid thatch buildup, higher susceptibility to disease and insect infestation, and higher water requirements. Overfertilized lawns are always the first to show wilting during dry periods in many species of turf, because excess N promotes top growth at the expense of the root system and can eventually lead to a deterioration of the root system. Of course, lush growth also means that the turf will require more frequent mowing. (See also the other CTAHR publications on specific turfgrasses and general lawn care listed at the end of this publication.)

The soil type is another important consideration in developing a fertilizer schedule. Many of Hawaii's soils are heavy clay soils. Clay soils have a high capacity for holding most plant nutrients (referred to as the soil's "exchange capacity"), and they do not require applications of fertilizer as frequently as sandy soils, which generally have low exchange capacity. Sandy soils are also much more susceptible to leaching of nutrients. Neither type of soil is able to hold soluble forms of nitrogen for very long. As a general rule, sandy soils require more frequent applications with lesser amounts of fertilizer at a time, and scheduling should be adjusted accordingly.

Before starting a turf fertilizer program, a soil test should be done to determine the existing fertility level and pH of the soil. The soil test will show the pH of the soil and the level of available phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg). These major elements are essential to normal plant growth and should always be present in adequate amounts. Nitrogen (N) is usually not determined in a soil test because most soils are inherently low in nitrogen because it is readily leached through the soil profile. However, N is the most important nutrient for plant growth and therefore must be continually supplied in a turf fertilizer program.

The first step in beginning a fertilizer program is to correct deficiencies of any element identified in the soil test results. Soil testing is available from commercial laboratories or the CTAHR Agriculture Diagnostic Service Center at UH-Manoa (beyond Oahu, contact the nearest CTAHR Cooperative Extension Service office). Fertilizer recommendations are given as a part of the soil test report.

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Correction of soil pH

The pH is a measure of the acidity or alkalinity of the soil. Alkaline soils are sometimes referred to as being "sweet," while acid soils are called "sour." It is important to maintain the pH within fairly narrow limits, because the availability of many of the soil nutrients is dependent upon the pH level. Deficiencies in many of the soil nutrients are often due to the ions becoming insoluble and unavailable to the turf roots at high or low pH, even though these nutrients are present in sufficient amounts.

Agricultural lime or finely ground coral may be used to raise soil pH to the desired level. Potassium bicarbonate can be used if a rapid change is required. Till the material into the soil to a depth of 6 inches if possible. Add only the amount recommended to correct the acid condition. An overapplication of lime will result in alkaline conditions that are as detrimental as the acid condition. Do not apply more than 50 lb per 1000 ft^2 of ground coral at one time. If more than this is required, split the application into two spaced six months apart.

Acid-forming fertilizers, such as ammonium sulfate, used regularly are effective in lowering the pH of alkaline soils. Care should be taken not to over-use these fertilizers on soils that are already acidic (see Table 1). Elemental sulfur (95% wettable) may also be used, but care must be taken not to apply excessive amounts because of the danger of foliar burn. No more than 10 lb per 1000 ft^2 should be applied at one time. If multiple applications of sulfur are required, they should be spaced at least 60 days apart.

Table 1. Acidifying effect of common fertilizers.

Ammonium sulfate	110
Diammonium phosphate	75
Urea	71
Ammonium nitrate	62
Monoammonium phosphate	58
Potash	0
Superphosphate	0
Treble superphosphate	0
Potassium nitrate	–23

Acidifying effect measures a fertilizer's ability to raise or lower pH. These values refer to the number of pounds of calcium carbonate necessary to neutralize the acidity in 100 pounds of the fertilizer. The negative value for potassium nitrate indicates a "sweetening" or alkalinizing effect.

Once the turf is established, any lime or sulfur applied must be washed off of the leaves to reduce danger of foliar burn. Applications in this manner are not very effective in modifying soil pH beyond the soil surface. The best way to apply lime or sulfur to modify soil pH in the root zone of established turf is to use a plug-type aerator to make holes in the soil before applying the material. This will increase the zone of pH change to the depth of these holes, reaching a greater part of the root zone.

Correction of soil nutrient levels

Phosphorus (P) is very important for root development, especially in new seedlings. Therefore, a fertilizer high in P and balanced with nitrogen and potassium should be used when establishing a new turf. These types of fertilizers are called "starter" fertilizers. Phosphorus deficiency in new seedlings results in slow development, and in established turf P deficiency results in blades that appear dull and tend to turn purple.

Low P levels can be corrected by applications of treble superphosphate. P applied to many of Hawaii's acidic soils tends to be retained tightly and released only gradually to plants. The most effective application of P is during soil preparation, when it can be incorporated by tilling.

Potassium (K) contributes to the vitality and hardiness of the plant and is considered a key to the prevention of disease and environmental stress, including improved tolerance of wear from traffic. K deficiency appears on older leaves that become streaked with yellow, turn brown at the tips, and eventually die. The turf also becomes more susceptible to disease and decreases in wear tolerance.

Low K is corrected by addition of potash (K_2O in various forms), muriate of potash (KCl), or potassium sulfate (K_2SO_4). P and K may also be added in a "complete fertilizer" (one which contains N, P, and K) such as a 10-30-10 (10% N, 30% P_2O_5, 10% K_2O) formulation. The amount to apply depends on results of the soil test and the type of fertilizer used.

Magnesium (Mg) deficiency, which appears in older leaves as light green or yellow stripes that turn to bright red, may be corrected by application of magnesium sulfate or magnesium ammonium phosphate.

Calcium (Ca) is normally present in sufficient quantities in Hawaii's soils, and deficiencies are rare. This is also true of sulfur, where deficiencies are almost always associated with soils low in organic matter.

Nutrient elements that are needed by the plant in very small quantities are called minor elements or micronutrients. These include iron, copper, manganese, zinc, boron, molybdenum, and chlorine (Fe, Cu, Mn, Zn, B, Mo, and Cl). Iron and manganese are the only micronutrients that are commonly deficient in Hawaiian soils, and this is usually the result of improper pH. Deficiencies in either of these elements results in yellowed (chlorotic) leaves with green stripes, and they often are difficult to tell apart. Minor elements are often added to turf fertilizers, or they can be applied individually as a foliar spray.

Nitrogen sources

Nitrogen, the nutrient required in the greatest amount by turfgrass, promotes growth and density as well as the turf's deep green color. To a greater degree than the other elements, it is subject to loss through volatilization, microbial activity, and leaching. This necessitates greater amounts and more frequent additions of N to meet the turfgrass' needs. N is therefore the most abundant nutrient in most turf fertilizers, and fertilizer recommendations are normally given in terms of pounds of N required per 1000 ft^2. N may be supplied in immediately available, water-soluble form or as a slow-release formulation, or as a mixture of both. The fertilizer analysis is given as a percentage of nitrogen, phosphorus, and potassium in that order. Fertilizers that contain these three nutrients are known as complete fertilizers. Products that contain equal amounts of each are considered balanced, such as 15-15-15. A typical turf fertilizer is high in N and might have an analysis such as 33-3-10. It may also contain added nutrients such as iron or sulfur or certain insecticides or preemergence herbicides.

Professionals also refer to a fertilizer's "ratio." A fertilizer with an analysis of 12-4-8 has a ratio of 3-1-2, or three parts N, one part P_2O_5, and two parts K_2O. Fertilizer application recommendations may be given in terms of the analysis or the ratio.

Fertilizers for turf use include an ever-growing and widely varied selection of products. As a homeowner or turf manager, one can quickly become overwhelmed with information about the many different formulations, analyses, and grades of products available for purchase. However, among the many choices to consider, *formulation* (fluid or granular) is one of the more important factors to consider in deciding which is the right product for your needs.

Fluid fertilizers

Fluid fertilizers are formulated and packaged as a liquid. This includes fertilizers that are clear liquids (solutions) or liquids that contain suspended solids (suspension fertilizers). Turf managers normally use fertilizers packaged and sold as fluids less frequently than solids (granules). Examples of fluid fertilizers include anhydrous ammonia (which is actually transported as a fluid and injected into soil in gaseous form), nitrogen solutions (usually made from a mixture of urea and ammonium nitrate), ammonium polyphosphate, and triazones. These formulations are usually used only on golf courses and resorts.

A more common source for fluid fertilizer applications on turf is the use of solid water-soluble fertilizers dissolved in water and applied as a liquid to the turf (called "foliar feeding"). MiracleGrow® or any readily soluble salt is applied this way. Liquid application of fertilizer uses a high spray volume (3–6 gallons per 1000 ft^2) to move nutrients to the soil and is a common application method for many commercial lawn-care companies. Foliar feeding uses a lower spray volume to apply a small amount of fertilizer (for example, iron is commonly applied this way) directly to the foliage, providing rapid uptake of nutrients and quick correction of a nutrient deficiency. Typically, applicators use foliar feeding to supply a small amount of a deficient nutrient (usually a micronutrient such as iron), or as part of a pesticide application, rather than to supply all the needed fertilizer for turf growth.

Benefits from using fluid fertilizer or soluble solids as liquid fertilizers include the ability to apply nutrients through irrigation ("fertigation"), possible use as a carrier for selective postemergence or preemergence herbicides, and flexibility of application as a foliar feed. Liquid application can reduce the risk of foliar burn, provide even coverage, and allow simultaneous application of fertilizers and pesticides. Liquid fertilizers can be applied at low rates on a frequent basis to spoon-feed turf, promoting even greening and consistent growth.

Application of small amounts of fertilizer at regular intervals can also prevent overapplication, lessening the risk of nutrient pollution in the environment.

Negatives to the use of fluid fertilizers may include the cost of new or specialized application equipment and the issues of handling a heavy, bulky, liquid material. Plus, it can be difficult to apply higher rates of nutrients in a spray volume appropriate to avoid burning the turf, in which case frequent application becomes the key. However, the need for frequent application can be a problem, especially if labor is in short supply.

Solid fertilizers

Solid fertilizers are dry, inorganic mineral salts that manufacturers size between an upper and lower limit of screen sizes. They may be finely crushed, granular, crystalline, powder, or processed into uniform "prills." These fertilizers, by themselves, are usually water-soluble for quick release. Although easy to apply, care is necessary to ensure even distribution of inorganic granular fertilizers. The effects of an incorrectly calibrated spreader or incorrect application of solid fertilizers are all too visible.

Solid fertilizers can be coated to become controlled-release products, which are also called slow-release, slow-acting, metered-release, or controlled-availability fertilizers.

Soluble materials

Water-soluble fertilizers are rapidly available for turf growth. Examples of common water-soluble turf products include ammonium nitrate (34-0-0), potassium nitrate (13-0-44), ammonium sulfate (21-0-0), potassium sulfate (0-0-50), and urea (45-0-0). Some water-soluble fertilizers are homogeneous products (every particle has the same composition). These have a uniform appearance and are made from blends of raw fertilizer materials such as superphosphate, ammonium solutions, monoammonium phosphate (MAP), diammonium phosphate (DAP), urea, potassium chloride, or potassium sulfate (not all phosphate fertilizers are completely water-soluble). Fertilizer bags always list the raw materials the manufacturer used and the specific fertilizer grade contained in the bag.

Other solid fertilizers are non-homogeneous blends (you can see the individual granules of different fertilizer materials), where the manufacturer simply has mixed particles together to produce a desired overall composition. Non-homogeneous products may not spread as uniformly as homogeneous products, especially if the particles are different sizes. Some products are a mix of soluble and slow-release fertilizers; the bag should list the percentage of each in the product.

Water-soluble fertilizers produce rapid greening, have a low cost per unit of nutrient, are easy to apply, and are readily available from a wide range of dealers. The rapid greening from these fertilizers is due to readily available nitrogen, and perhaps sulfur or iron in the fertilizer as well. These products are usually easy to handle and do not take expensive equipment or intensive training to ensure correct application. Regular application of these products may also offer a business bonus—your clients see you at their site frequently.

A soluble N source provides a readily available supply of N to the turf. The growth rate increases sharply about two days after application, reaches a peak in seven to ten days after application, and, depending on the rate of application, tapers off to the original growth rate in four to six weeks. A uniform growth rate could be produced if very small amounts of soluble N are applied on a daily schedule. However, the only practical method of applying N on a daily schedule would require fertigation, applying fertilizer through the irrigation system. Fertigation may prove economical for high-maintenance golf courses and parks.

The "peaks and valleys" in growth rate observed between applications of soluble N fertilizers may not be obvious on frequently mowed turf areas, but they can have a detrimental effect on the grass. Short bursts of growth after fertilizer application followed by a period of slow growth can deplete carbohydrate reserves in the grass, reduce root development, and eventually thin a turf, leading to a higher susceptibility of the grass to insects and diseases. These effects are not readily apparent by observing growth rate and color response to fertilizer. Long-term observations and responses to stress will more accurately establish the effect of soluble N sources on turf.

At rates of application above ½ pound of N per 1000 ft^2, soluble sources may desiccate or burn the foliage if not watered into the turf shortly after application (see Table 2). A commercial lawn service cannot depend on the homeowner to water the lawn as needed and may find that lower rates with more frequent applications are best suited to their needs. Also, at rates above ½ pound of N per 1000 ft^2, soluble N fertilizers produce the burst of growth for a short period after application that is undesirable from the standpoint of mowing, watering, and other maintenance requirements.

In their favor, soluble N sources have the lowest cost per pound of N, produce an immediate greening response, are effective at the range of temperatures encountered in Hawaii, and are suited to either liquid or dry programs. Where N can be applied at ½ pound per 1000 ft^2 at monthly intervals, the soluble products are the choice of most applicators. However, the need for frequent applications may limit their use in most lawn-service operations.

Slow-release nitrogen sources

Synthetic fertilizers are relatively new products that overcome several of the shortcomings of the soluble N sources. Many of these synthetics have a much longer residual N release pattern and a greatly reduced burn potential. Also, these products do not produce the rapid burst of growth produced by soluble N fertilizers.

A low, uniform supply of available N and other essential minerals during the growing season is the objective of most turfgrass fertilizer programs. Such a program is difficult to accomplish without the use of slow-release sources of N. Residual soil N, that which becomes available to the grass over a relatively long period of time, cannot be built up and maintained with soluble materials alone. Slow-release N sources build up residual soil N that is made available to the grass at various rates. This results in slow, even growth and avoids the damaging growth spurts produced by soluble sources. The rate at which residual N is made available (released) may vary with the N source, temperature, moisture, pH, particle size, microbial activity, and time of application. A single heavy application of slow-release fertilizer is insufficient to provide an adequate level of reserve N to meet the needs of turf. Supplemental applications of water-soluble N sources will be necessary during the first six months to one year that the slow-release fertilizer is used. After this, quarterly applications of slow-release sources will provide adequate N to maintain the turf. More frequent applications may be necessary to maintain bermudagrass turf at high maintenance levels. Knowledge of a particular N source and of conditions favorable for N release, as well as the requirements of the particular turf, is necessary for a turf manager to determine the timing and rates of application of slow-release fertilizers.

Table 2. Salt index of common fertilizers.

Ammonium nitrate	105
Sodium nitrate	100
Urea	75
Potassium nitrate	74
Ammonium sulfate	69
Calcium nitrate	53
Ammonia	47
Diammonium phosphate	34
Monoammonium phosphate	30
Treble ammonium phosphate	10
Superphosphate	8
Gypsum	8

Salt index is a relative measure of the salinity of fertilizers. A high salt index indicates high potential to burn turf as well as increase salinity. Sodium nitrate is the benchmark, given a value of 100.

Urea-formaldehydes (UFs)

These are synthetic products made by reacting urea with formaldehyde under carefully controlled temperature, pH, and reaction time. They contain about 40 percent N in the form of long-chain urea molecules. The N release characteristics of the materials produced are determined by the size of the molecule and the ratio of urea to formaldehyde in the product. Methylene urea (MU) has a ratio of 1.9 to 1 and is ⅔ water-soluble and ⅓ water-insoluble. Other UF products such as Nitroform® and Fluf® have a ratio of urea to formaldehyde of 1.3 to 1 and are ⅓ water-soluble and ⅔ water-insoluble. The rate of N release of these products is closely related to the solubility of the UF. Methylene urea has a faster N release and greening response than Nitroform, but the "residual" N is much greater for Nitroform. One form of MU is methylol urea, which can be applied at 1–1½ pounds of N per 1000 ft^2 in a single application without burning the foliage. However, the residual nitrogen effect for this product is only slightly greater than soluble N fertilizers. A further disadvantage is that the product is tightly bound to the foliage, and clipping removal after application can remove significant amounts of N. Methylol urea is a liquid concentration with 25–30 percent N. It mixes readily with other fertilizer nutrients and pesticides and is well suited to liquid applications. The user should be advised not to remove the grass clippings for at least two mowings after application.

The removal of grass clippings is generally not recommended for at least several weeks after any fertilizer application. This is particularly important with many of the synthetic products that have a much longer residual release of N. Removal of clippings during this time can result in the loss of up to 50 percent of the N supplied.

Mowing, which is likely to destroy the integrity of the fertilizer particles, is also not advisable for at least several days after application, especially on turf that is cut lower than 1 inch. The long-term residual N release of most of these synthetic fertilizers depends on the size of the particle or the intactness of the coating. These types of fertilizers are best allowed to settle into the turf in order to protect the particles from physical damage caused by mowing. Watering them in often helps the particles to settle.

All of the N in UF is dependent on soil microorganisms to break down the methylene urea chains to urea before N can be released. But the short-chain (water-soluble) methylene urea polymers are broken down much faster than the long-chain (water-insoluble) polymers. The water-insoluble fraction of UF may not be completely broken down in the first year, and some carryover (residual) can be expected into the second and third seasons. Where normal rates of UF are applied, two or three years may be required to build up residual N to a level such that annual applications of UF release an adequate amount of N. To overcome this lag in N availability, higher initial rates of UF can be applied, or supplemental soluble N can be used. Higher rates and supplemental sources are commonly applied to Hawaii's turf to compensate for our longer growing season.

Because microorganisms are required to break down UF, environmental conditions that favor microbial activity (high temperatures, neutral soils, and an adequate supply of moisture and oxygen) promote N release from UF. Conversely, low temperatures, nutrient deficiencies, and acid soils inhibit the release of N from UF. Depending upon these environmental conditions and the amount applied, UF products may continue to release adequate levels of N for up to five or six months. The faster acting MU products have a residual period of about 18 weeks.

Losses of N due to leaching and volatilization are less from UF than from soluble N sources. Therefore, over a period of several years, UF sources are at least equal to soluble sources in terms of N use efficiency. In addition, UF sources are more efficient under conditions that favor leaching and volatilization.

Nitrogen losses due to removal of fertilizer granules with grass clippings can be significant on closely mowed turf. Losses may be as high as 20 percent on golf greens. For the first several days after application, the grass should be allowed to dry before mowing. Urea-formaldehyde has little effect on soil pH and salinity. Thus, even at high rates of application, UF does not burn the grass.

Isobutylidene diurea (IBDU)

This condensation product of urea and isobutyaldehyde is an N fertilizer with slow-release characteristics that contains a minimum of 30 percent total N. Unlike UF, IBDU does not depend on soil microorganisms for the release of N. In the presence of water, IBDU is hydrolyzed to urea. The rate of hydrolysis varies with soil pH, temperature, particle size, and moisture. IBDU is effective as a controlled-release N source for turfgrasses in soils with pH between 5 and 8. Below pH 5, the rate of hydrolysis is very rapid, and above pH 8 the rate of hydrolysis is quite slow. IBDU products are commonly used on commercial turf in Hawaii.

Temperature does not influence the release of N from IBDU to the degree that it does for UF and organic N sources. But, high temperatures favor the hydrolysis of IBDU and significantly increase N release. The rate of N release from IBDU is two to three times faster at 75°F than at 50°F, whereas for UF and organic sources the same temperature difference may result in a tenfold increase in N release rates. The particle size of IBDU granules has a significant influence on hydrolysis rate and N release. The finer the particle, the greater the surface area and the faster the rate of hydrolysis. By varying the size of the IBDU granules, N release can be distributed over a longer period of time. A material with a range of particle sizes between 8 and 24 mesh is recommended for turfgrasses. The effective release time is therefore shortened if the particles are broken up by mower activity. It is best to allow the particles to settle into the turf for as long as possible before mowing. Particle size does not influence the rate of N release from UF.

Soil moisture levels also influence the release of N from IBDU. Wet soil conditions favor the release of N from IBDU. Soil moisture levels of 40–70 percent of field capacity are favorable for a controlled-release rate of N from IBDU. Above these levels N release is very rapid, and below these levels N release is very slow. IBDU would not provide a uniform level of available N where turf is exposed to prolonged wet or dry cycles. N losses due to leaching and volatilization are quite low from IBDU. And efficiency, in terms of N recovery, is similar to other slow-release N sources. N losses due to mower pick-up of the IBDU granules are similar to those that occur with UF sources.

Unlike UF sources, IBDU does not require a build-up of residual N to provide adequate levels of available N. Unless particle sizes of IBDU granules are quite large, greater than 2 mm in diameter, most of the N is hydrolyzed within 60 days after application. However, where particles are much over 2 mm in diameter, mowers will pick up significant quantities of IBDU granules on closely mowed turf.

IBDU has little effect on soil pH, although a temporary increase in pH may occur following a high rate of application. Also, IBDU does not damage turfgrasses at normal rates of application. However, temporary chlorosis has developed three to four weeks after the application of very high rates of IBDU (above 6 lb N per 1000 ft^2). This chlorosis has been attributed to excessive absorption of ammonia by the grass.

Sulfur-coated urea (SCU)

SCU is produced by spraying pre-heated urea with molten sulfur in a rotating drum. A wax coating may be applied on top of the sulfur coating to seal pinholes and cracks. Finally, the product is cooled, and a clay conditioner is applied to reduce cracking. The product is screened to remove oversize granules.

SCU granules have been shown to provide a slow-release N source. The rate of release of N from SCU depends on the time required for microorganisms to break down the sulfur coating. Thus, the N release rate can be decreased by heavier sulfur coating and by inclusion of a microbial inhibitor in the coating. However, a problem occurs with heavy sulfur coatings for turfgrass fertilizers because the mower crushes or picks up the larger fertilizer granules.

Factors that influence the release of N from UF (temperature, pH, and moisture) also affect N release from SCU. High temperatures, neutral pH, and moist soils favor the release of nitrogen from SCU.

Sulfur-coated urea is the least uniform of the slow-release N sources discussed. Imperfections exist in the coatings of SCU because of irregularities on the surface of urea. Also, the sulfur coating may not be uniformly applied to the urea granule. These defects, together with incompletely covered granules and cracks in the coatings, provide sites from urea can be released when SCU is exposed to water. Thus, each SCU granule will have a slightly different rate of N release, depending on the extent of the "imperfections," whereas UF and IBDU granules are homogenous and are not affected by "imperfections" in the coating. Sulfur-coated urea granules are also subject to being crushed by the fertilizer distributor during application.

Solubility rates for SCU are expressed as the percent urea released when the product is placed in water at 100°F for seven days. Commercial products usually have a dissolution rate between 20 and 30 percent. Below 20 percent the product is considered too slowly available, while above 30 percent the product would not be considered a slow-release N source.

Nitrogen losses from SCU due to leaching and volatilization are intermediate between those from urea and UF or IBDU. Perhaps the greatest losses of N from SCU occur when the sulfur coating is broken and urea is readily released or when the SCU granules are picked-up with the grass clippings by the mower. SCU has little effect on salinity, but it may reduce soil pH when sulfur is released after the coating is broken down. Where sulfur is deficient in the soil, SCU provides an additional benefit with this release of sulfur, which eventually becomes available to the grass.

Nitrogen recovery for SCU is greater than for urea and other soluble N sources. However, recovery would need to be measured over a longer period of time for SCU than for soluble sources.

Polymer-coated nitrogen

Polymer-coated fertilizers date back to the introduction of Osmocote® in the 1960s. More recent formulations are Scott's Poly-S'R'® and Pursell Industries' Polyon®. These products provide controlled release of N by diffusion through a polymer membrane (coating). They usually consist of coated potassium nitrate, urea, or potassium sulfate. Release rates are dependent on moisture, temperature, and the composition and thickness of the coating. Polymer-coated products are very uniform and provide predictable N release rates. However, like many of the coated fertilizers, these products are susceptible to destruction by mower pickup.

Liquid slow-release products

The triazones are examples of liquid slow-release N sources. They combine the advantages of using a liquid (such as low burn potential and tank mixing) with the benefits of controlled N release. However, like all liquid formulations, they require the appropriate application equipment and the capability to store and handle liquids.

Organic N sources

The oldest sources of N used for turfgrass fertilizer are the natural, organic materials: manure, composted crop residues, sludges, and humus. These materials are low in N content, difficult to store and apply, expensive, and, in some cases, contain undesirable substances such as salts, heavy metals, and weed seeds. Nevertheless, organic N sources can be effectively used in most turf maintenance programs. N release from organic sources is dependent on microorganisms; thus, factors that favor microbial activity increase the rate of N release from these materials. Organic materials are not considered good N sources during the cooler months because of the low activity of microbes. During most of the year in Hawaii, organic sources can be effective.

Organic sources should not be considered slow-release sources. When conditions favor N release from organic sources, the N usually becomes available to the grass within four to six weeks. A significant amount of the N from organic sources may remain tied up in the organic form for years.

Organic sources have the advantage that they will not "burn" the grass, have little effect on pH, contain nutrients other than N, and may moderate soil temperature during cool periods. Also, some of these materials such as manure, sludge, and compost may improve the physical condition of soils.

Milorganite®

This product of the Milwaukee Sewage Commission is a widely used organic N source on fine turf. Milorganite is a processed sewage sludge that contains 6 percent N. The product is granulated, screened, and packaged for application to fine turf. It is perhaps the most widely recognized N source for golf-green turf on the Mainland and is commonly used on Hawaii's golf courses for that purpose.

Advantages of Milorganite and similar products for putting green turf include a uniform N release rate over a period of three to four weeks, a very low burning potential, the addition of phosphorus and iron, and a minimum effect on soil pH and salinity. Leaching and volatilization losses of N from Milorganite are also very small.

Disadvantages of sewage-sludge products include low N content, a short period of residual N availability, a relatively high cost per pound of N, and poor cool-weather response. The limited availability of the products might also be considered a disadvantage.

Turf response to Milorganite in terms of growth rate and color are excellent throughout the year in Hawaii. Additionally, turf researchers have reported less thatch accumulation where Milorganite was used in place of soluble N sources.

Recent changes in Hawaii's landfill regulations have forced city sewage treatment plants on Oahu and Maui to seek alternative disposal methods for treated sewage sludge. Current pilot projects using sewage sludge composted with shredded green waste are currently under way and may lead to an available and inexpensive source of organic N in Hawaii.

Combinations of N sources for turfgrass

In low-maintenance turf areas a single source of N may meet the needs of the turf. But where demands are greater, as in golf courses, athletic fields, and some lawns, combinations of N sources may provide the most uniform level of N to the turf.

The objectives of a fertilizer program have a significant influence on the sources of N needed. If the objective is simply to maintain a grass cover, a single annual application of a slow-release fertilizer, or perhaps two applications of a soluble fertilizer, will meet the requirement of the grass. But where a continuous supply of N is needed to maintain growth, to recover from wear, or to maintain good color, more frequent applications of a combination of N sources will best meet the needs.

For lawns, fairways, athletic fields, and other intensively maintained turf areas mowed at a 1-inch height or greater, coated products, UF, SCU, or IBDU, can provide the "residual" N, while soluble sources can be used to produce rapid green-up. For closely mowed turf areas such as golf greens, tennis courts, and bowling greens, UF and IBDU should be used for residual N, and Milorganite or a similar organic source should be used for rapid green-up. During cooler periods, IBDU or soluble sources must be used to produce a fast greening response.

Other factors to consider include the acidifying potential of SCU and ammonium sulfate; the salinity hazard of ammonium nitrate, ammonium sulfate, and other inorganic salts; and the cost of the slow-release and organic nitrogen sources.

On a cost-per-pound-of-N basis relative to urea, SCU is about 2 times greater, UF and IBDU are 3–4 times greater, and organic sources are 5–6 times greater. Water-soluble inorganic salts are usually even less expensive than urea. Thus, for larger turf areas where soluble sources can safely be used, they may be the logical choice for N fertilizer.

The most important factors when using soluble sources include the rate and timing of applications.Single applications should not exceed 1 pound of N per 1000 ft^2 and should be made prior to—not during—a period of rapid growth. In Hawaii, a single yearly application of fertilizer on most types of turf is best applied in late April, just before the summer growth spurt.

Related CTAHR publications

AS-1 Liming acid soils in Hawaii
AS-2 Predicting soil phosphorus requirements
AS-4 Testing your soil—why and how to take a soil-test sample
TM-1 Seashore paspalum
TM-2 'Sunturf' bermudagrass
TM-3 St. Augustinegrass
TM-5 Bermudagrasses
TM-6 Maintaining bermudagrass athletic fields
TM-7 Watering lawns
TM-8 Zoysiagrasses
TM-9 Calculating the amount of fertilizer needed for your lawn
TM-12 Common lawn grasses for Hawaii
TMS-5 Centipedegrass

Summary of characteristics of nitrogen fertilizers

Fertilizer type and name	NPK analysis	Moisture dependence	Need for microbial activity	Residual N availability
Quickly available				
Ammonium nitrate	33-0-0	Minimal	None	4–6
Ammonium sulfate	21-0-0	Minimal	None	4–6
Urea	46-0-0	Minimal	None	4–6
Slow-release				
Sulfur-coated urea	22–38% N	Moderate	High	10–15
Polymer-coated (urea, nitrate)	24–25% N	Moderate	Low	15–38
Slowly soluble				
IBDU	31-0-0	High	Low	14–18
Ureaform reaction				
Nitroform®	38-0-0	High	Low	10–30
Fluf®	18-0-0	Moderate	Medium	6–10
Nutralene®	40-0-0	Moderate	Medium	6–10
Methylene urea	39-0-0	Moderate	Medium	12–16
Coron®	28-0-0	Mimimal	Moderately high	7–9 weeks
N-Sure® (triazone/urea)	28-0-0	Minimal	Moderately high	6–9 weeks
Natural organic				
Ringers® (blood and bone meal)	6-1-3	High	Medium	10–12 weeks
Sustaine® (composted turkey waste)	5-2-4	High	Medium	10–12 weeks
Milorganite® (activated sewage sludge)	6-2-0	High	Low	10–12 weeks

Notes:
Moisture dependence indicates degree of insolubility. Fertilizers that solubilize slowly need more water to get them into solution than highly soluble fertilizers. If water availability is a problem, use of a more soluble fertilizer would be advised.
Need for microbial activity refers to the degree upon which a fertilizer is dependent on microbial activity for decomposition and nutrient release. The optimum temperature for this microbial process to take place is around 67–74°F (30–35°C).
Residual N availability is a measure of how long an application of fertilizer will provide the plant the needed nutrient(s). In general, the quickly available (water-soluble) materials will have short residual activity, while the less-soluble and/or temperature-dependent materials provide a longer residual activity. This is highly dependent upon environmental conditions.