Fertilization Management

Plants make their own food. When conditions are right and the soil is adequately fertile, plants act as solar powered factories that draw in nutrients, then produce food for growth and release oxygen in the process of photosynthesis. While the soil generally provides most of the nutrients needed for optimum plant growth, there are times when fertilizers are needed, especially during production. Thus, the reason for fertilizing plants should be to supply nutrients for achieving clearly defined objectives, such as to increase growth, flowering, or fruiting; to establish newly planted trees and shrubs; to enhance foliage color and plant appearance; and to correct or prevent nutrient deficiencies.

Mineral Requirements for Growth

The 16 elements that plants require to complete their life cycle are referred to as ***essential elements***. Without any one of them, plants would not be able to complete their life cycle. These necessary elements are obtained by plants from air, water and the soil solution. Essential elements are not obtained by plants in pure form; rather, they are in combined forms, such as carbon from carbon dioxide (CO_2) in the air or hydrogen from water (H_2O).

The first three essential elements are carbon (C), hydrogen (H), and oxygen (O). These three are derived from air and water and are considered ***macronutrients***. The remaining thirteen elements are obtained through the soil from minerals naturally present or from added fertilizers.

Six additional elements, nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S), are also considered ***macronutrients***. Furthermore, nitrogen, phosphorus, and potassium, or N-P-K, are often referred to as the ***fertilizer elements*** because they are the most frequently applied nutrients during plant production and maintenance.

The seven remaining elements, boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), zinc (Zn), and chlorine (Cl), are referred to as ***micronutrients***. Although the amount of these elements required for plant growth is relatively low, they are still essential.

The terms macronutrients and micronutrients refer to the relative amounts of elements needed by plants. While no group is more important than the other, macronutrients are required in larger quantities than micronutrients. A common mnemonic device

C HOPKNS CaFe Mg B Mn CuZn Mo Cl

It reads:

C Hopkins Café managed by mine cousins Mo and Clyde.

or tool to aid memory of the 16 essential elements is found in the simple saying above.

Macronutrients

Macronutrients perform major roles within plants and are required in large quantities. On the basis of their functions, macronutrients have been classified into two groups: ***primary macronutrients*** (nitrogen, phosphorus and potassium) and ***secondary macronutrients*** (calcium, magnesium and sulfur). These primary and secondary macronutrients perform many beneficial activities in plant metabolism, such as protecting plants from environmental and biological stresses like drought, heat, diseases and insect attacks. The macronutrients also help increase yield, growth and plant quality. Each nutrient has specific roles and functions, and is involved in different metabolic processes of plant life.

photo by scot nelson, creative commons license

Figure 5-1. Nitrogen deficiency in a Cuban royal palm (*Roystonea regia*) growing in the landscape.

Nitrogen (N) produces dark green vegetative growth plus it increases the yields of foliage, fruit, and seed. It is also a factor in the protein quantity of food crops and improved water use efficiency. Nitrogen is a component of the chlorophyll molecule, and is therefore necessary for photosynthesis. Adequate N produces vigorous growth and green color in plants. Either too little or too much N can cause problems.

Most nitrogen in the soil is present as part of organic matter, such as lawn clippings, plant roots, and other organic materials. It becomes available for use by plants over time as it is decomposed by soil microorganisms. Before the nitrogen in organic matter can be taken up by plant roots, it must be broken down into soluble forms that can be absorbed by plant roots. However, the amount of nitrogen provided by these microbial actions is generally not adequate to maintain vigorous growth throughout the season; consequently, supplemental additions of N-containing fertilizer are usually required.

The nutrient deficiency that most gardeners will instantly recognize is nitrogen (Figure 5-1). The oldest leaves show symptoms first as they turn light green or yellow. As the deficiency continues, the whole plant turns light green to yellow. Too little available N further leads to slow growth, browning at the tips of lower leaves, increased chance of some diseases, and in turf, thinning that results in increased weed pressure. Too much N leads to excessive and succulent shoot and leaf growth, reduced root growth, delayed maturity and fruiting, low carbohydrate reserves, reduced tolerance to environmental stresses, and increased susceptibility to insects and diseases.

Phosphorus (P) is important in stimulating early root growth and promoting early plant vigor; the element also hastens maturity, stimulates blooming, and aids in fruit and seed formation. Phosphorus is necessary in the process of photosynthesis and as a component in the transfer of energy during respiration. Phosphorus is relatively immobile and moves very little in the soil; most of it is tightly bound to soil particles. However, P can move out of soils in surface runoff and erosion processes, thus leading to degradation of surface water quality.

Native Florida soils are naturally rich in phosphorus, so P deficiency is very rare. A soil test can determine the current level of P in a particular soil, and is the best way to determine if additional P is required. Soils naturally high in phosphorus provide sufficient levels to support vigorous plant growth for many years without adding fertilizers containing phosphorus.

Since phosphorus movement in the soil is limited, any additional P required should be mixed throughout the root zone for closer proximity to newly developing root systems. Mixing phosphorus into the soil (rather than applying it to the surface) also reduces the chance for P to move into lakes and streams.

Phosphorus deficiency symptoms (Figure 5-2) include stunted growth, purple leaves, delayed maturity, and decreased flower, fruit and seed yields. Phosphorus deficiency appears in ornamentals (such as ixora and firebush) as a reddish color on the oldest leaves. Reddish spotting may also be apparent and is sometimes mistaken for a disease. Phosphorus deficiency often occurs in combination with a potassium deficiency.

Potassium (K) is important in the synthesis of some cell or tissue components and in the regulation of many physiological processes, including the more efficient use of nitrogen by the plant. Potassium is essential to the formation of starches, sugars and proteins; the element also increases plant vigor and disease resistance, improves rigidity, contributes to cold hardiness, and is important for seed and fruit quality.

Potassium is held on the surface of soil particles and moves little in most soils, though it can gradually move out of the root zone in very sandy soils. Where soils are high in native potassium, supplemental K fertilization may be unnecessary.

Potassium deficiency symptoms (Figure 5-3) include scorching or burning of the outer edges or tips of lower leaves, poorly developed root systems, loss of disease resistance, reduced tolerance to environmental stress and reduced cold hardiness. Potassium deficiency occurs

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Figure 5-2. Phosphorus deficiency in blueberries (*Vaccinium* sp.).

photo by scot nelson, creative commons license

Figure 5-3. Potassium deficiency in fishtail palm (*Caryota mitis*).

fairly often in trees and shrubs within Florida. This deficiency manifests itself as spots of dead tissue, some yellowing between the leaf veins, or dead tissue along the edge of the leaf.

Calcium (Ca) is necessary in cell growth and division. It strengthens cell walls and is necessary for new growth in plants. Limestone and dolomite are sources of Ca, which also influence soil pH. Calcium deficiencies are not common, but can occur in sands and in acidic, leached soils where lime has not been added. If Ca deficiency occurs, symptoms appear initially as localized tissue necrosis (death of cells or tissues as seen in Figure 5-4), stunted plant growth, necrotic margins on young leaves or curling of the leaves, and eventually death of terminal shoot and root tips. Generally, the new growth and rapidly growing tissues of the plant are affected first, subsequently inhibiting root growth and deforming terminal leaves or branches.

photo by scot nelson, creative commons license

Figure 5-4. Calcium deficiency in tomatoes exhibited as localized dead tissue. This condition, known as blossom end rot, is a physiological disorder not a disease.

Magnesium (Mg) is another component of chlorophyll, along with nitrogen. It is also a catalyst for plant processes such as seed germination and sugar synthesis. Magnesium is perhaps the most often encountered deficiency in ornamental plants. Symptoms of this deficiency appear as yellowing between the veins and along the margins of the plant's oldest leaves. Severe Mg deficiency may even cause plants to drop their lower leaves. Plants will also appear stunted, and individual leaves will be smaller than normal.

Magnesium deficiency symptoms appear in a number of plants as a yellowing of older leaves in a "V" shape (Figure 5-5), with the area at the base of the leaf remaining green. In north Florida, this is most likely to appear in late summer or fall. In south and much of central Florida, deficiency symptoms are noted throughout the year. Podocarpus, pittosporum (Figure 5-6), boxwood, Canary Island and pygmy date palms, as well as flowering gingers are especially prone to Mg deficiency symptoms.

photo by uf/ifas

Figure 5-5. Magnesium deficiency in Nagi podocarpus (*Podocarpus nagi*).

photo by uf/ifas

Figure 5-6. Magnesium deficiency in pittosporum (*Pittosporum tobira*) shrubs.

Sulfur (S) is an essential component of several plant proteins. Though the element is not a component of the chlorophyll molecule, S is necessary for chlorophyll synthesis. Sulfur deficiency symptoms are often similar to nitrogen deficiency. However, symptoms of S deficiency start with chlorosis (yellowing) of the younger leaves and light green tissue appears between darker green veins.

Micronutrients

While macronutrients are most important in plant structure, micronutrients principally function as enzymes triggering a diverse range of life-sustaining processes. These nutrients are usually present in the soil or are needed only in relatively minute quantities. They can be supplied through fertilization where needed.

Micronutrient availability is strongly influenced by soil pH. In some gardens, particularly on marl soils, the land may be alkaline because of the high lime content of the soil. When alkaline water is used for irrigation, the soil may also become alkaline. In such cases, it may be necessary to use fertilizer containing minor elements, particularly manganese and boron. On the other hand, gardens on sand, muck and peat soils may be so strongly acid that lime is needed to correct acidity and supply sufficient quantities of calcium and magnesium.

Manganese (Mn), ***iron*** (Fe), ***copper*** (Cu), ***zinc*** (Zn), ***boron*** (B), ***molybdenum*** (Mo), and ***chlorine*** (Cl) are the seven elements considered micronutrients. Micronutrients are activators or catalysts for:

- chlorophyll formation (iron, manganese and zinc);
- protein formation (manganese);
- energy transfer (copper, molybdenum and manganese);
- sugar translocation (boron);
- nitrogen fixation (molybdenum); and
- photosynthetic reactions (chlorine).

Micronutrient deficiency symptoms are often specific for various crops. Symptoms such as chlorosis, stunted root systems, as well as stem and root death are similar to many of the macronutrient deficiencies. Tissue tests may be the only way to determine the exact micronutrient deficiency.

Iron and other metal ion micronutrients such as Cu, Mn, and Zn are often ***chelated*** (Figure 5-7), a process that binds them to organic substances and protects them from undesirable reactions in solution and the soil. ***Chelation*** improves the continuing availability of micronutrients, thus making fertilizer applications more effective and efficient.

graphic by gale albritton

Figure 5-7. Illustration of the chelation process.

Common Micronutrient Deficiencies

Iron (Fe) is not readily available in alkaline soils, so plants growing in these soils will often show iron deficiency symptoms. In other words, if the soil pH is too high (alkaline), plants cannot uptake this nutrient because it is bound in the soil in a form not usable by plants. Poorly drained soils can also predispose plants to Fe deficiency. If plants have damaged roots due to disease, injury or nematodes, iron deficiency may also occur. Often in the nursery, Fe deficiency is the most important of the micronutrient deficiencies.

Iron deficient plants (Figure 5-8) show a distinct yellowing (chlorosis) between the veins on new leaves. The symptoms of Fe chlorosis are progressive, starting with a gradual loss of green color, and then turning yellow with

photo by scot nelson, creative commons license

Figure 5-8. Iron deficiency in hibiscus (*Hibiscus rosa-sinensis*).

the veins remaining green. In extreme cases, younger leaves may turn almost white with spots of dead (necrotic) tissue. Iron deficiency symptoms can sometimes be temporarily alleviated by regular foliar applications of iron sulfate or chelates, but long-term correction will only occur when poor soil conditions have been corrected.

Manganese (Mn) is another deficiency often associated with alkaline soils. In some cases, cold soil temperatures during the winter and spring months reduce root activity and thus uptake of micronutrients (especially Mn). New leaves show this deficiency as yellowing between the veins (Figure 5-9) with spots of yellow or dead tissue. Deficient plants will develop new leaves that are small; tip dieback may also occur. Symptoms of Mn deficiency are similar to iron deficiency, and both are often treated simultaneously in Florida.

photo by uf/ifas

Figure 5-9. Manganese deficiency in orchid tree (*Bauhinia spp.*).

photo by uf/ifas

Figure 5-10. Boron deficiency in hibiscus (*Hibiscus rosa-sinensis*).

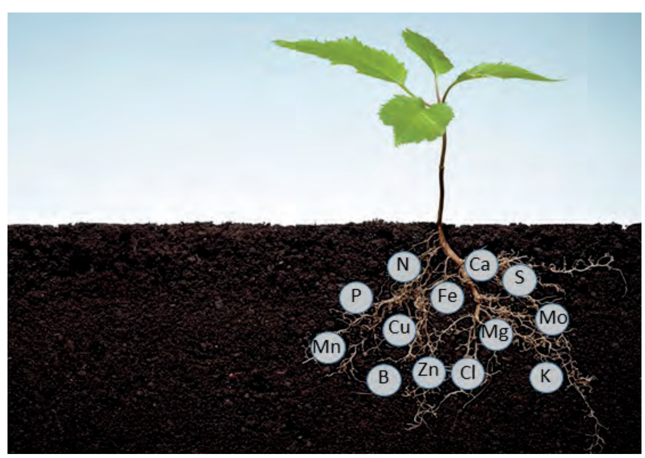
Boron (B) deficiency is somewhat rare, but has been observed in hibiscus. On this plant, deficiency symptoms appear as small, cupped, brittle, dark green leaves (Figure 5-10). The problem should not be confused with pink hibiscus mealybug infestations. Shoot stunting and dieback have also been noted. Boron deficiency is associated with leaching in sandy and high pH soils.

Deficiency Diagnosis

Soil testing is an important tool for determining nutrient deficiencies. Plants can be deficient in an essential element long before the deficiency becomes visible. Soil tests and tissue analyses can pinpoint deficiencies as well as indicate fertilizer elements that may not be needed. The *Key to Common Plant Nutrient Deficiencies* graphic in Figure 5-12 can aid in the diagnosis of nutrient deficiencies once symptoms become visual.

Fertilizers

Fertilizers are any substance that contains one or more recognized plant nutrients. These materials promote plant growth, control soil acidity or alkalinity, and provide enrichment or other corrective measures for the soil. Fertilizer nutrients can be used by the plant, lost by leaching or to runoff, or tied up in the soil by chemical reactions. Lost nutrients must be replaced to ensure plants have adequate nutrients for growth and development. The most common way to add nutrients back to the soil is through application of organic or inorganic fertilizers.



graphic by gale allbritton

Figure 5-11. Nutrients must be soluble before absorption.

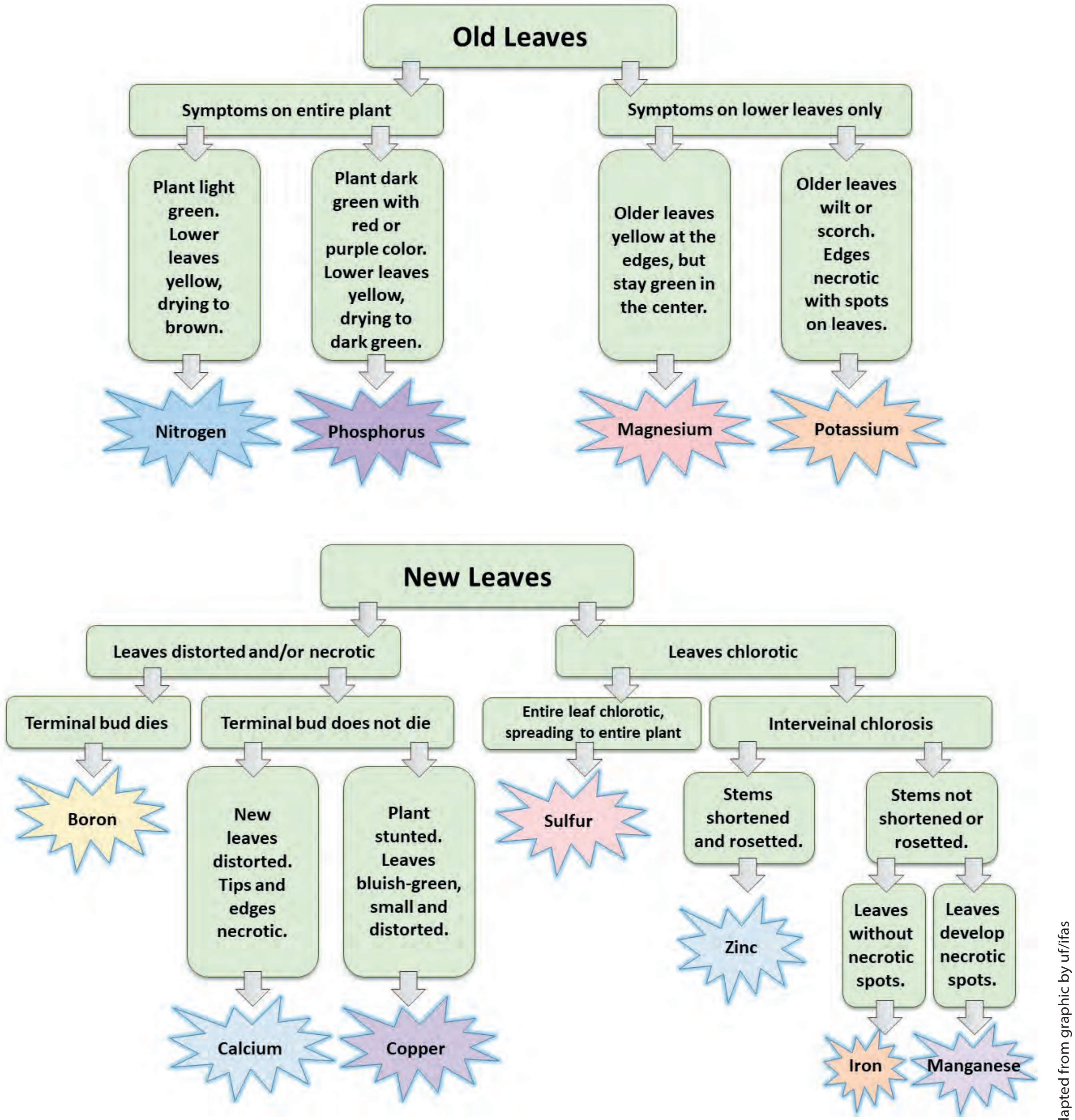


Figure 5-12. *Key to Common Plant Nutrient Deficiencies*, Amy L. Shober and Geoffrey C. Denny with the UF/IFAS Department of Soil and Water Science, Center for Landscape Conservation and Ecology.

Regardless of the source, plant nutrient availability is easily affected by soil pH. Nutrients are only available for plant uptake if they are soluble (Figure 5-11), but the solubility of nutrients changes with soil pH. If a nutrient is in an insoluble form, the plant cannot use it. Since the effects of pH are complex and vary with different nutrients, soil pH should be tested prior to making any nutrient management decisions. The *nutrient availability chart* found in Figure 5-13 on the following page illustrates the effects of pH on fertilizer elements in mineral soils. A change in the width of the white bar representing each nutrient indicates either increasing or decreasing nutrient availability over the given pH range.

Organic Fertilizers

Natural organic fertilizers are derived from either plant or animal products containing one or more of the primary nutrients necessary for plant growth. Most also provide significant quantities of organic matter, so they can likewise be classified as soil amendments. Organic fertilizers typically have a lower nutrient content and nutrients are more slowly available than in commercial fertilizers.

One of the most common forms of organic fertilizer is animal manure. ***Composted manure*** is an excellent source of organic matter for garden soils and is usually a good source of nitrogen. Some types of manure may also contain micronutrients.

Processed, composted manure comes from sources like cow, sheep, or turkey. Some are granulated to flow through a fertilizer spreader. Other forms of organic fertilizers are bone meal, dried blood, processed sewage sludge, fish emulsion, seaweed, and blended meal mixtures. Potential disadvantages of organic fertilizers are difficulty calculating the correct application rate due to unknown nutrient ratios, larger areas required for handling and storage, and pungent odors in some cases.

Inorganic Fertilizers

Inorganic fertilizers contain nutrient compounds derived from mineral salts. These synthetic fertilizers are chemically manufactured materials that have one or more of the primary nutrients necessary for plant growth. Commercial fertilizers are available with a wide variation in the amounts of nitrogen, phosphorus, and potassium in formulations created to meet the needs of individual crops. Inorganic fertilizers are easier to apply and store, available in both liquid and solid forms, and can be applied as a foliar spray or to the soil. Most commercial grades also have specified amounts of minor

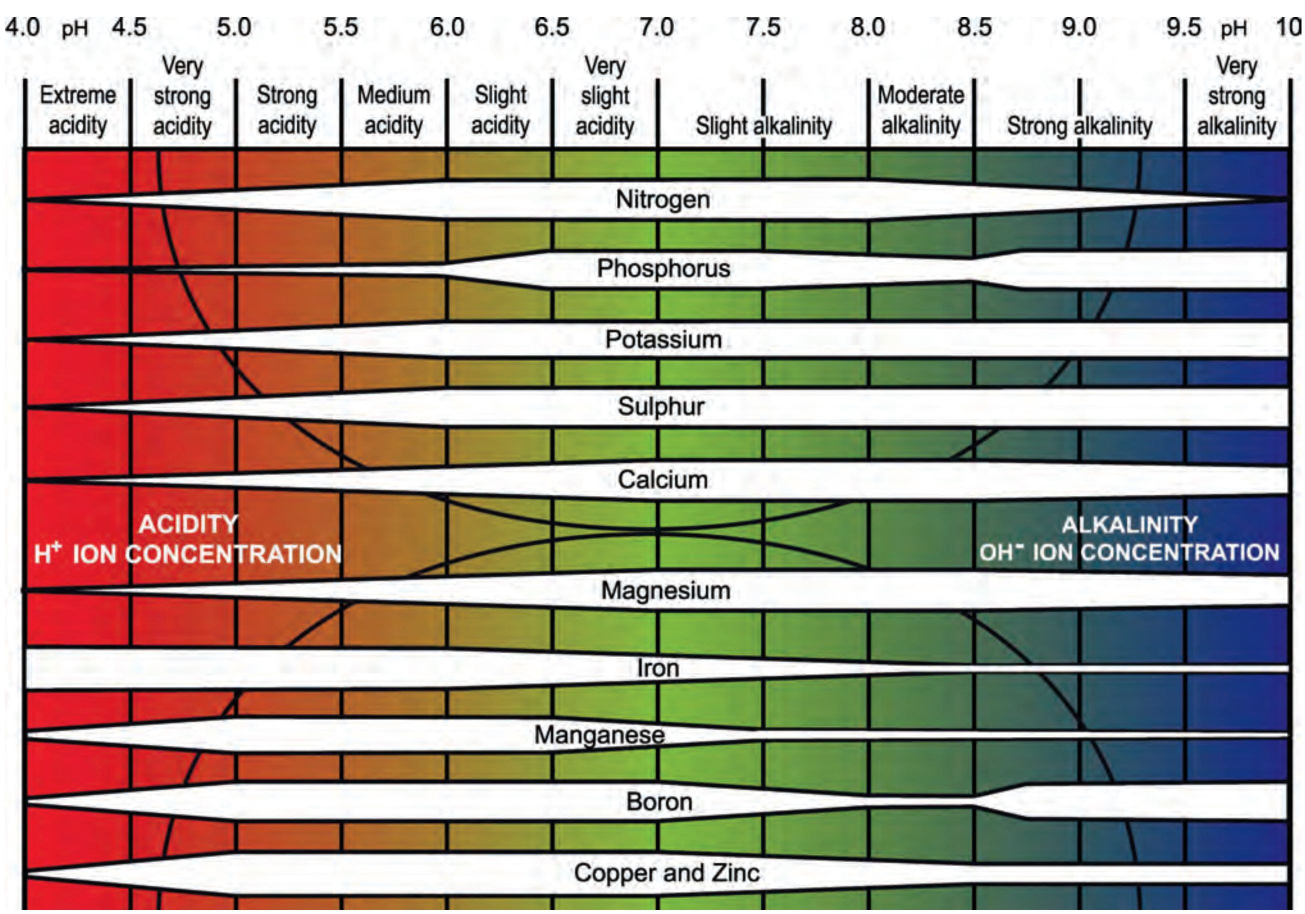


Figure 5-13. Nutrient availability at different pH levels in mineral soils. Bar width indicates increasing/decreasing nutrient availability.

elements (micronutrients). The kind of fertilizer selected will depend on soil type and previous treatment of the soil. The quick availability of nutrients, especially nitrogen, in commercial fertilizers is very important in plant production.

Fertilizer Analysis / Fertilizer Grade

The ***analysis*** or ***grade*** of a fertilizer is designated by three numbers, such as 5-10-5, 12-4-8, 20-20-20, etc. These numbers indicate the guaranteed minimum concentrations of available primary plant nutrients. Total nitrogen, available phosphate and soluble potash are defined by law as the primary plant nutrients in fertilizer mixtures. Often, to simplify matters, these numbers are said to represent nitrogen, phosphorus, and potassium, or ***N-P-K***. In all cases, these numbers refer to percentages of nitrogen (N), phosphate (P_2O_5), and potash (K_2O). The analysis or grade is always written in this order.

With the exception of N, nutrient contents are traditionally expressed in oxide form. This is the reason nutrients are actually expressed on fertilizer labels as nitrogen (N), phosphate (P_2O_5), and potash (K_2O). It should be noted that no fertilizer actually contains pure elements such as N, P or K. Elements in their pure or elemental form are useless to plants and some, such as elemental P and K, are dangerous substances. Plants can use N, P and K only in certain combinations with other elements. For example, nitrogen must be either combined with three oxygen atoms as NO_3^- (nitrate) or with four hydrogen atoms as NH_4^+ (ammonium) before a plant can absorb and use it.

Calculating Total Available Nutrients

Formula	***Example***
N + P + K = % total available nutrients	12 + 4 + 8 = 24% total available nutrients

Figure 5-15. Formula to determine the percentage of total available primary nutrients in a fertilizer.

To determine the amount of a nutrient present in a given volume of fertilizer, multiply the nutrient percentage by the weight of the bag (Figure 5-14). For instance, a 50-pound bag of a 12-4-8 fertilizer contains an equivalent of 12% nitrogen, 4% phosphate and 8% potash by weight. Therefore, it would contain six pounds of nitrogen (0.12 x 50 = 6), 2 pounds of phosphate (0.04 x 50 = 2), and 4 pounds of potash (0.08 x 50 = 4). The remaining weight is filler.

Fertilizer products that contain some amount of all three primary nutrients are often called ***complete fertilizers***. An ***incomplete fertilizer*** will be missing one of these major components. Additional nutrients may be contained in a fertilizer, but are typically listed in smaller print below the grade or guaranteed analysis. Fertilizers that have more than 30% total available primary nutrients are called ***high analysis fertilizers***. (To calculate total available nutrients, see Figure 5-15 above). The term ***low analysis fertilizer*** is applied to mixtures or grades of less than 16% total available primary nutrients. These mixtures cannot be sold unless a special permit is issued by the Department of Agriculture and the label indicates the grade of the low analysis fertilizer in proximity to the product name; for example, "African Violet Plant Food 2-1-1".

Calculating Nutrients Present in a Fertilizer Bag

Formula	***Example***
% N x bag weight = nitrogen weight	50 lb. bag of 12-4-8 0.12 N x 50 lbs. = 6 lb. N
% P_2O_5 x bag weight = phosphate weight	50 lb. bag of 12-4-8 0.04 P_2O_5 x 50 lbs. = 2 lb. P_2O_5
% K_2O x bag weight = potash weight	50 lb. bag of 12-4-8 0.08 K_2O x 50 lbs. = 4 lb. K_2O

Figure 5-14. Formula to determine the amount of each fertilizer nutrient in a bag of a given weight.

Specialty fertilizers are fertilizers packaged, marketed, and distributed for home and garden use in containers or bags weighing 49 pounds or less. Commercial fertilizers containing a total of 5% or less total nitrogen, available phosphoric acid and soluble potash may be guaranteed in other than whole percentages; however, each primary plant nutrient claimed can be no less than 0.5%. There are no minimum primary plant nutrient guarantees for ready to use spray fertilizer products. Potting soil and mulch products for above ground use may also be guaranteed in other than whole percentages.

It is important to note that one fertilizer grade is not best for all soils, since native soil phosphorus and potassium levels as well as previous fertilizer practices determine needs. If a soil is already high in phosphorus and potassium, a fertilizer with a grade such as 21-0-0 would be sufficient, while a soil with low phosphorus or potassium would require additions of fertilizer containing phosphorus or potassium with a grade such as 20-5-10.

Fertilizer Ratio

Fertilizer ratio is the relative proportion of the percentages of N-P-K and is determined by dividing the three numbers by the smallest of the three. Using 10-20-10 as an example, the ratio is 1:2:1 because all three numbers were divided by 10. For a fertilizer with an analysis of 10-30-10, the ratio is 1:3:1.

Two fertilizers with different analyses can have the same nutrient ratio (Figure 5-16). For example, 100 pounds of a 10-30-10 fertilizer contains 10 pounds of nitrogen, 30 pounds of phosphate, and 10 pounds of potash, whereas 100 pounds of a 7-21-7 fertilizer contains 7 pounds of nitrogen, 21 pounds of phosphate, and 7 pounds of potash. Both of these fertilizers have the same ratio (1:3:1) but different grades or analyses (10-30-10 versus 7-21-7) and different amounts of actual plant food. Therefore, different total amounts of fertilizer will be required to provide equal amounts of nutrients. Application rates must be determined on the basis of actual nutrients needed and the analysis of the product.

Figure 5-16. Comparison of different fertilizer analyses with the same ratio of 1:3:1.

Fertilizer Labeling

Commercial fertilizers, organic or manufactured, must have the guaranteed minimum analysis printed on the package label. The labeling of materials sold as fertilizers in Florida is regulated by the Agricultural Fertilizers Law (Chapter 576 F.S.). The required information and format make fertilizer labels consistent. If understood properly, a qualified comparison of fertilizers can be made.

Manufacturers are required to affix a label to each bag, package, container, or lot of fertilizer shipped in bulk and offered for sale in the state. The label provides the consumer with a written guarantee of the minimum nutrients claimed. This information must be in a readable and conspicuous form. For packaged products, this information must either 1) appear on the front or back of the package, 2) occupy at least one-third of a side of the package, or 3) be printed on a tag and attached to the package.

Labels must also appear on individual materials sold as fertilizers, even if they are not mixed fertilizers. Guarantees for such products are similar to those on the label of a mixed fertilizer. All composts, soil conditioners, soil amendments, manipulated manures, and soil additives are defined as fertilizers by law, and should be labeled appropriately.

The law requires that each label show specific information about the analysis and composition of the mixture or material. The Florida fertilizer label must include the following information (see example on page 132):

1) The Florida ***fertilizer license number*** must be easily discernible on all fertilizer labels with a capital "F" preceding the license number. The number must be clear, legible and appear prominently and conspicuously on the label in proximity to the brand name or guaranteed analysis.
2) A ***brand name*** used by the licensee to identify ownership of the product. Brand means a term, design, or trademark used in connection with one or several grades of fertilizer.
3) A ***grade*** in proximity to the brand. The grade means the percentages of total nitrogen expressed as N, available phosphate expressed as P_2O_5 and soluble potassium expressed as K_2O, stated in whole numbers in that order.
4) The ***net weight*** or actual weight present in the package or container. If sold in bulk, five labels containing all the required information must accompany a delivery ticket that shows the certified net weight of the bulk material.
5) The ***name and street address*** of the manufacturer or registrant of the fertilizer.
6) When the term "organic" is used in the label, labeling, or advertisement for any fertilizer, ***water insoluble nitrogen*** (WIN) must not be less than 60% of the total guaranteed nitrogen so designated.
7) The ***guaranteed analysis*** section of the label is divided into the percentage of total nitrogen, which is the sum of all forms of nitrogen present in the mixture, available phosphate, soluble potassium, and a statement of each secondary plant nutrient present in the mixture. When applicable, the chlorine content is guaranteed as the maximum percentage present in agricultural fertilizer.
8) A ***derived from*** section located below the guaranteed analysis of the nutrients claimed. It is a listing of the actual plant food source materials that constitute essential element guarantees.

Some fertilizer mixtures contain pesticides and are required by law to have the words "CAUTION – CONTAINS PESTICIDE" conspicuously on the face of the label or tag in bold red lettering. Fertilizer manufacturers can include only registered and approved pesticides at a rate below or equal to the maximum legal rate. The label must include crops for which the pesticide(s) are recommended, required precautionary statements, and directions for use. The percent of active ingredient by weight must appear on the label along with the pounds of active ingredient per ton of fertilizer. However, pesticides are often not warranted at the time fertilizer is applied. Therefore, it is better practice to avoid using combination materials and applying pesticides separately only when needed.

Guaranteed Analysis

More specific details must be provided within the guaranteed analysis section of a fertilizer label (Figure 5-17) to provide the following information about each nutrient within the fertilizer bag.

Total Nitrogen may be included in the form of (1) nitrate nitrogen, (2) ammoniacal nitrogen, (3) water soluble nitrogen, (4) urea nitrogen, or (5) water insoluble nitrogen. A statement of the percentage of each form

photo by bob cook

Figure 5-17. Guaranteed analysis statement on a fertilizer label.

Example of Florida Fertilizer Label

BRAND NAME

GRADE X – X - X

Guaranteed Analysis

Total Nitrogen (N)		________ %
________ %	Nitrate Nitrogen (NO_3^-)	
________ %	Ammoniacal Nitrogen (NH_4^+)	
________ %	Water Soluble Nitrogen	
________ %	Urea Nitrogen	
________ %	Water Insoluble Nitrogen (WIN)	
Available Phosphorous (P_20_5)		________ %
Soluble Potassium (K_20)		________ %
Chlorine (Cl), Not More Than		________ %
	Total Magnesium as (Mg)	________ %
	Water Soluble Magnesium as (Mg)	________ %
	Chelated Magnesium (Mg)	________ %
	Total Manganese as (Mn)	________ %
	Water Soluble Manganese as (Mn)	________ %
	Chelated Manganese as (Mn)	________ %
	Total Copper as (Cu)	________ %
	Water Soluble Copper as (Cu)	________ %
	Chelated Copper as (Cu)	________ %
	Total Iron as (Fe)	________ %
	Water Soluble Iron as (Fe)	________ %
	Chelated Iron as (Fe)	________ %
	Total Zinc as (Zn)	________ %
	Water Soluble Zinc as (Zn)	________ %
	Chelated Zinc as (Zn)	________ %
	Combined Sulfur as (S)	________ %
	Free Sulfur as (S)	________ %

Derived from: (Actual materials and forms used in the fertilizer mixture, e.g., Diammonium Phosphate, Urea, Potassium Chloride, Magnesium Sulfate, Manganese Nitrate, etc.)

Manufactured by:
Name (FXXXX)
City, State & Zip

Net Weight - ________ lb.

(Note: The forms of N listed must add up to the Total Nitrogen (N) guarantee) present in the fertilizer must be given. This breakdown supplies information on the immediate availability and/or leachability of nitrogen in the mix.

Nitrate nitrogen includes all nitrate (NO_3^-) forms in the fertilizer mixture. ***Ammoniacal nitrogen*** includes all the ammonium (NH_4^+) forms of nitrogen in the fertilizer. Both forms are available for immediate uptake by plant roots. When urea is present, it may be guaranteed as ***water soluble nitrogen*** or ***urea nitrogen***. ***Water insoluble nitrogen*** sources may be materials such as urea-formaldehyde, isobutylidene diurea, magnesium ammonium phosphate, or other similar materials. Natural organic materials such as dried blood and tankage are also considered water insoluble sources. Natural organic sources become available by microbial action, which first converts the nitrogen to ammonium and then to the nitrate form.

Some water insoluble nitrogen forms are rendered insoluble by coating them with sulfur or plastic-based materials, by chemical combination with other elements, or by inhibiting the activity of microorganisms that release nitrogen from insoluble forms. Many of these sources are treated in ways that sustain a longer continued release of nitrogen.

Sulfur-coated urea products provide a form of slow-release nitrogen, but the fertilizer label may not list it as water insoluble nitrogen (WIN). If the fertilizer contains sulfur-coated urea, that portion should be included as part of WIN when determining the percentage of total N that is slowly available. In most cases, the higher the water insoluble N (WIN) percentage, the longer lasting the fertilizer.

The formula in Figure 5-18 below can be used to determine the percentage of slow-release nitrogen (SRN) within a fertilizer mix containing water insoluble nitrogen (WIN). As an example, a fertilizer with an analysis of 16-4-8 has 4% of the total N available in water insoluble nitrogen (WIN) form. Therefore, the mix contains 25% total N in slow-release nitrogen (SRN) form.

Available Phosphoric Acid represents the oxide equivalent of the phosphorus in the mixture; in other words, phosphorus is bonded to one or more oxygen ions to make it water soluble or soluble in the weak acids of a soil solution. The terms "available phosphorus" or "available phosphate" may be used instead of "available phosphoric acid".

Soluble Potash is the oxide equivalent of potassium present in the mixture. The actual form of potassium in the fertilizer is the potassium ion (K^+). All the potassium guaranteed on a fertilizer label is soluble K, implying it goes into solution readily when applied to the soil and that it is immediately available for plant uptake. The term "soluble potassium" may be used instead of "soluble potash".

Total Available Primary Plant Nutrient is the sum of the total nitrogen, available phosphate, and soluble potash.

Chlorine must be stated as "not more than" because this element may be toxic to many plants. Some vegetable crops and greenhouse flowers show toxicity symptoms, and reduced quality and yields from excessive chlorine. It is required that the statement "chlorine, not more than" be placed on the label, so the purchaser is aware of the Cl content in the mix. Specialty fertilizers are exempt from chlorine guarantees.

Derived From is a statement of the actual source materials for the guaranteed primary plant elements. A "derived from" statement is also required to give the sources of secondary elements contained in the mixture, such as magnesium sulfate and manganese sulfate.

Calculating Percentage of Slow Release Nitrogen (SRN)

Formula	***Example***
Percent Water Insoluble Nitrogen (WIN) ÷ Percent Total Nitrogen = Percent of SRN	0.04 ÷ 0.16 = 0.25 or 4% ÷ 16% = 25% SRN

Figure 5-18. Formula for the calculation of slow release nitrogen percentages in fertilizer products.

Secondary and Micro Plant Nutrients must be specified in the guaranteed analysis in their elemental form. Magnesium, iron, zinc, copper and manganese must be expressed as total and/or water soluble depending upon the source materials formulated in the product. Chelated elements are guaranteed separately when a chelating agent is expressed in the "derived from statement" below the guaranteed analysis. Sulfur must be guaranteed as sulfur (combined) and/or sulfur (free) in the elemental form, depending upon the source material in the formulation. Specialty fertilizers are exempt from sulfur guarantees.

Slow and Controlled-Release Nutrients claimed or advertised have to be shown as a footnote after the listing of source materials and must be expressed as a percent of the actual nutrient. Listing of source materials providing slow or controlled-release characteristics that delay or extend nutrient availability for plant uptake and use after application constitutes a claim of controlled release, and a guarantee for such nutrients is required. No guarantee, claim, or advertisement can be made or required on the fertilizer label when a slow or controlled-release nutrient is less than 15% of the total guarantee of that nutrient.

Fertilizer Selection

Nutrients can be purchased as mixed or single ingredient fertilizers. ***Mixed fertilizers*** contain two or more of the primary elements, nitrogen, phosphorus and potassium (Figure 5-19). ***Single ingredient fertilizers*** are used to supply one element essential for plant growth, such as ammonium nitrate or urea to supply N, triple superphosphate to supply P, and muriate of potash to supply K.

Figure 5-19. Chemical symbols for the three primary elements.

Most fertilizers are formulated as dry materials. These products are usually finely crushed, granular, powder or processed into uniform prills (spherical solids) that can either be mixed into soil or applied to the surface. Some fertilizers are formulated as liquids. Liquid fertilizers can be applied with irrigation, making them convenient and labor saving at times.

Quick-Release Fertilizers

Quick-release fertilizers (QRFs), also known as fast-acting fertilizers, are ***water soluble*** chemicals that release their nutrients rapidly. These nutrients are readily available for plants when properly placed in the soil, and plants respond quickly. However, if too much is applied at one time, quick-release fertilizers have a tendency to burn plants or move below the rooting depth to potentially impact underground water supplies. Since these materials are easily leached by rain or overirrigation, frequent and more careful application is required.

Quick-release fertilizers are the least expensive fertilizers and are always synthetic products. Examples include ammonium nitrate, ammonium sulfate, calcium nitrate, and urea. Complete release of nitrogen from these fast release sources usually occurs within one week after application.

Slow-Release Fertilizers

Slow-release fertilizers (SRFs), sometimes called ***water insoluble*** types, release nutrients gradually with time and can be inorganic or organic. They are often applied at higher rates and less frequently than quick-release formulas because they are designed to release at a rate more consistent with plant needs. Synthetic SRFs are sparingly water soluble and usually are coated or in pelletized form. The breakdown of this type of fertilizer depends on soil moisture and temperature. Organic forms must be broken down by microbial activity before nutrients can be released.

The initial response of SRFs is slower than quick-release types, and these materials continue to provide nutrients over a period of eight to 10 weeks or more. Even so, slow-release fertilizers can occasionally be released very quickly when excessive moisture and high temperatures occur at the same period of time. These products are a little more expensive and include certain synthetic fertilizer products, and all the natural organic fertilizers. Examples include sulfur-coated urea, urea formaldehyde, isobutylene diurea (IBDU), and organic fertilizers such as animal manure and compost.

Controlled-Release Fertilizers

Controlled-release fertilizers (CRFs) are typically coated or encapsulated with inorganic or organic semipermeable coatings and sealants that control the rate, pattern, and duration of plant nutrient release. Most importantly, the release rate of a CRF fertilizer is designed in a pattern synchronized to meet changing crop nutrient requirements ranging from eight to 52 weeks after application. Polymer-coated urea and resin-coated Osmocote® are common examples of controlled-release fertilizers (Figure 5-20).

Comparing Fertilizer Costs

Of all the essential nutrients, nitrogen is required by plants in the largest quantities and is most frequently the limiting factor in crop productivity. As a result, the best way to compare fertilizer cost is probably on the basis of cost per pound of nitrogen. However, other factors such as slow-release characteristics and micronutrients also affect fertilizer cost and value. Generally, three fertilizer characteristics increase the value and add to the cost of fertilizer. These include the:

1) slow-release characteristics;
2) presence of micronutrients (especially fritted or chelated); and
3) fertilizer form (granules, pellets, free flowing prills).

The choice of soluble or slow-release nitrogen depends on the reason for fertilization. Soluble fertilizers may be required when a quick response is desired, and slow-release fertilizers are excellent for regular maintenance. Some fertilizers are formulated with both water insoluble (slow-release) and

photo by bob cook

Figure 5-20. Examples of slow-release and controlled-release fertilizers.

water soluble (quick-release) nitrogen. When such combinations are used, plants green up quickly and continue to receive nutrients over a period of time. For the most effective product, at least one-fourth (1/4) or 25% of the nitrogen should be in water insoluble or slow-release form to limit negative environmental impacts from fertilization practices.

Nutrient Test Results

Soil testing should be the basis for any fertilizer application. Soil tests are essential to determine nutrient levels of the soil and to plan a fertility program. Fertilization management programs should be developed based on plant needs and nutrients present in the soil. It is important to generally understand soil testing procedures and the variety of methods used to conduct the analysis. However, it is more important to understand the information generated in reports in order to make good judgments about fertilizer type, amount, and timing of application.

Due to the mobility of essential nutrients in Florida soils, precise measurements of the nutrients available to plants at any one moment is difficult to obtain through soil analysis. Tissue analysis offers a more precise estimate of the plant's nutritional status at the time of sampling. Nutrient deficiencies can be detected with tissue analysis before visual symptoms appear. When used in combination, a ***soil analysis*** can serve as a guide for the level of fertilization required to correct a deficiency and a ***tissue analysis*** can be used to indicate the specific nutrient deficiency and level of that deficiency, especially micronutrients. For growers, tissue analyses should be used in conjunction with media analyses to obtain the nutritional status of the container plant system.

Testing Procedures

A soil testing program is a three-step process involving soil testing, interpretation and nutrient application recommendations. A routine landscape soil analysis supplies information on soil pH and the extractable phosphorus (P), potassium (K), magnesium (Mg), and calcium (Ca) status of the soil.

Laboratories use different extraction procedures for soil analyses. The UF/IFAS Extension Soil Testing Laboratory (ESTL) uses soil test methods developed specifically for Florida soils. The lab offers tests that determine ***soil pH and lime requirement*** (using the Adams-Evans buffer method) and ***standard soil fertility*** (using the Mehlich-3 method). Private laboratories may or may not use soil tests adjusted for Florida conditions; therefore, it is important to know the exact test methods used. Liming and fertilizer recommendations are specific to the soil test methods, which is important information when interpreting the results.

Since container media differ greatly from agricultural or landscape soils in their physical and chemical characteristics, the UF/IFAS ESTL offers a ***standard fertility test*** that estimates water soluble plant nutrients in soilless container media. This test is designed

Interpretations of Nutrient Concentrations in Soil using the Mehlich-3 Method

	Low	*Medium*	*High*
		parts per million	
P	≤5 ppm	26–45 ppm	>45 ppm
K	≤35 ppm	36–60 ppm	>60 ppm
Mg	≤20 ppm	21–40 ppm	>40 ppm
Ca	No interpretation is made for Mehlich-3 extractable Ca levels because the extractant dissolves calcium compounds in the soil, which may not be readily available to plants.		

Figure 5-21. Comparison of nutrient test results and applicable management ranges.

for estimating the nutritional needs of Florida grown plants under intensive management typical of container plant production.

Interpretations

Soil test reports contain the test results (soil pH, ppm extractable P, K, Mg, and Ca), a ranking of nutrient ranges, and fertilization recommendations. The *Interpretations of Nutrient Concentrations in Soil* chart (Figure 5-21) specifies ranges of extractable nutrients in low, medium and high categories based upon nutrient concentrations in parts per million (ppm) using the Mehlich-3 method. Fertilizer applications are recommended when nutrient values fall within the ***low*** and ***medium*** categories. No fertilizer is recommended when nutrient values fall within the ***high*** category.

Container media is commonly tested for pH, electrical conductivity, nitrate-N, phosphorus, potassium, calcium and magnesium. Interpretations of these *Container Media Test* results in Figure 5-22 below are meaningful only in commercial nursery container production. Plant growth and response to fertilizer management should be observed, and nutrient status should be monitored through a regular program of media testing.

Whenever media tests in the ***low*** range, plants may respond to added nutrients. The ***acceptable*** range should be viewed as adequate for good plant growth; therefore, addition of nutrients may or may not result in further plant growth. In general, plants may be ready for market one to two weeks earlier if nutrients in the media are maintained in the ***optimum*** range. No additional benefits are expected from added fertilizer when media nutrients test in either the ***high*** or ***very high*** range. In fact, one may experience excessive nutrient loss from media during irrigation when nutrients are maintained in either of these two ranges. When making interpretations, one must consider that container nutrient levels are influenced by many factors including environmental, fertilizer solubility or release characteristics, and water management.

Application Recommendations

Recommendations are composed of two parts: (1) the application rates of nitrogen, phosphate, and potash fertilizer and (2) footnotes that give important information about fertilization management such as application timing, special crop requirements, etc.

Fertilizer rate recommendations for N are determined by research on plant response to N, whereas recommendations for P, K, Ca, and Mg are determined based on the index of nutrient availability (for example, low, medium, high, etc.) measured in the soil sample. The lime recommendation is based on results of the pH and lime requirement test, and the pH considered optimum for the turf or plant species.

Interpretation of CONTAINER MEDIA TEST for Woody Ornamentals*

Analyses	***Rating Category***				
	Low	**Acceptable**	**Optimum**	**High**	**Very High**
pH	<5.0	5.0 to 5.5	5.5 to 5.8	5.8 to 6.5	>6.5
Electrical conductivity, dS/m	<0.7	0.7 to 1.0	1.0 to 1.5	1.5 to 3.0	>3.0
Nitrate-N, mg/L or ppm	<40	40 to 80	80 to 100	100 to 200	>200
Phosphorus, mg/L or ppm	<3	3 to 8	8 to 12	12 to 18	>18
Potassium, mg/L or ppm	<10	10 to 20	20 to 40	40 to 80	>80
Calcium, mg/L or ppm	<10	10 to 20	20 to 40	40 to 100	>100
Magnesium, mg/L or ppm	<10	10 to 15	15 to 20	20 to 60	>60

* Plants of the Ericaceae family (e.g., azaleas) and salt sensitive plants require only one half the electrical conductivity amounts and can tolerate only half the levels of nutrients (NO_3-N, P, K, Ca, and Mg) shown in this table.

Figure 5-22. Ranges and rating categories for results of commonly performed tests in soil labs.

Be sure to read the soil test report carefully and thoroughly (including all footnotes). Remember, private labs may use different analytical procedures, which may or may not be calibrated to conditions in Florida, so avoid comparing reports from ESTL with those. Local UF/IFAS Extension offices can answer questions related to soil test results.

The *Recommended Fertilization Rate* chart (Figure 5-24) in the next section provides target pH and recommended nitrogen, phosphate and potash fertilizer rates for lawns and landscape ornamentals.

Fertilizer Application

Proper nutrient management should include the "Four R's" of fertilizer use: apply the right nutrient, at the right rate, at the right time, and in the right place for the selected crop. Horticulturists must know what fertilizer is best for the situation as well as how to apply fertilizers. The analysis of products used, sold or recommended must be understood, including other factors that cause one formulation of a particular fertilizer with the same analysis to be more valuable than another.

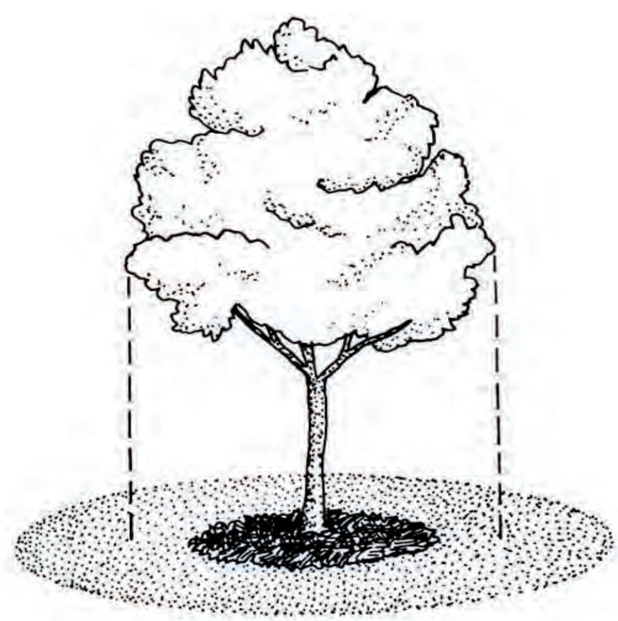
Premium quality fertilizers will contain the best ingredients formulated for easy and effective application. Knowing how long it has been since the last fertilization and using soil test results to make application decisions is an important starting point in any fertility management program. The relationship between when, how much and how often should always be carefully considered.

Horticulturists must also know the type of fertilizer program needed or desired. Is cost, maximum result or convenience being considered? Is the landscape well established, or has it recently been planted and still becoming established? Do plants have special nutrient requirements? Are there special considerations due to the proximity of salt water? Are there extremes in soil pH? The area of the state in which the customer lives can also have an effect on the fertilization program. With so many questions regarding fertilization, it must be understood that some generalizations and compromises have to be made.

Fertilizer Placement

Studies have indicated that root depths are usually a maximum of 10 to 14 inches due to naturally high oxygen concentrations near the soil surface. In fact, many roots of mulched plants are located just beneath the mulch surface. Since most feeder roots on trees and shrubs are shallow, fertilizer should be applied to the soil or mulch surface within the plant's root zone for maximum absorption. There is no need to inject or place fertilizer deep in the soil. Nevertheless, shallow soil injections on mounds, berms and slopes and in compacted soil will reduce the amount of fertilizer runoff due to irrigation or rain.

The growth range of more than half the roots of several tree species extends well beyond the dripline by as much as three times. However, fertilizer should be applied to the mulch surface and to the unmulched area around a tree not to exceed one and one half to two times the canopy diameter (Figure 5-23). If turf in the vicinity was fertilized within the past two weeks, do not apply additional fertilizer to the turf area around the tree. In this case, fertilize the mulched area only, and base the amount



graphic by north carolina state university

Figure 5-23. Guideline for fertilizer placement around trees.

of fertilizer applied on the square footage of the mulched area. The fertilizer nutrients will move rapidly with irrigation water through the mulch.

Most trees, which are established for three to five years and found growing in landscapes where turf and shrubs are fertilized, do not need additional fertilizer. Their root systems extend throughout the landscape past the edge of the tree canopy and receive nutrients when these areas are fertilized. Supplemental applications may be needed for some trees if the potential for nutrient deficiencies exists.

There are a few situations where trunk injection of fertilizer is warranted. A good candidate for trunk injection would be a tree with a micronutrient deficiency that did not respond to soil applications of fertilizer, or one growing within the limited soil space of a parking lot island, or a tree well within an urban sidewalk. Since each situation is different, the merits of injection should be judged by a professional tree specialist. Remember that trees are permanently damaged by trunk injections and the potential benefits of the decision must outweigh this damage.

Recommended fertilization rates correlated to soil test results

Crop Description	***Target pH***	***N***	***lb. / 1,000 ft^2 / year***									
			P_2O_5					***K_2O***				
			VL	LO	MED	HI	VH	VL	LO	MED	HI	VH
Bahiagrass lawn	5.5	2.0	1.0	1.0	0.5	0	0	2.0	2.0	1.0	0	0
Bermudagrass lawn, North	6.5	4.0	1.0	1.0	0.5	0	0	2.0	2.0	1.0	0	0
Bermudagrass lawn, South	6.5	5.0	2.0	2.0	1.0	0	0	3.0	3.0	1.5	0	0
Carpetgrass lawn	5.5	2.0	1.0	1.0	0.5	0	0	1.0	1.0	0.5	0	0
Centipedegrass lawn, North	5.5	2.0	1.0	1.0	0.5	0	0	2.0	2.0	1.0	0	0
Centipedegrass lawn, South	6.0	2.0	1.0	1.0	0.5	0	0	2.0	2.0	1.0	0	0
Ryegrass lawn	6.5	1.4	0.5	0.5	0.2	0	0	1.0	1.0	0.5	0	0
St. Augustine lawn, North	6.5	2.0	1.0	1.0	0.5	0	0	2.0	2.0	1.0	0	0
St. Augustine lawn, South	6.5	3.0	1.0	1.0	0.5	0	0	3.0	3.0	1.5	0	0
Zoysiagrass lawn, North	6.5	3.0	2.0	2.0	0.5	0	0	2.0	2.0	1.0	0	0
Zoysiagrass lawn, South	6.5	4.0	1.0	1.0	0.5	0	0	2.0	2.0	1.0	0	0
Commercial woody ornamental nursery growing plants in the ground	6.0	6.9	2.3	2.3	1.1	0	0	4.6	4.6	2.0	0	0
Commercial nursery growing azaleas, camellias, gardenias, hibiscus, or ixora in the ground	5.5	3.4	1.1	1.1	0.7	0	0	2.3	2.3	1.1	0	0
Woody ornamentals or trees in the landscape	6.0	2.3	0.7	0.7	0.4	0	0	1.4	1.4	0.7	0	0
Azaleas, camellias, gardenias, hibiscus or ixora in the landscape	5.5	1.1	0.3	0.3	0.2	0	0	0.7	0.7	0.3	0	0

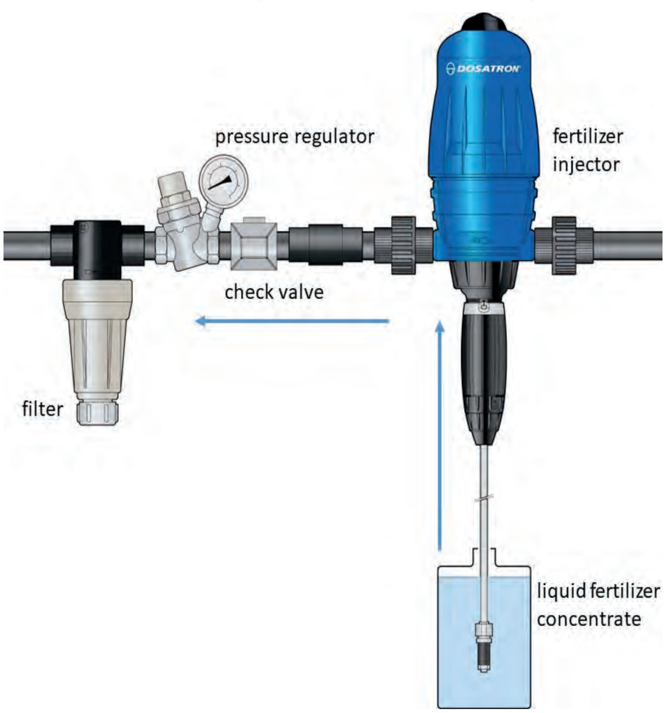
Figure 5-24. Fertilization rates based on target pH and recommended N, P and K in lawns, landscapes and field production.

Fertigation

Fertigation is the application of liquid fertilizer through an irrigation system. Microirrigation and fertigation offer the potential for precise control of water and nutrients, which are the main grower controlled inputs to plant growth. The uniformity of the fertilizer application depends on the uniformity of the water application. For that reason, high water application uniformity is very important for fertigation.

A major benefit of fertigation (Figure 5-25) is that it provides greater flexibility and control of applied nutrients than conventional broadcast applications. Fertilizers are applied when needed and in small doses, so water soluble nutrients are less subject to leaching by excess rainfall or overirrigation. However, caution should still be taken to minimize leaching from the container and creating nutrient runoff.

Care must be exercised to avoid emitter plugging problems resulting from reactions of the fertilizer with higher pH irrigation water. Chemical reactions between soluble fertilizer materials can result in the formation of ***precipitates*** (solid compounds) that can clog the irrigation system. All irrigation systems through which any chemical is applied must be equipped with proper backflow prevention as required by law in Florida.



adaptation from graphic by dosatron®

Figure 5-25. Illustration of basic fertigation system components.

Fertilizer Recommendations

A good water and fertilizer schedule promotes healthy plants that are less susceptible to and tolerant of insect damage and fungal diseases. Fertilizer programs are commonly based on plant type and annual nutrient needs, plus a fertilization plan that spreads specific nutrient needs out over a year. Consequently, fertilizer recommendations vary greatly among turfgrass, landscape plants and palms grown throughout Florida (Figure 5-24).

Fertilizer Recommendations for Turfgrass

Turfgrasses commonly require higher rates and more frequent applications of N fertilizers than other nutrient sources. However, it should be pointed out that turfgrasses are one of the most efficient ground covers for N absorption. Nitrogen leaches very sparingly, if at all, from the turfgrass system when fertilized at the recommended rate and frequency. Poor quality, slow-growing, and improperly fertilized turfgrasses actually leach much more N than do turfgrasses growing at optimum levels. A mixture of soluble and slow-release N sources is recommended for use on turfgrasses to reduce the potential for leaching losses of applied N.

Nitrogen fertilization is often based on the desired growth rate and the type of turfgrass being grown. A quality turfgrass furnishes a complete and uniform cover of the soil surface. The highest quality turfgrass is not necessarily the darkest green or most rapidly growing turfgrass, but the turfgrass that has acceptable color and density without excessive growth. Excess N application can lead to a dark green turfgrass growing at unnecessarily fast rates. This will require more frequent mowing and possibly result in contamination of the groundwater with nitrate nitrogen.

Fertilization Guide for Turfgrass Maintained Without the Benefit of a Soil Test*

Turfgrass	*Maintenance Level*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
North Florida**													
Bahiagrass	Basic	--	--	--	C	--	--	--	--	C	--	--	--
	Moderate	--	--	--	C	--	SRN	--	--	C	--	--	--
	High	--	--	--	C	--	SRN	Fe	--	C	--	--	--
Bermudagrass	Basic	--	--	--	C	--	SRN	--	--	C	--	--	--
	Moderate	--	--	--	C	--	SRN	--	--	C	--	--	--
	High	--	--	--	C		SRN	Fe	--	C	--	--	--
Centipedegrass	Basic	--	--	--	C	--	--	--	--	--	--	--	--
	Moderate	--	--	--	C	--	Fe	--	--	--	--	--	--
	High	--	--	--	C	--	SRN	Fe	--	--	--	--	--
St. Augustinegrass	Basic	--	--	--	C	--	Fe	--	--	C	--	--	--
	Moderate	--	--	--	C	--	SRN	Fe	--	C	--	--	--
	High	--	--	--	C	--	SRN	Fe	--	C	--	--	--
Zoysiagrass	Basic	--	--	--	C	--	SRN	--	--	--	--	--	--
	Moderate	--	--	--	C	--	SRN	--	--	N	--	--	--
	High	--	--	--	C	--	SRN	--	--	C	--	--	--
Central Florida**													
Bahiagrass	Basic	--	--	C	--	N	--	--	--	C	--	--	--
	Moderate	--	--	C	--	N	--	Fe	--	--	C	--	--
	High	--	--	C	N	--	SRN	--	Fe	--	C	--	--
Bermudagrass	Basic	--	--	C	--	N	--	SRN	--	C	--	--	--
	Moderate	--	--	C	--	N	--	SRN	--	SRN	--	C	--
	High	--	--	C	N	SRN	--	C	Fe	SRN	--	C	--
Centipedegrass	Basic	--	--	C	--	SRN	--	--	--	--	--	--	--
	Moderate	--	--	C	--	SRN	--	--	Fe	--	--	--	--
	High	--	--	C	--	SRN	--	--	--	C	--	--	--
St. Augustinegrass	Basic	--	--	C	--	--	--	Fe	--	C	--	--	--
	Moderate	--	--	C	--	SRN	--	Fe	SRN	--	C	--	--
	High	--	C	--	N	SRN	--	Fe	SRN	--	C	--	--
Zoysiagrass	Basic	--	--	C	--	SRN	--	--	--	--	--	--	--
	Moderate	--	--	C	--	SRN	--	--	--	--	N	--	--
	High	--	--	C	--	SRN	--	--	--	--	C	--	--
South Florida**													
Bahiagrass	Basic	--	C	--	--	--	Fe	--	--	--	C	--	--
	Moderate	--	C	--	N	--	Fe	--	--	--	C	--	--
	High	--	C	--	N	--	SRN	--	--	--	C	--	--
Bermudagrass	Basic	--	C	--	N	--	SRN	--	--	C	--	C	--
	Moderate	--	C	N	--	C	--	SRN	--	SRN	--	C	--
	High	--	C	N	SRN	C	SRN	Fe	--	SRN	--	C	--
Centipedegrass	Basic	--	--	C	--	--	Fe	--	--	--	C	--	--
	Moderate	--	C	--	SRN	--	--	--	--	--	C	--	--
	High	--	C	--	SRN	--	Fe	--	--	--	C	--	--
St. Augustinegrass	Basic	--	--	C	--	SRN	--	SRN	--	--	C	--	--
	Moderate	--	C	--	N	--	SRN	--	SRN	--	--	C	--
	High	--	C	--	N	SRN	--	SRN	--	SRN	--	C	--
Zoysiagrass	Basic	--	--	C	--	SRN	--	--	--	--	N	--	--
	Moderate	--	C	--	N	--	SRN	--	--	--	N	--	--
	High	--	C	--	N	SRN	--	SRN	--	--	--	C	--

***** This guide is for turfgrass fertilization under circumstances where a soil test does not exist. In order to properly apply the rate of P and K required, a soil test is required. It is recommended to always test soil.

****** The arbitrary dividing line between north and central Florida is a straight east-west line from coast to coast through Ocala, and the dividing line between central and south Florida is a line from coast to coast through Tampa and Vero Beach.

C = Complete fertilizer applied at 1.0 lb. N/1,000 ft^2 containing no more than 0.7 lb. soluble N.

N = Soluble N applied at no more than 0.7 lb. N/1,000 ft^2.

SRN = Slow-release N applied at no more than 2.0 lb. N/1,000 ft^2 in the spring and summer only; no more than 1.0 lb. N/1,000 ft^2 in the fall and winter.

Fe = Apply Fe to provide dark green color without stimulating excessive growth. For foliar application, use ferrous sulfate (2 oz./3-5 gal water/1,000 ft^2). If Fe is applied to an acidic soil, use 1 lb. of iron sulfate per 1,000 ft^2. If the soil is calcareous, use the container label recommended rate of an iron chelate.

Figure 5-26. Recommended turfgrass fertilizer application cycles for varying maintenance levels.

The rate of nutrient application, particularly nitrogen, depends on a number of factors: turfgrass species, maintenance level goals, the location in the state where the turfgrass is being grown, time of year, and the type of fertilizer source being used (soluble or slow-release). For Florida turfgrasses, the best yearly fertilization program usually includes a combination of one or two applications of multiple nutrient fertilizations and several supplemental applications of N fertilizer as indicated in the *Fertilization Guide* in Figure 5-26 on the previous page. Maximum applications of nitrogen and phosphate are established by the Urban Turf Fertilization rule discussed in the next section.

Phosphorus (P) is not always required due to the inherent nature of some Florida soils and past fertilization practices. The off-site transport of P is often associated with soil erosion from unvegetated and thin turfgrass areas. A recent soil test should be used to determine if P is required. If soil tests indicate an adequate level of extractable soil P, choose a fertilizer blend that does not contain P as one of the supplied nutrients, such as 15-0-15.

Another source of P is reclaimed water. Turf irrigated with reclaimed water may receive an excess amount of P, so do not add phosphorus to a site irrigated with reclaimed water without a soil test recommendation to do so.

Second only to nitrogen in total fertilization requirement is potassium (K). Potassium influences root growth along with the water and stress tolerance relationships in turfgrasses. Potassium is highly mobile in most of Florida's sandy soils. An annual soil test is adequate for determining the K fertilization requirement of most turfgrasses grown in the state.

The tables on the next page provides *Recommended Application Rates* for Florida lawns using turfgrass fertilizers relative to the slow-release nitrogen (SRN) content (Figure 5-27). To use the tables, match the lawn size with the percentage of nitrogen (N) to determine the amount of a given fertilizer formulation needed.

Urban Turf Fertilizer Rule

In 2015, the Florida Department of Agriculture and Consumer Services revised the 2007 Urban Turf Fertilizer Rule 5E-1.003(2) F.A.C. The purpose of the rule is to limit the nitrogen and phosphorus application of fertilizer on urban turf and lawns in an attempt to protect Florida's natural water resources. It regulates what can be sold and marketed as lawn fertilizer and requires specific wording on the fertilizer bag. The rule also directs the manufacturer to recommend the use of BMPs for professional applicators and golf course or athletic field managers.

While this rule only applies to the manufacturer's label for fertilizer, many local government ordinances, and future state requirements, may compel applicators to abide by the recommendations on the label. In addition, weed and feed products are legally recognized as pesticides. For these pesticide-fertilizer combination products, the label recommendation carries the full force of state and federal law.

The fertilizer labeling rule requires that specific guidelines for nitrogen and phosphate application rates be followed. Fertilizers labeled for use on urban turf, sports turf or lawns must have no phosphate or low phosphate content. Labels must also have restrictions for single and yearly application rates of nitrogen and phosphate.

The rule further specifies that:

- Nitrogen cannot be applied at a rate greater than 0.7 lbs. of readily available nitrogen per 1,000 square feet at any one time. This amount is based on the soluble fraction of formulated fertilizer.
- Not more than 2 lbs. of total nitrogen per 1,000 square feet per application may be applied during the spring or summer; not more than 1 lb. total nitrogen per 1,000 square feet per application may be applied during the fall or winter. Nitrogen cannot be applied in the winter months in north Florida.

- Not more than 35% of the nitrogen in controlled-release fertilizer can be released within the first seven (7) days after application.
- ***No Phosphate Fertilizer*** means phosphate levels below 0.5% intended for established urban turf or lawns. ***Low Phosphate Fertilizer*** means phosphate levels equal to or above 0.5% intended for new or established turf.
- Fertilizers labeled as low phosphate shall have directions for use that do not exceed an application rate of 0.25 lbs. phosphate per 1,000 square feet and not to exceed 0.5 lbs. phosphate per 1,000 square feet per year.
- ***Starter fertilizer*** must have use directions that do not exceed an application rate of 1.0 lb. phosphate per 1,000 square feet. Starter fertilizer recommendations are intended for one-time application to encourage root growth. Subsequent applications must be made with products meeting the definition of low or no phosphate fertilizers. The term starter fertilizer must be part of the brand name.

New urban turf is any turf that has been established for less than 12 months. New sod should not be fertilized with nitrogen during the first 30 days, or until it has firmly rooted into the soil. Plugs can be fertilized at the time of installation to encourage runner growth.

Recommended Application Rates for Turfgrass Fertilizers

with 30% or more SRN							
Lawn Square Footage	**6% N**	**10% N**	**12% N**	**15% N**	**16% N**	**23% N**	**27% N**
1,000	16.5 lbs	10 lbs	8.5 lbs	6.5 lbs	6 lbs	4.5 lbs	4 lbs
1,500	25 lbs	15 lbs	13.5 lbs	10 lbs	9.5 lbs	6.5 lbs	5.5 lbs
2,000	33.5 lbs	20 lbs	17 lbs	13 lbs	12 lbs	9 lbs	8 lbs
2,500	41.5 lbs	25 lbs	21 lbs	16.5 lbs	15.5 lbs	11 lbs	9.5 lbs
3,000	50 lbs	30 lbs	25.5 lbs	19.5 lbs	18 lbs	13 lbs	12 lbs
3,500	58 lbs	35 lbs	30 lbs	23 lbs	21.5 lbs	15.5 lbs	13.5 lbs
4,000	66 lbs	40 lbs	34 lbs	26 lbs	24 lbs	18 lbs	16 lbs
4,500	74 lbs	45 lbs	38 lbs	29.5 lbs	27.5 lbs	20 lbs	17.5 lbs
5,000	82 lbs	50 lbs	42.5 lbs	33 lbs	31 lbs	22 lbs	19 lbs

with 15–30% SRN							
Lawn Square Footage	**6% N**	**10% N**	**12% N**	**15% N**	**16% N**	**23% N**	**27% N**
1,000	8.25 lbs	5 lbs	4.25 lbs	3.25 lbs	3 lbs	2.25 lbs	2 lbs
1,500	12.5 lbs	7.5 lbs	6.75 lbs	5 lbs	4.75 lbs	3.25 lbs	2.75 lbs
2,000	16.75 lbs	10 lbs	8.5 lbs	6.5 lbs	6 lbs	4.5 lbs	4 lbs
2,500	20.75 lbs	12.5 lbs	10.5 lbs	8.25 lbs	7.75 lbs	5.5 lbs	4.75 lbs
3,000	25 lbs	15 lbs	12.75 lbs	9.75 lbs	9 lbs	6.5 lbs	6 lbs
3,500	29 lbs	17.5 lbs	15 lbs	11.5 lbs	10.75 lbs	7.75 lbs	6.75 lbs
4,000	33 lbs	20 lbs	17 lbs	13 lbs	12 lbs	9 lbs	8 lbs
4,500	37 lbs	22.5 lbs	19 lbs	14.75 lbs	13.75 lbs	10 lbs	8.75 lbs
5,000	41 lbs	25 lbs	21.25 lbs	16.5 lbs	15.5 lbs	11 lbs	9.5 lbs

Figure 5-27. Application rates of turfgrass fertilizers relative to the slow-release nitrogen content.

Established urban turf is older than 12 months. Fertilizer recommendations are intended for an application rate to maintain plant health. At any given site, application rates above those provided in the Urban Turf Rule would require a soil test to justify an increase in phosphate or a turf tissue test to justify an increase in nitrogen.

The label of urban turf fertilizers must also have the following statement in a conspicuous place: "*Apply only to actively growing turf. Do not apply near water, storm drains or drainage ditches. Do not apply if heavy rain is expected. Apply this product only to your lawn, and sweep any product that lands in the driveway, sidewalk, or street, back onto your lawn. Check with your local Cooperative Extension Agency to obtain specific information on local turf best management practices. Check with your county or city government to determine if there are local regulations for fertilizer use.*"

Total nitrogen fertilizer applications cannot exceed the annual nitrogen recommendations for the three regions of Florida listed in the *Nitrogen Recommendations* table in Figure 5-28.

Rate Calculations

To calculate the pounds of fertilizer needed to apply **one-half (0.5) pound of nitrogen per 1,000 square feet**, simply divide the nitrogen percentage (the first number of the analysis) into 0.5 (the application rate). The rate of application is easy to calculate from the information given on the fertilizer bag.

For example, you have purchased a 16-4-8 fertilizer and need to apply 0.5 lb. of nitrogen per 1,000 square feet (Figure 5-29). Divide 16% into 0.5 (0.5 ÷ 0.16 = 3.125). The results are 3.125 or 3 pounds (always round DOWN for fertilizer application amounts) of 16-4-8 to supply one-half (0.5) pound of nitrogen distributed over 1,000 square feet of landscape area.

Calculating Fertilizer Application Rates

Formula	*Example*
0.5 ÷ N% = pounds of fertilizer / 1,000 ft^2	0.5 ÷ 0.16 = 3.125 pounds of fertilizer / 1,000 ft^2 (round down to 3 lbs / 1,000 ft^2)

Figure 5-29. Formula for calculating fertilizer application rates.

According to the Urban Turf Rule, the percent of slow-release nitrogen (SRN) determines the application rate. No more than 0.7 pounds of soluble (quick-release) nitrogen per 1,000 square feet can be applied at any one time. Based on the SRN content:

- Apply only 0.5 lb. nitrogen per 1,000 square feet of lawn area per application if using a fertilizer with less than 30% of its total nitrogen in a slow-release form.
- Apply up to 1 lb. nitrogen per 1,000 feet of lawn area per application if the fertilizer has at least 30% total slow-release nitrogen.

Using the fertilizer label in Figure 5-30, note the guaranteed analysis indicates this 16-4-8 fertilizer mixture contains 8% water insoluble

Nitrogen recommendations (lbs N / 1,000 ft^2 / year) *

Species	*North***	*Central***	*South***
Bahiagrass	2 - 3	2 - 4	2 - 4
Bermudagrass	3 - 5	4 - 6	5 - 7
Centipedegrass	1 - 2	2 - 3	2 - 3
St. Augustinegrass	2 - 4	2 - 5	4 - 6
Zoysiagrass	2 - 3	2 - 4	2.5 – 4.5

* Homeowner preferences for lawn quality and maintenance will vary, so a range of fertility rates for each grass species and location is recommended. Suggested rates are based on years of nitrate leaching and turf quality research.

** North Florida is considered to be north of Ocala, Central Florida from Ocala to State Road 60, and South Florida the remainder of the state south of State Road 60.

Figure 5-28. Maximum annual nitrogen recommendations for turfgrass species in Florida.

photo by graco fertilizer company

Figure 5-30. Sample slow-release turf fertilizer label.

nitrogen. Therefore, one-half (or 50%) of the total available nitrogen (16%) is in SRN form. Because the SRN content is greater than 30%, use the application rate of 1 lb. nitrogen per 1,000 square feet (Figure 5-31). Using the formula from the previous *Calculating Fertilizer Application Rates* table, 1 ÷ 0.16 = 6.25 pounds of fertilizer per 1,000 square feet. Therefore, 6.25 lbs. of 16-4-8 can be applied per 1,000 square feet of lawn area. Remember to round down the application amount to 6 lbs.

Lawn Fertilizer Application Rates using SRN

Form of Nitrogen	*Rate of Application*
If SRN < 30%	0.5 lb. N per 1,000 ft^2
If SRN > 30%	1 lb. N per 1,000 ft^2

Figure 5-31. Recommended rates based on slow-release N.

Fertilizer Spreader Calibration

Fertilizer application is only effective if uniform coverage is achieved. Dry fertilizers can be applied with either a drop (also known as a gravity) spreader or a cyclone (also known as a rotary, broadcast or centrifugal) spreader.

A ***drop spreader*** has the advantage of applying a fairly exact pattern since it is limited to the distance between the wheels (Figure 5-32). This also allows a "tight" pattern (line) to be cut but requires that each pass meet exactly with the previous one or skips will be noticeable. Wide drop spreaders (greater than 6 feet) can become cumbersome in the landscape by limiting access around trees and shrubs or getting through gates. The agitator in the bottom of the drop spreader's hopper also may break the coating of some slow-release fertilizers.

Figure 5-32. Example of a drop or gravity spreader.

Figure 5-33. Example of a cyclone or rotary spreader.

The ***cyclone spreader*** generally has a wider pattern of distribution (Figure 5-33) compared to a drop spreader and thus can cover a larger area in a shorter time. The application pattern of the cyclone spreader also gradually diminishes away from the machine, reducing the probability of an application skip. The uneven, wide pattern of the cyclone spreader is initially harder to calibrate, and heavier fertilizer particles tend to sling farther away from the machine. However, proper calibration and experience minimize these.

Spreader calibration involves measurement of the fertilizer output as the spreader is operated over a known area (Figure 5-34). A scale for weighing the material may be needed to accurately calibrate and measure product output. To calibrate a spreader:

1) Determine the amount of fertilizer needed for 100 square feet. For example, the fertilizer bag weighs 25 lbs. and covers 5,000 square feet. Calculate the needed amount: 25 lbs. $\times$ (100 $ft^2 \div$ 5,000 ft^2) = 0.5 lb.
2) Place this amount in the spreader.
3) Mark off the area. For a cyclone spreader, use a 10 x 10 area (100 square feet). For a single pass with drop spreaders, the length required would depend on the spreader width; for a $1^1/_2$, 2, and 3 foot spreader, use $66^2/_3$, 50, and $33^1/_3$ feet respectively.
4) Apply using the suggested setting.

If the product runs out before completing the area, decrease the setting. Mark off another area the same size and repeat the test until the correct application rate is achieved. On the other hand, if any product remains in the spreader, increase the setting. Again, mark off another area the same size and repeat the test until the correct application rate is achieved.

The following method of calibration can be used if a scale and a hard flat surface is available. The hopper should be filled to the level that will be used when the material is actually applied. Spread fertilizer over the marked-off area. Catch or sweep up the material and weigh it on a scale. The result will provide the application rate for the setting used. If the application rate is too high or too low, do the test again with the setting adjusted accordingly.

Figure 5-34. Fertilizer spreader calibration in marked area.

Fertilizer Recommendations for Landscape Plantings

Topsoil is often removed from landscape sites during development and backfilled with soil of inferior quality. Since this practice creates soils low in critical plant nutrients, fertilization becomes a routine and very important part of landscape management. Wide variations exist in amounts, timing, materials and application techniques. Landscape fertilization programs are further complicated by different types, sizes, and nutrient requirements of plants growing in proximity to one another. The plant's location also impacts the fertility program and plant response. Plants growing in a residential setting require less critical attention to nutrition than plants growing in parking lot islands or other urban situations.

Fertilization is not a universal remedy for problems encountered in the landscape. Horticulture and landscape professionals must be sure plant symptoms are due to a nutrient deficiency before applying fertilizers. The strategy or reason for applying fertilizer must be considered. The goal with young plants may be to aid in establishment or to increase their growth rate. With mature plantings, fertilizer may be applied to maintain foliage color and health.

Fertilizer may not be required if plants are established and if clients are pleased with the appearance of their landscape plants. If nutrient deficiencies persist, plants may not be suited for a particular site due to soil pH, soil drainage, soil salts, limited soil volume, irrigation water quality or mineral content of the soil. In this case, replacing such plants with others adapted to the site conditions is a better remedy.

Mature trees can benefit from the application of certain fertilizers in instances where there is a deficiency. However, simply adding fertilizer around otherwise healthy, mature trees may NOT accomplish anything.

Adding fertilizer, especially nitrogen, around stressed or root damaged trees can be harmful if the stress is due to a nutrient deficiency. Harm can also occur when a tree with low nutrient reserves due to root damage or old age attempts to incorporate nitrogen into cell components. Since this metabolic process requires energy expenditure, reserves can be lowered further, leading to a decline in health and a reduced ability to fight the effects of injury and pests.

It is important to remember nutrients in fertilizers are only available for use when they are kept in plant root zones. Keeping nutrients in the root zone protects surface water and groundwater, prevents waste, encourages plant health and saves money. While proper fertilization and watering practices are safe for plants and the environment, improper practices can damage plants and can contribute to surface and groundwater pollution from nutrient leaching and runoff.

When it has been determined that fertilization is necessary, most established landscape plants should be fertilized at rates within suggested ranges to match the maintenance levels presented in the *Recommended Annual N Fertilizer Rates for Established Plants in Florida* table below (Figure 5-35). The rate of application per 1,000 square feet of bed area per year for various nitrogen-containing fertilizers is presented in the table on the next page (Figure 5-36).

Recommended Annual N Fertilizer Rates for Established Plants in Florida

Level of Maintenance	*Amount of Nitrogen Fertilizer*
Basic	0-2 pounds N / 1,000 ft^2 / year
Moderate	2-4 pounds N / 1,000 ft^2 / year
High	4-6 pounds N / 1,000 ft^2 / year

Figure 5-35. Nitrogen application rates for established plants.

Water soluble fertilizers should be applied at no more than one-half (0.5) lb. of actual nitrogen per 1,000 square feet per application. Application rates of controlled-release fertilizers depend on the release rates of the product.

The phosphorus content of landscape fertilizers should be 0% to 2% phosphate. Historically, the ratio of nitrogen (N) to potassium (K_2O) in landscape plants has been in the range of 1:1 to 2:1. A 15-0-15 analysis is an example of a fertilizer utilizing the 1:1 N to K_2O ratio. Due to the prevalence of magnesium (Mg) deficiency in certain landscape plants in many parts of the state, up to 2.5 pounds Mg per 1,000 square feet per year may be applied to address this problem.

Micronutrients should be applied as needed at specified rates and timing to achieve fertilization objectives. They may be applied as part of a fertilizer or applied separately as a special mix. Due to the danger of applying excessive amounts that may be toxic to plants, micronutrients should be applied singularly to the soil only in the case of severe deficiencies. Chlorotic plants are common in soils with high pH. This occurs because many micronutrients such as iron (Fe), manganese (Mn) and zinc (Zn) are tied up in alkaline soils. Nutrient sprays applied to the foliage, or a micronutrient mixture applied to the soil may correct the problem temporarily; however, long-lasting correction will involve lowering the soil pH. Maintenance of recommended pH levels will minimize micronutrient deficiencies.

Special Recommendations

Some plants have precise nutritional requirements. Recommendations are specific for certain groups of plants that require a different pH or special culture. Three examples

Number of Pounds of Fertilizer (per 1,000 ft² / yr.) to Use for Fertilizer Containing Various Percentages of N

	Rate (lbs N / 1,000 ft² / yr.)						
% N in Analysis	**0.5**	**1**	**2**	**3**	**4**	**5**	**6**
6	8	17	33	50	67	83	100
7	7	14	29	43	57	71	86
8	6	12	25	38	50	63	75
9	6	11	22	33	44	56	67
10	5	10	20	30	40	50	60
11	5	9	18	27	36	45	55
12	4	8	17	25	33	42	50
13	4	8	15	23	31	39	46
14	4	7	14	21	29	36	43
15	3	7	13	20	27	33	40
16	3	6	13	19	25	31	38
17	3	6	12	18	24	29	35
18	3	6	11	17	22	28	33
19	3	5	11	16	21	26	32
20	2	5	10	15	20	25	30
33	1	3	6	9	12	15	18
39	1	3	5	8	10	13	15
46	1	2	4	7	9	11	13

Figure 5-36. Fertilizer application rates based on pounds of nitrogen per 1,000 ft² and the percentage of nitrogen in the analysis.

are roses, azaleas, and citrus. In general, ***acid-loving plants*** require frequent and light applications of special fertilizers due to the heavy leaching of nutrients from sandy soils. For example, 0.5 pound of 12-4-8 or 15-5-15 should be applied per 100 square feet of planting area four (4) times a year. Applications are recommended:

1) before spring growth begins;
2) after the first growth flush;
3) midsummer; and
4) early winter after the danger of late growth has passed.

Use care when fertilizing ***flowering plants*** (such as azaleas) after the first growth flush. Too much nitrogen results in a flush of growth that causes flowers to abort. Avoid late summer fertilization since it may cause tender new growth to occur that could be injured by early cold periods. Water the plants before and after fertilizer applications.

Groundcover plantings and other areas where plants more or less cover the entire surface area can be fertilized with 1 lb. of nitrogen per 1,000 square feet of surface area, per application, occurring two (2) to four (4) times per year.

Fertilizer Recommendations for Palms

Palms have very different nutritional requirements than other landscape plants. They suffer quickly and conspicuously from improper mineral nutrition, whether due to insufficient or incorrect fertilization. Palms also may exhibit certain nutritional disorders in unique ways compared to other ornamental plants. Some nutritional problems are difficult to diagnose accurately because symptoms of several different mineral deficiencies may overlap. Nutritional disorders common to palms in the production field, container nursery and landscape are briefly discussed in the following section. Fertilization recommendations for palms in these situations are also provided.

Palm Nutritional Disorders

Palms growing in Florida landscapes or nurseries are subject to a number of potentially serious nutrient deficiencies. These nutrient deficiencies are more easily prevented than corrected once they occur. Correction of nutrient deficiencies can take as long as two (2) or three (3) years for some elements.

Nitrogen

Nitrogen (N) deficiency is fairly common in Florida palms and is typically the most limiting element in container production. However, deficiencies of other elements such as potassium (K), magnesium (Mg) and manganese (Mn) are much more prevalent and serious in the landscape. Symptoms of N deficiency (Figure 5-37) in palms include an overall light green color and decreased vigor. Growth virtually stops when N deficiency is severe, but the palms may linger in this condition for a considerable length of time. Older palms in the landscape or field exhibit greatly reduced canopy size, very light green color, and tapered trunks (known as ***pencil pointing***). This problem is easily corrected by applying any N fertilizer to the soil. Leaf color quickly darkens in response to either soil or foliar fertilization.

photo by uf/ifas

Figure 5-37. Nitrogen deficiency in Alexander palm (*Ptychosperma elegans*).

Potassium

Potassium (K) deficiency is perhaps the most widespread and serious of all disorders in Florida palms (Figure 5-38). Symptoms occur first on the oldest leaves and progressively affect newer leaves as the deficiency becomes more severe. Symptoms vary among palm species, but typically begin as translucent yellow or orange spots on the leaflets. These may or may not be accompanied by necrotic spots. As the symptoms progress, the leaflet or entire leaves will become withered or frizzled in appearance. The midrib usually remains alive on K deficient leaves, although it may be orange instead of green in some species.

photo by scot nelson, creative commons license

Figure 5-38. Potassium deficiency in blue cane palm (*Dypsis cabadae*).

photo by bob cook

Figure 5-39. Magnesium deficiency in Canary Island date palm (*Phoenix canariensis*).

Magnesium

Magnesium (Mg) deficiency is also quite common in Florida palms (Figure 5-39), but especially in *Phoenix* species. As with K deficiency, symptoms occur first on the oldest leaves and progress up through the canopy. Typical symptoms are a broad, light yellow band along the margin of the older leaves with the center of the leaf remaining distinctively green. In severe cases, leaflet tips may become necrotic, but Mg deficiency is rarely if ever fatal to palms.

Sulfur

Sulfur (S) deficiency occasionally occurs in containers if sulfate fertilizers are not used. Symptoms are virtually identical to those of Fe deficiency and can only be correctly diagnosed by leaf nutrient analysis.

Manganese

Manganese (Mn) deficiency or ***frizzletop*** is a common problem in palms growing in the alkaline soils that cover much of south Florida (Figure 5-40). Symptoms occur only on new leaves, which emerge chlorotic, weak, reduced in size, and with extensive necrotic streaking in the leaves. As the deficiency progresses, succeeding leaves will emerge completely withered, frizzled, or scorched in appearance and greatly reduced in size. Later, only necrotic petiole stubs will emerge and death of the bud quickly follows.

photo by bob cook

Figure 5-40. Manganese deficiency in queen palm (*Syagrus romanzoffiana*).

Manganese deficiency is primarily caused by the element's insolubility in high pH situations. In some palms, such as coconut, cold soil temperatures during the winter and spring months reduce root activity and thus the uptake of micronutrients (especially Mn). Coconut palms severely deficient in Mn during the winter and spring will usually grow out of the problem without special treatment once soil temperatures warm in late spring. Other palms such as queen, royal, paurotis, and pygmy date palms are highly susceptible to Mn deficiency and must be treated with soil or foliar applications of manganese sulfate, or they will likely die.

Iron

Iron (Fe) deficiency usually appears on palms growing in poorly aerated soils or those that have been planted too deeply. Waterlogged soils and deep planting effectively suffocate the roots. Symptoms appear first on the new leaves (Figure 5-41); in most palms, the deficiency consists of uniformly chlorotic new leaves. As the deficiency progresses, new leaves will show extensive tip necrosis and reduced leaf size. Early symptoms in queen palms include pea-sized green spots on otherwise yellowish new leaves.

photo by uf/ifas

Figure 5-41. Iron deficiency in queen palm specimen on the left (*Syagrus romanzoffiana*).

Boron

Boron (B) deficiency results in a wide array of symptoms that always occur on newly emerging leaves (Figure 5-42). The symptoms remain visible on these leaves as they mature. One of the earliest symptoms of B deficiency in several species is a crosswise, translucent streaking on the leaflets. Mild B deficiency can be exhibited as sharply bent leaflet tips, commonly called ***hookleaf***. These sharp leaflet hooks are quite rigid and cannot be straightened without tearing the leaflets. A temporary shortage of B can cause necrosis (dead tissue) on leaflet tips.

One of the most common symptoms of B deficiency is the failure of newly emerging leaves to open normally. They may be tightly fused throughout their entire length or the fusion can be restricted to only the bottom or top parts of the leaf. An acute B deficiency often produces leaves greatly reduced in size and crumpled in a corrugated fashion ("accordion leaf"). Perhaps the most unusual symptom of chronic B deficiency is the tendency for the entire crown to bend in one direction. Boron deficient palms often abort their fruits prematurely and inflorescences may have extensive necrosis near their tips. These symptoms are very similar to those of lethal yellowing in species affected by that disease.

Boron is readily leached through most soils. A single heavy rain event can temporarily leach most available B out of the root zone. When this leaching stops, a release of B from decomposing organic matter will again provide adequate B

photo by uf/ifas

Figure 5-42. Boron deficiency in Sagisi palm (*Heterospathe elata*).

for normal palm growth in most cases. Extreme caution should be exercised when applying B fertilizers because the difference between deficiency and toxic levels of B within plants is rather small. Many landscape maintenance fertilizers typically contain 0.05% to 0.15% B, and that appears to be sufficient to prevent B deficiencies in most cases.

Palm Deficiency Diagnosis

Diagnosis of nutrient deficiencies by visual symptoms alone can be difficult, since various symptoms overlap considerably in some species. For instance, Mn and late stage K deficiencies are easily confused in queen and royal palms. Potassium and Mg deficiencies are very similar in pygmy date palms, and K and Fe deficiencies can be very similar in royal palms. Correct diagnosis can be assured only if leaf nutrient analysis is performed on symptomatic palms.

Palm Fertilization Programs

Special palm fertilizers (Figure 5-44) contain additional Mg and a complete micronutrient amendment (1% to 2% Fe and Mn, plus trace amounts of Zn, Cu, and B). The regular use of a fertilizer having an analysis of 8-2-12 + 4% Mg with micronutrients has been shown to correct mild to moderate deficiencies and prevent their recurrence in most Florida soil types. It is essential that 100% of the N, K, and Mg in such a fertilizer be in slow-release form since Florida soils have very low nutrient holding capacities to retain these elements in the root zone during periods of heavy rainfall or irrigation. Unlike the slow-release form of the macronutrients N, K, and Mg, most micronutrients need to be in a water soluble form. However, granular slow-release forms of boron are safer and more effective for Florida landscape soils.

Because field and landscape soils are very different in chemical and physical properties from those used in container production, recommended fertilizer formulations are also very different for these two growing environments. Fertilization of field nursery or landscape palms depends on the soil type and climate in which they will be grown.

Field Grown Palms

Fertilization rates for field grown palms (Figure 5-43) will vary with the soil type and size. The 8-2-12 + 4% Mg with micronutrients fertilizer blend described previously should release nutrients for up to three months. The suggested application rate for field nurseries is 3 lbs. per 100 square feet of palm canopy area. Fertilizers should be applied four (4) times per year for maximum growth, but on the more fertile marl and muck soils, fewer applications may be adequate.

Foliar fertilization is a fairly common practice in palm production. This is a rather inefficient method for providing macronutrient elements such as N, K and Mg. However, it is very useful for supplying micronutrients such as Mn and Fe to the plants when soil conditions prevent adequate uptake of these elements by the roots. Foliar fertilization is best used as a supplement in a normal soil fertilization program, particularly for micronutrients, and can be accomplished in conjunction with regular fungicide applications.

Liquid fertilization programs are not the most resourceful delivery system for field nurseries, especially when overhead irrigation is used. The soluble nature of liquid fertilizer results in leaching or runoff of a great deal of the nutrients before uptake by the roots. If drip irrigation is used in the field, injection of liquid fertilizer through the system may be cost-effective, and the problems inherent in overhead delivery may be minimized.

photo by gale albritton

Figure 5-43. Recently field harvested Washington palms (*Washingtonia robusta*).

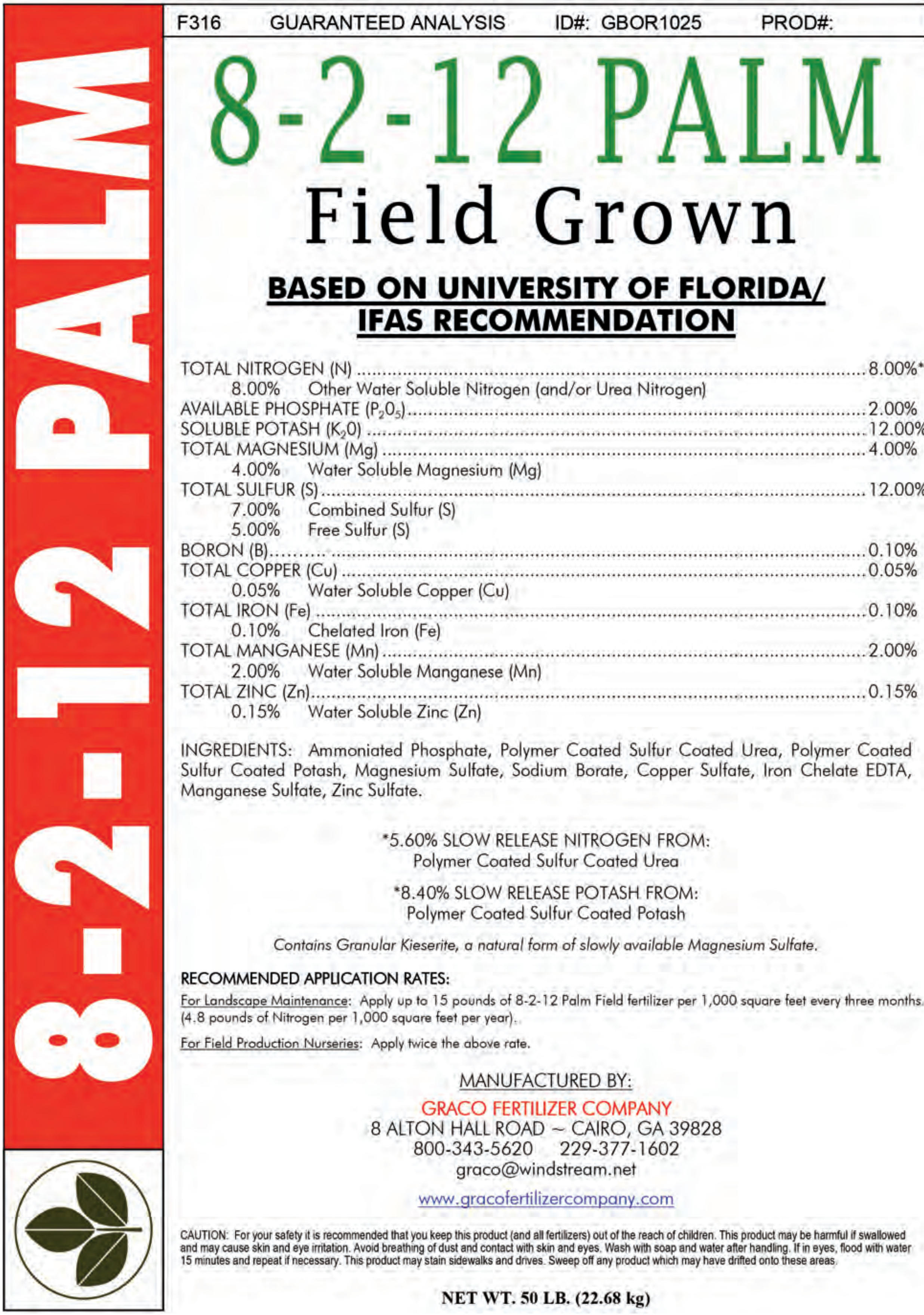


photo by graco fertilizer company

Figure 5-44. Specially formulated palm fertilizer with additional magnesium and micronutrients.

Container Grown Palms

For containerized palms (Figure 5-45), a fertilizer with an N-P-K ratio of 3-1-2 is commonly used, but a 3-1-3 is preferable. An 18-6-12 or similar slow-release fertilizer is often incorporated into the container medium at planting time at a rate of seven (7) to 10 lbs. per cubic yard. Additionally, one and one-half (1.5) to two (2) lbs. of a micronutrient blend containing sulfate forms of Mn, Zn, Cu and Fe should also be incorporated per cubic yard of planting medium. Magnesium (Mg) is typically lacking or insufficient in most container fertilizers. Therefore, 12 to 15 lbs. of dolomite per cubic yard is commonly combined with the mix. The primary purpose of incorporating dolomite into potting soils used for palm production is to provide a slow-release form of Ca and Mg rather than increase pH.

If constant liquid fertilization programs are used instead, approximately 200 ppm N and 150 ppm K with 50 to 75 ppm Mg, will probably be adequate. Leaching should be performed once a month if the crop subjected to constant fertilization is not exposed to rainfall. When soil temperatures drop below 65^{0}F, fertilization rates should be reduced. Research has shown that controlled-release fertilizers are slightly better than liquid fertilization, both in terms of palm growth response and in terms of reducing nutrient leaching losses into the environment.

Landscape Palms

Mature palms in the landscape (Figure 5-46) should optimally receive a complete granular fertilizer formulated for palms such as the 8-2-12 + 4% Mg with micronutrients. Apply up to 15 pounds of 8-2-12 palm fertilizer per 1,000 square feet of canopy area every three (3) months or four (4) times per year. For landscapes in central and north Florida, winter applications can be omitted, but lower application rates may also be adequate. When palms are an important landscape feature, dropping below a minimum of two applications per year is not recommended, even for the most budget-conscious maintenance schedules. On fill soils, even two applications may not be enough.

Fertilizers should be broadcast or banded under the canopy of the palm, but should not be placed up against the trunk where newly emerging roots may be injured. Concentrating fertilizer in holes, with spikes, or in bands around the trunks of palms is less effective than spreading the same amount of fertilizer uniformly throughout the area under the canopy. This is because nutrient movement is almost exclusively downward; thus, only that small proportion of the palm root system directly under concentrated fertilizer will ever be exposed to these nutrients. A concentration of fertilizer is also much more likely to burn palm roots than fertilizer spread out over a larger area.

photo by joy dorst

Figure 5-45. Container production of Sago palm (*Cycas revoluta*).

photo by gale allbritton

Figure 5-46. Pygmy date palm (*Phoenix roebellini*) in the landscape.

Trunk injection of micronutrients is not recommended for palms except in cases where soil applications have been ineffective in alleviating chronic micronutrient deficiency symptoms. Since palms lack a vascular cambium and, thus, the ability to heal over wounds in the trunk, any holes created in the process of injecting palm trunks will remain as permanent scars and may provide entry sites for diseases or insect pests.

A fertilizer that is suitable for palms will be more than suitable for other types of plants because palm nutritional requirements are higher than most other landscape plants. Use of 8-2-12 + 4% Mg with micronutrients fertilizer on the entire landscape not only simplifies fertilization by having to use only a single product, but eliminates a serious problem encountered when high N turf fertilizers are applied to turf areas with palms growing nearby.

Sometimes it may not be possible to control what kinds of fertilizer are applied within the area covered by a palm's root system (Figure 5-47). If turfgrass near a palm has been fertilized with a typical high N:K ratio turf fertilizer, negative impacts can be prevented by fertilizing the area under the canopy of the palm with a fertilizer formulation having no N or P, such as 0-0-16 + 6% Mg, instead of the usual 8-2-12 + 4% Mg. This approach may also be more cost-effective than fertilizing the entire landscape with 8-2-12 + 4% Mg for mixed landscapes containing palms and turfgrass.

Fertilizer Application Precautions

Excess water moving over and through the ground picks up and carries varied natural and human-made pollutants along the way only to deposit them into lakes, rivers, wetlands, coastal waters and groundwaters. Excessive nutrient loading to Florida's surface and ground waters is one of the biggest water quality issues facing our state. A major source of nutrient loading is from fertilizers applied to urban landscaping; so remember, it is far easier and much less expensive to minimize the amount of nutrients that get into our waters than it is to treat stormwater and other ***non-point sources*** of pollution.

photo by gale albritton

Figure 5-47. Palms growing in landscape beds among other plant types surrounded by turf.

Fertilizer application can increase water use by creating the need for an additional irrigation cycle following nutrient application. Furthermore, too much fertilizer can weaken plants and have downstream impacts on water quality. Fertilizer in runoff from urban landscapes can impair ecosystems and waterbodies. To minimize the impact of such fertilizers, the State of Florida has undertaken several initiatives to promote Florida-Friendly Landscaping™. One of the principles of Florida-Friendly Landscaping™ includes appropriate fertilization along with efficient watering to reduce stormwater runoff potential and protect water quality.

Several precautions and practices can be implemented when applying fertilizers to ensure that no injury occurs to plants or the environment. They include:

- **Apply the right fertilizer.** This is especially important for fertilizers with pesticides mixed in them. If using a "weed and feed" type of fertilizer, be sure that it is applied only to the correct grass and that it does not get into the roots of shrubs and trees.
- **Use the right application rate.** Overfertilization is a major cause of plant injury (Figure 5-48). Excess fertilizer also leaches and may cause water pollution.

photo by bob cook

Figure 5-48. Too much fertilizer applied to a landscape palm.

- **Be sure plants being fertilized have adequate moisture.** Plants under water stress or wilted plants can be severely injured by applying fertilizers to them.
- **Spread the fertilizer evenly according to the method of application.** Broadcast fertilizers should be evenly dispersed over the entire area (Figure 5-49). When fertilizing individual plants, the same amount of fertilizer should be applied to each plant of the same size and type. Row fertilization and side dressing should be evenly distributed within the row.

photo by bob cook

Figure 5-49. Uneven fertilizer disperal results in highly visible light and darker green strips throughout.

- **Avoid getting dry fertilizer on the leaves and green stems of plants.** In situations where fertilizer does get on the leaves (Figure 5-50), remove as much as possible prior to watering. Watering after fertilizer application will wash any fertilizer dust off the leaves and will begin to activate the fertilizer. Dry fertilizers should never be applied to wet plants. If a foliar application

photo by gale allbritton

Figure 5-50. Fertilizer remaining on leaves after application is unattractive and will burn foliage.

of liquid fertilizer is used, the plants should not be watered immediately after application.

- **Always leave a "ring of responsibility"** (Figure 5-51) around or along the shoreways of canals, lakes or waterways except when adjacent to a protective seawall. This avoids fertilizing too close to a body of water. It is important to ensure that fertilizers and other lawn chemicals do not come into direct contact with the water or with any structure bordering the water, such as a sidewalk, brick border, driveway or street.

Fertilizer Applicator Certification

Florida requires the use of best management practices (BMPs) for commercial fertilizer applications. BMPs provide specific management guidelines to minimize negative secondary and cumulative environmental effects associated with the misuse of fertilizers. Application of any fertilizer "for hire" requires a certification per Florida law. The ***Limited Urban Commercial Fertilizer Certification*** allows applicators to perform fertilizer treatments on urban properties. It does not allow any other kind of pesticide applications (including weed and feed fertilizers) to turf or ornamental areas.

Examples of applicators impacted by this regulation include commercial lawn maintenance or landscape maintenance individuals who apply fertilizers to lawn and ornamental plants in turf and plant bed areas associated with residential, governmental or commercial structures such as homes, schools, municipal/agency offices, banks, grocery stores, apartments, condominium common areas, hotels, restaurants, etc. This certification does not allow or authorize the maintenance company or the applicator to operate a pest control business. Neither does it allow supervision of noncertified fertilizer applicators.

More information about procedures to obtain fertilizer applicator certification is presented in the *Business Practices* chapter of this text.

photo by marion county soil & water conservation district (IN)

Figure 5-51. Ring of responsibility around a lake.

BMPs for Landscape Management

Many of Florida's water resources are particularly susceptible to pollution because of the state's unique geology and climate. Floridians obtain almost all of their drinking water from groundwater via wells. Groundwater supplies often lie near the surface and may be covered by nothing but sandy soil. Furthermore, surface waters in Florida are very sensitive to even small additions of pollution, which cause widespread ecosystem changes in sensitive estuaries, lakes, rivers, springs (Figure 5-52) and the Everglades.

Best management practices (BMPs) are individual practices or combinations of practices that, based on research, field testing, and expert review, have been determined to be the most effective and practical means for maintaining and/or improving water quality. BMPs typically are implemented in combination to prevent, reduce, or treat pollutant discharges. To be useful, BMPs must be based on sound science, and be technically and economically feasible. It is good stewardship to prevent or minimize impacts of non-point sources of pollution (both urban and agricultural) by using BMPs.

Fertilizer BMPs

- ► Become knowledgeable in soil sampling procedures and soil test interpretation.
- ► Do not fertilize if heavy rainfall is expected, especially tropical or frontal weather systems.
- ► Avoid both leaching and surface runoff. Match the product to the situation. Remember, all fertilizers, even slow-release products, contain nutrients that can cause pollution if allowed to escape the root zone.
- ► Be aware of the effects soil pH, shade, overwatering, or other stresses may have on plants. Be sure fertilization is the correct response to the problem.
- ► Become proficient in reading and understanding the fertilizer label.
- ► Know the exact square footage of the area where fertilizer is being applied and make sure the spreader/application equipment is properly calibrated and set to deliver the correct amount of fertilizer to that area.
- ► Remember that the rate and timing of nitrogen (N) fertilization depends on the turfgrass species, season of the year, level of maintenance desired, source of N applied, and location in the state.
- ► Limit water soluble (quick-release) nitrogen applications to 0.5 lb. per 1,000 ft^2. This includes the water soluble part of slow-release blends. Limit total N to 1 lb. per 1,000 ft^2 per the Urban Turf Rule.
- ► Phosphorus (P) application should be limited to soils that require additional P based on soil or tissue testing.
- ► Limit nitrogen (N) and phosphorus (P) fertilization at establishment to one time 30 days after seeding/sodding. Do not add N or P before installation, but amend the soil as needed with lime or organic matter.
- ► Always leave a Ring of Responsibility near waterbodies or impervious surfaces. Always use deflector shields on cyclone spreaders when applying fertilizer near water or sidewalks, driveways and streets.
- ► Sweep any fertilizer left on impervious areas back into the vegetated area.
- ► When fertilizing (other than when watering restrictions apply), irrigate with ¼ inch of water following fertilization to avoid the loss of N and increase uptake efficiency. If water restrictions apply, irrigate as allowed, but more than ½ inch may cause some N to be leached past the root zone.
- ► Use iron (Fe) and/or manganese (Mn) instead of nitrogen (N) to enhance turfgrass color on soils having a pH greater than 7.0, especially during times of enhanced rainfall.
- ► Maintain a healthy, actively growing turfgrass to minimize the environmental impact of fertilizer and pesticide application, erosion, and stormwater runoff.
- ► There is no significant difference between liquid and dry applications of similar products. In terms of BMPs for environmental protection, the proper application of fertilizer is more important than the type of product.

The Florida Friendly Best Management Practices for Protection of Water Resources by the Green Industries, while not regulatory in nature, provides guidance for landscape practices that help reduce pollution and conserve water. The guide provides information on many areas, especially pertaining to irrigation and fertilizer use, in an effort to enhance the protection of water resources and reduce the potential of pollution from non-point source pollution.

Environmental and Cultural Factors

Soil susceptibility to leaching and runoff, distance to the water table, slope of the land and distance to surface waters or storm drains are factors that should be considered when fertilizers and pesticides are used. Soil texture, organic matter content, soil moisture and permeability all influence fertilizer and pesticide movement. Some materials readily move through soils that are well drained, sandy, or low in organic matter. If sinkholes are present, surface water runoff (Figure 5-53) can quickly reach groundwater with little natural soil filtering, thus resulting in fertilizer or pesticide contamination in these vulnerable areas.

Figure 5-52. BMPs help preserve clear, natural springs.

Figure 5-53. Routine adjustment of sprinkler heads improves horticultural maintenance and helps avoid surface water runoff.

Plant selection and location are the most important factors when planning a lawn and landscape. Cultural practices including irrigation, fertilization, mowing and pruning, aeration and dethatching are some of the biggest factors in determining how well a horticultural maintenance program performs. The amount of pesticides, fertilizers and water often required directly correlates with plant selection and the resulting cultural practices necessary to properly maintain a landscape.

BMPs for Nursery Plant Production

The Water Quality / Quantity Best Management Practices for Florida Nurseries is designed to help growers identify and promote exceptional management practices, methods and procedures. The practices outlined in this guide enable container and field grown plant producers to implement proactive management practices necessary to produce plants with minimal environmental impact at a higher level of efficiency and effectiveness.

The BMP approach to managing nutrients depends on maximizing nutrient efficiency while reducing nutrient loss to the environment. Using the correct amount of fertilizer and applying that fertilizer according to a proper schedule and method of placement can accomplish optimum fertilization. The goal of fertilization management is to ensure that applied nutrients benefit plant yield and quality, yet reduce negative environmental impact. Remember that nutrients in the substrate solution can be leached regardless of the type of fertilizer applied. Good irrigation management is also critical to successful fertilization management (Figure 5-54).

Below are key guidelines for implementing specific BMPs included in the *Water Quality/ Quantity Best Management Practices for Florida Nurseries* manual:

1) **Understand Water Quality Issues.** Water quality includes chemical, biological, and physical characteristics. Elevated levels of phosphorus, nitrogen, sediment, bacteria, and organic material contribute to the degradation of water quality. The potential for discharges from nursery operations to cause water quality problems varies, depending on soil type, slope, drainage features, nutrient management, and activities in or near wetlands, surface waters, or sinkholes.
2) **Manage Nutrient Sources Properly.** Minimize the pollutants that leave nursery property by controlling the types and uses of materials applied. Nutrient related

Figure 5-54. BMP practices such as drip irrigation to manage nutrient discharges and irrigation applications along with reduced water volume to minimize erosion potential. Exposed soil in aisles is covered as an erosion control measure.

pollutant discharges can come from excessive use or inefficient placement or timing of commercial fertilizer, manure, and/or biosolids applications. Managing nutrients carefully is critical to protecting water quality.

3) **Manage Irrigation Carefully.** Water is the carrier for nearly all pollutants. Precisely managing irrigation inputs to keep moisture primarily in the plant's root zone will significantly reduce nutrient related impacts from fertilizers. Overirrigating may exceed the soil's water holding capacity and lead to runoff or leaching.

4) **Minimize the Potential for Erosion Impacts.** Land clearing, culvert installation, road building, and ditch or canal maintenance can expose soil and lead to erosion that can increase pollutant loading. It is important to take appropriate erosion control measures during these activities.

It is the responsibility of the nursery industry to protect water quality by implementing good land and water management practices. BMPs include many preventative measures that minimize potential water quality and quantity impacts. Implementing BMPs helps demonstrate the industry's commitment to protecting water resources, and garners support for this nonregulatory approach.

Summary

The goal of any fertilization program is to compensate for nutrient deficiencies in the soil and to sustain healthy growth that allows plants to remain competitive against disease, insect, and weed invasion. Too much nitrogen promotes excessive growth, which increases maintenance costs and time. Disposing of excess growth as yard waste is an additional problem and expense. Application of too much soluble nitrogen also causes environmental concerns, such as, nitrogen leaching into water supplies or polluting surface waters of lakes, rivers, bays and retention ponds. Additionally, nitrogen is not utilized efficiently by unhealthy plants. Diseased or damaged roots, improper soil pH, waterlogged sites and plantings that are too deep can result in inefficient nutrient absorption and nutrient deficiency symptoms.

Protecting surface water and groundwater is not something to be taken lightly. Neither should neglecting lawn and landscape areas for fear of introducing nutrients and pesticides into water supplies be considered a way to protect these resources. Properly maintaining turf and landscape areas with appropriate but modest use of fertilizers and pesticides will do more to protect water resources than to hurt them.

Best management practices are science-based, practical, effective and environmentally safe landscape management and production strategies. Research has shown that properly managed turfgrass, landscapes and production nurseries do not significantly contribute to nonpoint source pollution. Developing low-risk irrigation, fertilizer, and pesticide programs, and ensuring that these programs are properly administered and periodically reviewed, reduces the possibility of nutrient movement off site. BMPs help conserve and protect Florida's ground and surface waters, save money, time and effort, increase the beauty of the landscape, and protect the health of people, pets and the environment. FNGLA certified professionals (Figure 5-55) safeguard the environment through adherence to industry best management practices.

Figure 5-55. Horticulture professional monitoring plant production to ensure application of BMPs in the nursery.

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