CHAPTER III
Requirements for Plant Growth

Table of Contents

LEARNING OBJECTIVES, CHAPTER III

The FNGLA Certified Horticulture Professional should be able to:

-Describe the role of soil in plant growth.
-Name the desired characteristics of soils or growing media.
-Describe the importance of organic matter in soils.
-Explain the importance of soil pH in growing plants.
-Describe the procedure for taking a soil sample.
-Name the materials that may be used to raise the pH and explain why it is difficult to lower the pH in some soils.
-Using references, determine the kind of material and amount to apply, in a given situation, to change the pH.
-Describe the difference between macronutrients and micronutrients.
-Name the primary fertilizer elements. Given the analysis of a fertilizer, determine how much nitrogen is in a given amount of that fertilizer.
-Name the factors, other than the primary fertilizer content, that add to the cost and value of fertilizer.
-Explain the importance of the Florida Fertilizer Label and understand changes to urban turf labels
-Using references make fertilizer recommendations for ornamental plants, turfgrasses and palms. Include: when, what fertilizer, how much and how often.
-List the major precautions and procedures when applying fertilizers
-List precautions in applying dry fertilizers.
-Describe the procedure for calibrating a fertilizer spreader.
-List water-stress symptoms in plants.
-Describe the symptoms of excessive water in plants.
-Describe and compare two of the methods for deciding when to water.
-List undesirable contaminants that may reduce the quality of irrigation water.
-Name the tests that should be made on irrigation water.
-Describe the influence light and temperature have on plant growth.

Soils and Plant Nutrients

Soil is composed of inorganic material, organic matter, air, water, and living organisms. Inorganic material in the soil is formed from the weathering of parent rock or parent material. An essential difference between a fertile soil and a mass of rock fragments is the organic content of the soil. Organic matter comes from decaying plant and animal life, animal excretion and other living organisms. Organic matter improves water and nutrient holding capacity, aeration, granulation, and supports bacterial life and other soil organisms that make nutrients available to plants. Bacteria and fungi live in the soil and exist mainly on plant and animal residues. Most are beneficial, by helping to breakdown complex organic compounds into simpler chemicals that higher plants can use. Some bacteria and fungi in the soil may be harmful as plant disease-causing organisms.

Most soils in Florida are coarse textured mineral soils. Soil texture refers to the size of the mineral soil particles (inorganic material). Sand particles are large and coarse, whereas, silt and clay particles are much smaller and are considered fine textured. Fine textured soils have slower water percolation and hold more nutrients than coarse textured soils. However, fine textured soils may be poor soils for growing plants due to poor drainage and aeration. An ideal soil for growing plants combines the drainage and aeration of a coarse textured soil, with the water and nutrient holding capacity of a fine textured soil.

The "ideal" soil would have mineral material, air, water and organic matter in the amounts approximated in Figure III-1. These characteristics are often present in loam soils, which are not very common in Florida. Often the soil characteristics are not ideal for plant growth, in which case they can be modified using soil amendments.

Soil amendments are added to improve physical characteristics of the soil. Soil characteristics that can be altered using amendments are: structure, drainage, water holding capacity, and nutrient holding capacity.

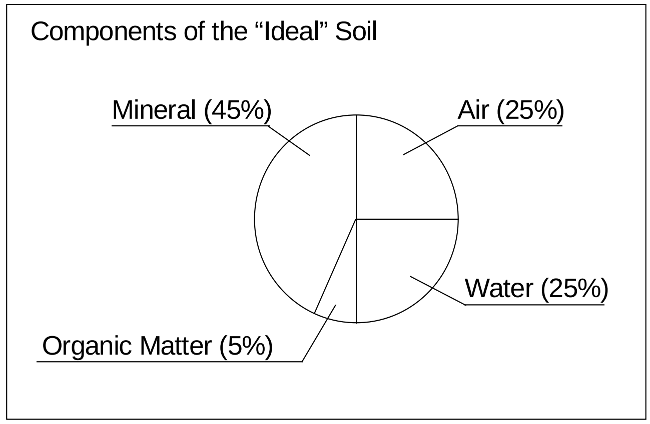
Organic matter is often considered the most important soil amendment. Organic materials recommended for soil modification include various composts, sphagnum peat, Florida peat, wood chips, pine bark, sawdust, and wood shavings. If wood products are used, a nitrogen source (fertilizer) should be present while the wood is decaying. Green manure (vegetation) from a cover crop or other source is excellent for improving soil conditions, but decomposition time needs to be allowed.

To be effective, a large volume of any organic material should be used. Organic matter should be applied at a depth of 1 to 3 inches and incorporated uniformly into the top six (6) inches of the soil. The use of organic mulches will, over time, improve soil conditions. In established plantings, the use of organic mulch is the best method of incorporating organic matter into the soil. Other amendments such as nitrogen, phosphorus, or lime may also need to be incorporated depending on existing soil conditions.

Several inorganic products may be used to improve soil conditions. Calcined clay improves water holding capacity, and in some instances, may improve drainage and aeration. Colloidal phosphate has also been used successfully as a soil conditioner. Vermiculite is sometimes used to increase water and nutrient holding capacity. Perlite is yet another inorganic conditioner that is used to improve drainage characteristics.

In determining whether to use a soil amendment, availability, cost and the difficulty of applying the material must be weighed against the potential improvements. Nearly all soil conditioners require incorporation into the soil.

Figure III-1

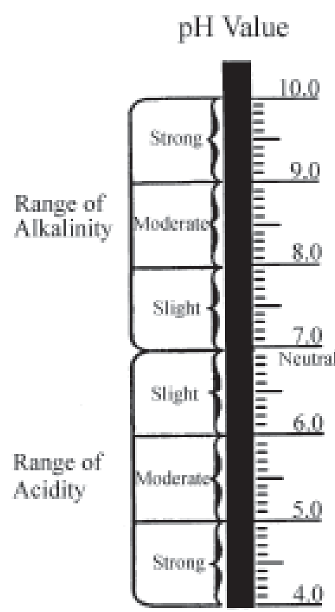


Soil Reaction (pH)

Soil reaction refers to the acidity or alkalinity of the soil. Soil reaction is measured as pH on a scale of 0 to 14, with the midpoint, 7, being neutral. A pH above 7 is alkaline, and alkaline soils are often referred to as basic or sweet. A pH below 7 is referred to as acidic or sour. See Figure III-2.

Most plants grow best in a pH range of 5.5 to 6.5. Some plants, such as azaleas, gardenia, and ixora, do better in acid soils with a pH of 4.5 to 5.5, while other plants grow well over a wide pH range. Plant pH requirements are determined from scientific experimentation or extended accurate observation. It is wrong to assume a particular species will grow best at pH 5.5 to 6.5 simply because most plants do best in that range; however, if it is necessary to speculate, 5.5 to 6.5 would be the best guess. Specific examples of desirable pH ranges for selected plants are shown in Figure III-3.

Figure III-2



Well-drained sandy soils, low pine flatwoods, and organic soils are frequently acidic in Florida. If the pH is low, any of these soils can benefit from the addition of lime. In contrast, many of the soils in extreme South Florida and along coastal areas have a high pH.

Be aware that many pesticides, herbicides, insecticides and liquid forms of fertilizer perform best with a water pH of 5.5 to 8. Be sure to test your water as well as your soil.

Soil pH cannot be measured visually and should always be tested before adding amendments. Measuring pH can be done easily. A number of simple chemical tests are available which are accurate enough for horticultural use. A wide variety of pH meters, ranging from several dollars to more than a thousand dollars, are also available. You should work closely with your University of Florida Extension Service office on soil testing both for pH and nutrients.

Soil testing "sample collection and submission forms" are available from your local Extension office or the University of Florida Extension Soil Testing Laboratory. UF publications Container Media Test Information Sheet SL-134, Producer Soil Test Information Sheet SL-135 or Landscape & Vegetable Garden Test Information Sheet SL-136 should be referenced for additional information (see Bibliography).

Soil Testing Procedures

A soil test will provide information to you about the nutritional status of a soil and may aid in the detection of potential problems which could limit growth. Test the soil area to be fertilized prior to purchasing fertilizer. To test soil in the landscape, obtain a composite soil sample by removing subsamples from 10 to 15 small holes dug throughout the sample area (i.e. the front yard). Carefully pull back mulch, grass or ground covers to expose bare soil. With a trowel or shovel, dig the small holes 6-inches deep and remove a 1-inch thick by 6-inch deep slice of soil from the side of each hole. Combine and mix the subsamples in a clean plastic bucket. Obtain separate composite samples from areas that have different soil types, receive different cultural practices or contain plants that have distinctly different fertility requirements. Two to three areas of a ¼ - to 1-acre lot will often be sampled separately.

Composite container media samples should be collected from blocks which contain plants that are treated and grown under similar conditions, such as media, irrigation, container size, etc. Using a soil probe, collect 5 to 20 subsamples from plants within the block. Samples should include media from the entire container profile, removing the top layer to avoid inclusion of fertilizer. Combine and mix media in a clean plastic bucket prior to submitting sample for testing.

Soil samples should be sent immediately to the University of Florida Extension Soil Testing Laboratory or a commercial laboratory. Samples sent to the University of Florida should be accompanied by the appropriate IFAS sample collection and submission form along with all requested information. Remember that sample collection of landscape soil should precede spring fertilization by a couple of months. Container media should be sampled more often coinciding with production schedules.

Adjusting the pH

Raising pH

If an application of lime is recommended after soil testing, the amount of lime to apply to acid soils depends largely on the initial pH and the buffering capacity of the individual soil. The Soil Testing Laboratory at the University of Florida uses a method which considers pH and buffer capacity in determining the lime requirement of individual soils. Much of the difference in buffer capacity of individual soils is related to the amount of silt, clay and organic matter present. The greater the amounts of these that are present, the higher the buffer capacity. This test is run when specifically requested through your local UF County Extension Agent or the Soil Testing Laboratory.

Crushed agricultural limestone or dolomite are the liming materials that are typically used to raise soil pH. Dolomite is preferable in most locations in Florida because it contains magnesium as well as calcium carbonate, and magnesium is often deficient in Florida soils. Hydrated lime may also be used; however, the amount should be reduced by 25% because hydrated lime can burn plants more easily than carbonate lime.

Figure III-3

Desirable pH Ranges for Common Garden and Landscape Plants

Strongly acid (pH ≤5.4)	Mod. to Strongly acid (pH 5.5-5.9)	Moderately acid (pH 6.0-6.4)	Slightly acid (pH 6.5-7.0)
Woody Ornamentals			
Acca	Acca	Acca	Acca
Azalea	Allamanda	Allamanda	Arborvitae
Bougainvillea	American redbud	American redbud	Butterfly-bush
Crape-myrtle	Arborvitae	Arborvitae	Crape-myrtle
Firethorn	Bougainvillea	Butterfly-bush	Firethorn
Flowering dogwood	Camellia	Camellia	Pink hydrangea
Gardenia	Citrus	Citrus	Oleander
Hibiscus	Crape-myrtle	Crape-myrtle	Palms
American holly	Croton	Croton	Southern red cedar
Blue hydrangea	Firethorn	Firethorn	Sycamore
Ligustrum	Flowering dogwood	Flowering dogwood	Yucca
Magnolia	Gardenia	Gardenia	
Oleander	Glossy abelia	Glossy abelia	
Podocarpus	American holly	Ligustrum	
Yaupon	Ligustrum	Magnolia	
	Magnolia	Oleander	
	Oleander	Palms	
	Palms	Pittosporum	
	Pittosporum	Podocarpus	
	Podocarpus	Southern red-cedar	
	Shrimp-plant	Shrimp-plant	
	Wisteria	Wisteria	
	Yaupon	Yaupon	
		Yucca	
Garden Flowers and Bulbs			
Blue lupine	Amaryllis	Amaryllis	Begonia
China aster	Begonia	Begonia	Carnation
Coreopsis	Blue lupine	Calendula	China aster
Pansy	Calendula	Carnation	Day lily
Phlox	China aster	China aster	Marigold
	Chrysanthemum	Chrysanthemum	Nasturtium
	Coreopsis	Day lily	Petunia
	Gladiolus	Gladiolus	Poinsettia
	Lycoris	Easter lily	Rose
	Marigold	Impatiens	Snapdragon
	Narcissus	Lycoris	Zinnia
	Nasturtium	Marigold	
	Pansy	Narcissus	
	Phlox	Nasturtium	
	Rose	Pansy	
	Snapdragon	Petunia	
	Zinnia	Poinsettia	
		Rose	
		Snapdragon	
		Zinnia	
Warm Season Turfgrasses			
Centipede	Centipede	Bermuda	Bermuda
Bahia	Bahia	St. Augustine	St. Augustine
		Zoysia	Zoysia

Figure III-4

Agricultural Limestone or Dolomitic Limestone to Increase pH
Pounds to Increase pH One Unit

Soil of Low Organic Matter Content
Pounds of Limestone per Unit Indicated

Soil Texture	10 Sq Ft	100 Sq Ft	1000 Sq Ft	4 Cu Ft	1 Cu Yd
Sand	.4	3.7	37	.3	2
Loamy Sands	.5	4.7	47	.4	2.5
Sandy Loams	.6	6.0	60	.5	3.25
Sandy Clay Loams	.9	9.3	93	.75	5

Soil of Moderate Organic Matter Content
Pounds of Limestone per Unit

Soil Texture	10 Sq Ft	100 Sq Ft	1000 Sq Ft	4 Cu Ft	1 Cu Yd
Sand	.4	7.0	70	.6	3.8
Loamy Sands	.8	8.4	84	.7	4.5
Sandy Loams	.9	9.3	93	.75	5.0
Sandy Clay Loams	1.1	10.9	109	.9	5.9

Because lime needs to be incorporated within the top six inches of the soil, pH adjustments with lime must be done prior to planting.

Over-liming or adding lime when the soil doesn't need it can have negative effects that can be worse than doing nothing. Lime may also be added to artificial growing mixes as described in this chapter. In this case, the lime must be carefully measured and thoroughly mixed into the media. An approximation of the amount of lime needed for raising pH can be made from the tables in Figure III-4 and Figure III-6.

Lowering the pH

Florida has some strongly alkaline soils in which it is difficult or impossible to correct the pH. In contrast, if a high pH is the result of over-liming, correction may be possible. In many cases, however, alkaline soils in Florida are the result of a large percentage of limerock or shell in the soil. Limerock and shell are composed primarily of calcium carbonate and perhaps magnesium carbonate, both of which increase the soil pH. Adding an acidifier will temporarily adjust the pH of the soil, but the acidification causes the limerock or shell to become soluble, which then neutralizes the acidifier.

High pH in a landscape is not always due to natural soil characteristics. Use of crushed limestone or crushed shell as a road base, fill, or foundation can increase the pH of the surrounding area. For this reason limerock should not be used as decorative rocks in the landscape. Other rocks, such as river gravel, are less soluble and have little effect on pH.

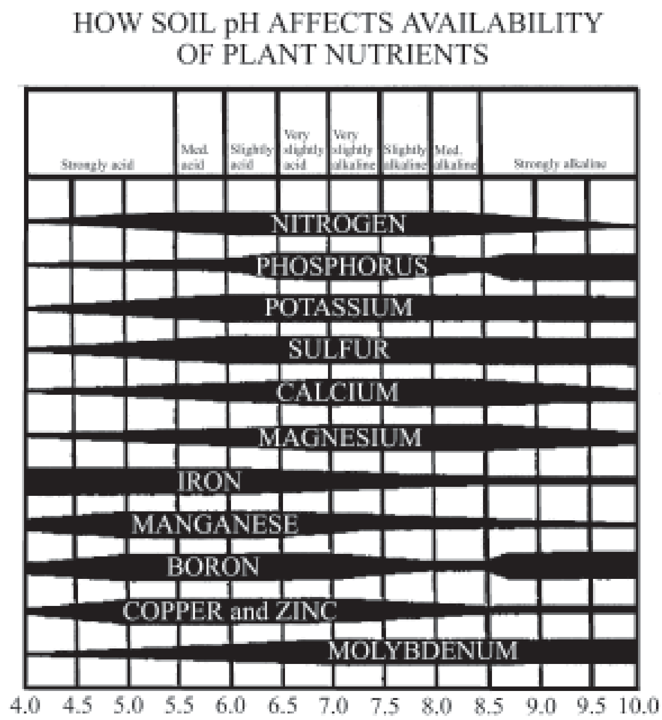
In alkaline conditions where a pH adjustment is warranted, sulfur is the recommended soil amendment for lowering pH. Super-fine wettable or dusting sulfur is also used to lower soil pH. The rate for dusting sulfur to decrease the soil pH one unit is approximately one-third of the amount of limestone used to raise the soil pH one unit. The amount applied should not exceed 1 pound per 100 square feet at any one application. If sulfur is being applied around living plants, the same amount should be applied; however, two separate applications should be made 60 days apart.

Iron sulfate *(ferrous sulfate)* can also be used to lower soil pH, with a faster more temporary effect than wettable sulfur. Iron sulfate does add iron, which is often unavailable with high pH. The standard rate for iron sulfate is one pound per 100 square feet, and it may be necessary to reapply in 60 days. Repeated applications may reduce the amount of manganese available in the soil.

Of the metallic sulfates, iron sulfate is relatively expensive and will stain sidewalks, while aluminum sulfate is effective in correcting pH, but too much aluminum can be harmful to plant growth. As indicated previously, the correction of pH in highly alkaline soils will be very short lived.

Plant nutrient availability is easily affected by soil pH, therefore, changes in pH can adversely affect plant growth. Nutrient solubility changes with soil pH. If a nutrient is in an insoluble form, the plant cannot use it. Figure III-5 shows the effect of pH on plant nutrient availability. In this figure, decreasing availability of each nutrient is indicated by a decrease in the width of the bar. Again, in order for a plant to use a nutrient, the nutrient must be present in the soil in a soluble form. Nutrient solubility is changed with the pH changes.

Figure III-5



Adjusting pH in Soilless Mixes

Because of the relationship between pH and nutrient availability, maintaining the correct pH in nursery potting mixes is crucial to successful production of plants. Most foliage and woody plant crops tolerate an acid potting mix (pH 4.5 - 6.5 for foliage crops; pH 5.0 - 6.5 for container-grown woody plants). Changing the pH after plants are potted and growing is difficult. Therefore, adjustments are most easily made prior to planting.

Low pH levels can be raised in potting media by adding liming materials, such as dolomite or calcium carbonate; high pH levels are lowered by adding sulfur. The amounts of these materials needed to provide a desired pH depends on the type of organic material in the potting mix and the original pH.

In sandy potting media, small amounts of lime or sulfur are needed, while larger amounts are required to affect the pH of pure peat. The table in Figure III-6 serves as a guide for adjusting pH levels during preparation of the potting media. The table illustrates pH adjustment to 5.7 for container grown crops.

If pH must be altered after crops are already growing in a potting mix, the following materials and rates should be used. To raise pH, hydrated lime (calcium hydroxide), should be used, but with caution. Hydrated lime can damage plants if applied in solution at more than one pound per 100 gallons per 100 square feet of surface area (pots or benches). The crop may need to be treated again four weeks later if pH has not reached the desired level. Calcium carbonate, applied to the surface of the potting mix and watered in, will also raise pH. However, it may take longer for it to be effective.

If pH levels are too high in potting mixes of established crops, sulfur can be applied at the rate of 1 pound per 100 square feet of surface area to lower pH. Sulfur should not be applied more often than every four weeks because rapid pH changes may damage plants.

Alternatives To Correcting pH

1. Select plants tolerant of existing soil pH. This is a step toward low maintenance landscaping.

2. Use a fertilizer program specially designed to overcome the nutrient problems. This alternative requires considerable expertise, and may involve regular use of soil acidifiers, chelated fertilizers and foliar applications of plant nutrients.

Figure III-6

The approximate amount of lime and sulfur required to adjust pH of potting mixtures.

Dolomitic lime (pounds per cubic yard) or equivalent amount of calcium to raise pH of indicated media to 5.7			
Beginning pH	50% Peat + 50% Sand	50% Peat + 50% Bark	100% Peat
5.0	1.7	2.5	3.5
4.5	3.7	5.6	7.4
4.0	5.7	7.9	11.5 *
3.5	7.8	10.5	15.5 *

Sulfur (pounds per cubic yard) needed to lower pH of indicated media to 5.7			
Beginning pH	50% Peat + 50% Sand	50% Peat + 50% Bark	100% Peat
7.5	1.7	2.0	3.4
7.0	1.2	1.5	2.5
6.5	0.8	1.0	2.0

* Addition of more than 10 pounds of dolomite per cubic yard often causes micronutrient deficiences.

(Adapted from Light and Fertilizer Recommendations for Potted Foliage Plants, by Charles Conover and R.T. Poole, Agricultural Research and Education Center, Apopka, FL)

3. Remove and replace enough soil in the planting holes, to allow the plant to grow in an "island" of good soil. This method can be expensive and must be done at planting.

4. Regularly apply an organic mulch to the soil surface, so that the organic content of the soil gradually increases. This gradually reduces the pH.

Plant Nutrients: The Essential Elements

The 16 elements that plants require to complete their life cycle are referred to as *essential elements* or nutrients. These elements are obtained by plants from air, water and the soil solution. Elements are not obtained by plants in the pure form; rather, they are in combined forms, such as carbon from carbon dioxide in the air or hydrogen from water.

The first three essential elements are carbon (C), hydrogen (H), and oxygen (O). These three are derived from air and water and are considered macroelements. The terms macro- and micro- refer to the relative amounts of elements needed by plants. The remaining thirteen elements are obtained by the plant through the soil. The nutrients are supplied to the soil with application of fertilizers and are in soluble form when soil pH is in the proper range.

Six other elements, nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S), are considered macroelements along with C, H, and O. In addition, N, P, and K are often referred to as fertilizer elements or primary elements because they are most often applied as fertilizers.

The seven remaining elements, boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), zinc (Zn), and chlorine (Cl) are referred to as the microelements. Although the amounts of these elements required for plant growth is relatively low, they are still essential. Micronutrients are the elements most often affected by pH.

A common mnemonic device for remembering the 16 essential elements is as follows.

C HOPKNS CaFe Mg B Mn CuZn Mo Cl

It reads: C. Hopkins cafe managed by mine cousin Mo and Clyde.

By remembering this simple saying you can more easily remember all of the essential nutrients.

The rest of this section provides brief descriptions of the macro- and micronutrients and how plants use them.

Nitrogen produces dark green vegetative growth as well as increased yields of foliage, fruit, and seed. Nitrogen is also a factor in the protein quantity of food crops and increased water use efficiency. Nitrogen is a component of the chlorophyll molecule, and is, therefore, necessary for photosynthesis. Nitrogen deficiency symptoms include light green color of the vegetative growth, slowed or stunted growth and browning at the tips of lower leaves. Excess nitrogen produces succulent growth, delays maturity and fruiting, and increases susceptibility to insects and disease.

Phosphorus stimulates root formation, hastens maturity, stimulates blooming, and aids in fruit and seed formation. Phosphorus is necessary for the processes of photosynthesis and respiration as a component in energy transfer. Phosphorus deficiency symptoms include stunted growth, purple leaves, delayed maturity, and decreased flower, fruit and seed yields. Phosphorus is a naturally-occuring element in many Florida soils, so there are times when fertilizers containing phosphorus are not required. Always use a soil or tissue test to determine if additional phosphorus is required.

Potassium increases plant vigor and disease resistance, improves rigidity, contributes to cold hardiness, and is important for seed and fruit quality. Potassium is essential to the formation of starches, sugars, and proteins. Potassium deficiency symptoms include scorching or burning of outer edges or tips of lower leaves, poorly developed root systems, loss of disease resistance, and decreased fruit yields.

Magnesium is another component of chlorophyll, along with nitrogen, and is a catalyst for other plant processes such as seed germination and sugar synthesis. Magnesium deficiency symptoms appear in a number of plants as a yellowing of older leaves with a “V” shaped 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 year around, and most plants benefit from magnesium applications. Especially prone to these symptoms are podocarpus, pittosporum, boxwood, Canary Island and pygmy date palms, and flowering gingers.

Calcium is necessary in cell growth and division. It is fixed in cell walls and is necessary for new growth in plants. Deficiency symptoms of calcium include inhibition of root growth, deformed terminal leaves or branches, and death of shoot and root tips.

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

Manganese, iron, copper, zinc, boron, molybdenum and chlorine are the seven elements considered micronutrients. Micronutrients control and influence plant processes involved in plant growth. 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 often are specific for various crops. Symptoms such as chlorosis, stunted root systems, and stem or root death are similar to many of the macronutrient deficiencies. Reference materials on micronutrient deficiencies for specific crops should be consulted. Often in the nursery, iron deficiency is the most important of the micronutrient deficiencies.

Iron is not readily available in alkaline soils, and plants growing in these soils will often show iron deficiency symptoms. The symptoms of iron chlorosis are progressive, starting with a gradual loss of green color, then turning yellow with the veins remaining green. In extreme cases, younger leaves may turn almost white. The color change is due to loss of chlorophyll which requires iron for its production. 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 deficiency is primarily caused by the elements insolubility in high pH situations. In some cases, cold soil temperatures during the winter and spring months reduce root activity and thus uptake of micronutrients (especially Mn). Symptoms of manganese deficiency are similar to iron deficiency, and both are often treated simultaneously in south Florida.

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 analysis can pinpoint deficiencies as well as indicate fertilizer elements that may not be needed.

Fertilizers

Fertilizers are organic or inorganic materials added to the soil to supply plants with nutrients. The law designates nitrogen, phosphorus and potassium as primary plant nutrients, and they are always listed on the tag in that order. For example, a 12-4-8 fertilizer contains an equivalent of 12% nitrogen, 4% phosphoric acid and 8% potash, by weight. To determine the amount of a nutrient present in a given amount of fertilizer, multiply the percent nutrient by the weight. For example, a 50 pound bag of 12-4-8 fertilizer would contain six pounds of nitrogen (.12 x 50 = 6).

Total nitrogen, available phosphoric acid and soluble potash are defined by the fertilizer law as the primary plant nutrients. The three numbers such as 10-30-10, are known as the guaranteed analysis of the material. The sum of these, or the total available primary plant nutrient, is the grade of the mixture. A statement of “total available primary plant nutrient” is no longer required on the label and does not appear in the sample label shown in Figure III-7. However, the law states that a mixture of less than 16% cannot be sold unless a special permit is received from the Commissioner of Agriculture and the label states “Low Analysis Fertilizer” in as conspicuous a manner as the brand name. The guaranteed analysis must be in whole numbers except for specialty fertilizers.

Specialty fertilizers have been defined as “commercial fertilizers in packages sold or offered for sale for home use.” 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.

Many excellent fertilizer products are commercially available. The discussion and recommendations in this manual are generic and are meant to emphasize the importance of understanding not only the fundamental concepts of what fertilizers are and how they are used, but also how to compare one product with another.

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 affect fertilizer cost and value. Generally, three fertilizer characteristics increase the value and add to the cost of a fertilizer. These are: slow release characteristics; presence of micronutrients (especially fritted or chelated); and whether the fertilizer is prilled.

Slow release characteristics extend the period of time the fertilizer remains effective in the soil. Micronutrients are added to supply an important plant need, while fritting and chelating are methods of increasing or extending micronutrient availability to plants. Prills are formulated as BB sized balls that are clean and easy to spread. Customers will buy these premium fertilizers if they are aware of their increased value. Numerous specialty fertilizers are available that can enhance growth when used for the special situations for which they are prepared.

Fertilizer BMPs & Laws

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 ground water via wells. Ground water supplies often lie near the surface and may be covered by nothing but sandy soil. Surface waters in Florida are very sensitive to even small additions of pollution, which cause widespread ecosystem changes in our sensitive estuaries, lakes, rivers and the Everglades.

Users of fertilizers and pesticides need to consider the soil's susceptibility to leaching and runoff, the distance to the water table, the slope of the land and the distance to surface waters and storm drains in addition to plant nutrition, disease and pest factors. Selected properties of soils have been used to develop a rating system for runoff and leaching potential of soils. The USDA Natural Resources Conservation Service has rated soils according to this system in counties having published soil survey reports.

Determine the susceptibility of the soil to leaching: Soil texture, organic-matter content, soil moisture and permeability all affect pesticide movement. Some pesticides readily move through soils that are well drained, sandy, or low in organic matter. Label language will alert users of such limitations. If sinkholes are present, surface-water runoff can quickly reach groundwater with little natural soil filtering. The slope of the field and the relative location of lakes, ponds, streams, canals, or wetlands to the application site also determine the vulnerability of these surface-water bodies to contamination from pesticides.

The Florida Friendly Best Management Practices for Protection of Water Resources by the Green Industries, while not regulatory in nature, provides information and guidance on reducing pollution and conserving water.

Since the original publication of this BMP manual in 2002, several new laws have been passed, new research completed, and new products developed. Therefore, the 2008 version contains new information in many areas, especially concerning irrigation systems and fertilizer use.

After weather, cultural practices are the biggest factors in determining how well a horticultural program performs. They include irrigation, fertilization, mowing and pruning, aeration and dethatching. Plant selection and location are the most important factors when planning a lawn and landscape. The amount of pesticides, fertilizers and water required often directly correlate with cultural practices and how well they are carried out.

Employees whose job duties include activities related to BMPs should be properly trained to perform those activities before going in the field.

Remember, an ounce of prevention is worth many dollars of cure.

Labeling of materials sold as fertilizers is regulated by the Florida Commercial Fertilizer Law. The information and format required make fertilizer labels comparable and, if understood properly, a qualified comparison of fertilizers can be made. The label works on the basis of a guaranteed analysis, with each of the elements guaranteed to be present in a minimum amount. Guaranteed analysis is on the basis of percent by weight of the specified element or compound. A detailed discussion of the Florida fertilizer label follows.

The Florida Fertilizer Label

Fertilizers are manufactured from a wide variety of materials to supply required plant nutrients. Once these materials are mixed, it becomes difficult to distinguish the materials present. In the past a few unscrupulous manufacturers have taken advantage of this to increase their profit. To protect consumers and legitimate manufacturers from such practices, the Florida legislature enacted the first fertilizer law in 1889. The law has been amended many times since its enactment to regulate the manufacture and sale of fertilizers in the state. The most recent changes to the rules took place in 2007.

Manufacturers are required to purchase and affix a label to each bag, package, container or lot of fertilizer offered for sale in the state. For packaged products, this information shall 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. This information shall be in a readable and conspicuous form. For bulk products, this information in printed form shall accompany delivery and five analysis tags attached to the delivery ticket shall be supplied to the purchaser at time of delivery.

The law requires that each label show specific information about the analysis and composition of the mixture or material. The terms "Available Phosphoric Acid" or "Available Phosphate" and "Soluble Potash" may be used instead of "Available Phosphorus" and "Soluble Potassium", respectively.

An example of the Florida Fertilizer Label appears in Figure III-7 on page 13. The following information explains the details of label requirements.

1. **License number**: Each label of fertilizer shall bear the Florida license number. The Fertilizer License Number, shall appear and be clearly identified 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. **Brand name**: A brand name is used by the licensee to identify his product. "Brand" means a term, design, or trademark used in connection with one or several grades of fertilizer. The label shall also include a grade in close proximity to the brand. The "Grade" means the percentages in fertilizer 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.

3. **Net weight**: The "net weight" is the actual weight present in the package or container. The term "bulk" shall suffice for bulk products.

4. **Name and address**: The "name and street address" of the manufacturer or registrant of the fertilizer must be included.

5. **Organic**: When the term "organic" is used in the label, labeling, or advertisement of any fertilizer, the water insoluble nitrogen must not be less than 60% of the total guaranteed nitrogen so designated.

6. **Guaranteed analysis**: 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 the statement of each secondary plant nutrient present in the mixture. The chlorine content is stated as the maximum percentage present in the mixture.

7. **Derived from**: A "derived from" section is a listing of the actual source materials that constitute the primary and secondary plant nutrients guarantees. Only those materials which actually constitute sources of primary, secondary plant and micro nutrients shall be shown on the application for registration and the label under the statement "Derived from: ____". Commercial, registered or copyrighted brand or trade names shall not be permitted in guarantees or listing of source materials and only in the product name of fertilizer produced by or for the firm holding the rights to such a name.

Guaranteed Analysis

Total Nitrogen: Nitrogen may be included in the form of: 1) nitrate nitrogen, 2) ammoniacal nitrogen, 3) other water soluble nitrogen, 4) urea nitrogen, and 5) water-insoluble nitrogen. A statement of the percentage of each form present in the fertilizer must be given.

Nitrate nitrogen includes all of the nitrate (NO_3^-) form in the fertilizer mixture. Ammoniacal nitrogen includes all the ammonium (NH_4^+) form of nitrogen in the fertilizer. The nitrogen breakdown shall be equal to the total nitrogen guarantee. When urea is present it may be guaranteed as other water soluble nitrogen, or urea nitrogen at the option of the licensee. When urea formaldehyde is present, not more than 40 percent of the total nitrogen from this source may be claimed as other water soluble nitrogen, or urea nitrogen at the option of the licensee. Many of the common fertilizer sources of nitrogen are listed in Figure III-8.

Water insoluble nitrogen originally meant such natural organic materials as dried blood and tankage. Natural organic sources become available in the soil by microbiological action that converts the nitrogen first to ammonium and then to the nitrate form. Many forms of water insoluble nitrogen have been developed so that now organic and inorganic water insoluble sources are included in this figure.

Some other water insoluble nitrogen forms are rendered insoluble by coating with sulfur or other materials, by chemical combination with other elements, or by inhibiting the activity of microorganisms that release the nitrogen from insoluble forms. Many of these sources are treated in such a way as to provide for a long continuous release of nitrogen.

Available Phosphoric Acid: Includes water soluble and citrate soluble phosphorus which is soluble in weak acids found in the soil solution. The guaranteed available phosphoric acid is the oxide equivalent of the actual phosphorus in the mixture. Elemental phosphorus (P) comprises 44% of the amount of available phosphoric acid guaranteed in the mixture.

Soluble Potash: This is the oxide equivalent of the potassium present in the mixture. Elemental potassium comprises 83% of the guaranteed soluble potash. All of the potassium guaranteed on a fertilizer label is soluble K which implies that it goes into solution readily when applied to the soil and that is immediately available for plant uptake.

Chlorine, Not More Than: Because chlorine is often toxic to plants or may reduce plant quality and yields, it is stated as a maximum possible percentage ("not more than"). Some greenhouse floral and vegetable crops 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 that the purchaser is aware of the chlorine content of the product.

The Guaranteed Analysis specifies the **secondary plant nutrients** present in elemental form. Magnesium, iron, zinc, copper and manganese shall be expressed as "Total" and/or "Water Soluble/Soluble" depending upon the source materials formulated in the product. Chelated elements must be guaranteed separately when a chelating agent is denoted in the derivation statement below the guaranteed analysis. When sulfur is claimed as a plant nutrient, it shall be specified as to the form present, either "free" or "combined" or both.

Figure III-7

Example of Florida Fertilizer Label

BRAND NAME
Nitrogen ...% organic (...% synthetic, ...% natural)

GUARANTEED ANALYSIS

Total Nitrogen . . . .%
__ % Nitrate Nitrogen
__ % Ammoniacal Nitrogen
__ % Other Water Soluble Nitrogen
__ % Urea Nitrogen
__ % Water Insoluble Nitrogen

Available Phosphorus . . . . %

Soluble Potassium . . . .%

Chlorine Not More Than. . . . .%

Derived from:
(Actual source materials for primary plant nutients, e.g. Urea, Concentrated Superphosphate, Potassium Chloride, Milorganite, etc.)

Secondary & Micro Plant Nutrient
Total Magnesium as Mg . . . .%
Water Soluble Magnesium as Mg . . . .%
Total Manganese as Mn .. . . %
Soluble Manganese as Mn . . . . %
Total Copper as Cu . . . . %
Soluble Copper as Cu . . . . %
Total Iron as Fe . . . . %
Soluble Iron as Fe . . . . %
Sulfur (combined) as S . . . .%
Sulfur (free) as S . . . .%

Derived from:
(Actual materials and in forms used in the fertilizer mixture, e.g., Manganese Oxide or Manganese Sulfate, etc.)

Manufactured by:
Name (Fxxxxxx)
Address
City, State, Zip
Net weight _____lbs.

Figure III-8

Examples of Nitrogenous Fertilizer Materials

Fertilizer Material	Percent Nitrogen	Rate of Nitrogen Availability
Nitrate of soda	16.2	Very rapid
Nitrate of soda-potash	15.0	Very rapid
Nitrate of potash	13.2	Very rapid
Calcium nitrate	15.5	Very rapid
Ammonium nitrate	33.5	Very rapid
Ammonium nitrate plus lime **	20.5	Very rapid
Ammonium nitrate solutions	16-21	Very rapid
Ammonium sulfate-nitrate	26	Very rapid
Ammonium phosphate	11-21	Rapid
Anhydrous ammonia	82	Rapid
Aqua ammonia	24	Rapid
Ammoniated superphosphate	Variable	Rapid
Ammonium sulfate	20.5	Rapid
Urea	45-46.6	Rapid
Isobutylidene diurea (IBDU)	31	Moderate
Sulfur-coated urea	35-40	Moderate
Cottonseed meal *	6.7-7.4	Moderate
Castor pumice *	4.1-6.6	Moderate
Hoof meal *	10.7-15.6	Moderate
Dry fish scraps *	6.5-10.0	Moderate
Peruvian Guano *	12	Moderate
Sewage sludge (activated) *	14.1-6.4	Moderate
Ureaform	38	Moderate
Beetle scrap dust	19.0	Slow
Processed tankages *	5.0-10.0	Slow
Raw bone meal *	3.3-4.1	Very slow
Hull meals *	1.2-3.0	Very slow
Beetle molded scrap	19.0	Very slow
Garbage tankange *	2.5-3.3	Very slow

**Natural organics.*
***A-N-L, Cal Nitro, Calcium ammonium nitrate, etc.*

Some fertilizer mixtures contain pesticides and are required by law to have a yellow label with conspicuous lettering, in a contrasting color. Fertilizer manufacturers can include only 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.

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 a label for 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 label must contain the product's brand name, common name, and analysis in terms of the primary plant nutrient.

Fertilizer Labeling for Turf

In 2007, changes to the fertilizer labeling rule for urban turf, sports turf or lawns took place, Rule 5E-1.003(2). The purpose of this rule modification was twofold. First was the clarification of existing verbiage. Second was to establish labeling criteria for urban lawn or turf fertilizer products and the adoption of Best Management Practices for nitrogen applications for the green industry and golf course industry.

Any fertilizers labeled for use on urban turf, sports turf or lawns shall be no phosphate or low phosphate and have label restrictions for the application of nitrogen. It further specifies that "No Phosphate Fertilizer" means phosphate levels below 0.5% and intended for established urban turf or lawns,. "Low Phosphate Fertilizer" is intended for new or established turf, with phosphate levels equal to or above 0.5% New urban turf is any turf established less than 12 months. Established urban turf is older than 12 months.

No phosphate fertilizers shall not contain more than 0.5% of available phosphate expressed as P_2O_5. The "grade" shall indicate a zero guarantee.

Fertilizers labeled as low phosphate shall have use directions that do not exceed an application rate of 0.25 lbs P_2O_5/1000ft^2 per application and not to exceed 0.50 lbs P_2O_5/1000 ft^2 per year. Label use directions may be included that allow higher rates if an annual soil sample representative for the site shows the need for a higher application rate.

Nitrogen shall not be applied at an application rate greater than 0.7 lbs. of readily available nitrogen per 1,000 sq. ft. at any one time based on the soluble fraction of formulated fertilizer, with no more than 1 lb. total N per 1,000 sq. ft. to be applied at any one time.

The following language shall appear conspicuously on bags of fertilizer sold at retail: *"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/garden, and sweep any product that lands on the driveway, sidewalk, or street, back onto your lawn/garden."*

Fertilizers, other than specialty fertilizers, labeled for urban turf shall have directions for use not to exceed rates recommended in the Florida Friendly Green Industries Best Management Practices document. (See bibliography Chapter 9.) Application rates for turf are covered more thoroughly under "Fertilizer Recommendations for Turfgrass" later in this chapter.

Fertilizer Application

Horticulturists must know what fertilizer is best for their application, as well as when, how much, how often and how to apply fertilizers. Horticulturists must know the products they are using, selling or recommending. We must know not only the analysis, but also the other factors that cause one formulation of a particular fertilizer to be more valuable than another with the same analysis.

For example, fertilizer recommendations vary greatly among landscape plants, palms and turfgrass. Recommendations for each of these types of plants are discussed in greater detail on the following pages.

Additionally, the horticulturist must know the type of fertilizer program the customers want to use. Are they interested in low cost, maximum results or convenience? Does the customer have a well-established landscape, or has it recently been planted and is still establishing? Do the plants have special nutrient requirements? Are there special considerations due to 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, some generalizations and compromises have to be made.

When should you fertilize? The best response is, "When was the last time you fertilized?" and "Was that application based on soil test results?" Knowing how long it has been since the last fertilization and using soil test results to make application decisions is an important starting point. When working with fertilizer always consider the relationship between when, how much and how often.

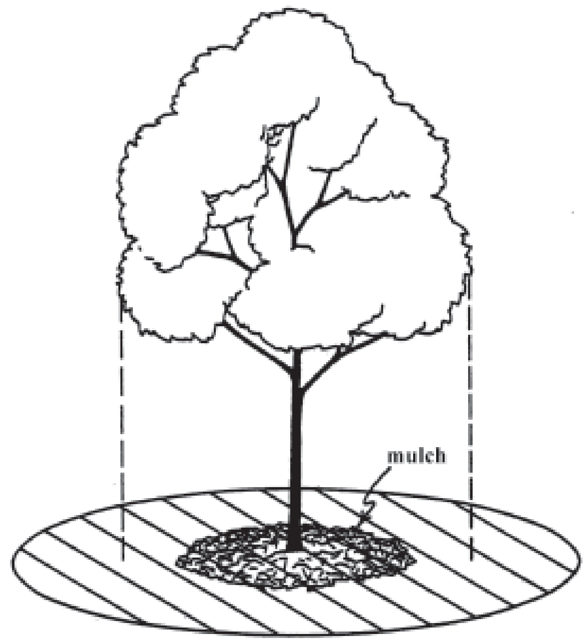
Which fertilizer is best? Premium quality fertilizers will contain the best ingredients formulated and blended in such a way that they are easy to apply and effective. When determining fertilizer needs of plants in the landscape, soil testing is an easy, cost-effective way to determine mineral deficiencies. The use of soil test results will determine the analysis needed for site specific conditions.

Because of the mobility of most essential nutrients for landscape plant and turfgrass growth in Florida soils, one of the best indicators of appropriate fertilization and plant health is tissue analysis. In the landscape, leaf analysis of turfgrass, along with appearance and soil analysis, can be used to diagnose the problems and the effectiveness of a fertilization program, especially for micronutrient deficiencies. For growers, tissue analyses should be used in conjunction with media nutritional analyses to obtain the nutritional status of the container plant system. Relying totally on media or tissue analyses for the basis of nutritional management decisions could result in improper management.

Fertilizer Placement

Fertilizer placement on plants in the landscape in relation to the plant root zone is very important. Studies have indicated that root depths are usually a maximum of 10 to 14 inches due to the naturally high oxygen concentrations near the soil surface, and more than 50% of the roots of several tree species extend beyond the dripline by as much as three times. Many roots of mulched plants are located just beneath the mulch surface. Consequently, for maximum utilization, fertilizer should be applied to the soil or mulch surface. Since most feeder roots on trees and shrubs are shallow, there is no need to inject or place fertilizer deep in the soil. However, shallow soil injections on mounds, berms and slopes and in compacted soil will reduce the amount of fertilizer runoff due to irrigation or rain.

Figure III-9



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. See Figure III-9. If the turf was fertilized within the past 2 weeks, do not apply additional fertilizer to the turf area around the tree; only fertilize the mulched area and base the amount of fertilizer applied on the mulch square footage. The fertilizer nutrients will move rapidly with irrigation water through the mulch.

Most established trees (3 to 5 years after transplanting) 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. However, supplemental applications may be needed for some trees because nutrient deficiencies could develop.

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. Each situation is different, and 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 must outweigh this damage.

Fertilizer Type

Fertilizer should always be applied at the lowest of the ranges recommended, unless a soil test indicates that more is warranted. A complete fertilizer with a ratio of approximately 3:1:2 or 3:1:3 (i.e. 15-5-10 or 15-5-15) of nitrogen, phosphorous pentoxide (P_2O_5), and potassium oxide (K_2O) is generally recommended unless the soil test reveals that phosphorus and potassium are adequate. Fertilizers that are "slow-release," "controlled release," sulfur coated, or with nitrogen as IBDU or ureaformaldehyde have extended release periods compared to fertilizers that are readily water soluble. Thirty to fifty percent of the nitrogen should be water insoluble or slow-release. This is beneficial because plant roots can absorb the nitrogen over a long period of time. A fertilizer containing 30-50% slow-release potassium should be used in south Florida or where soil potassium is frequently inadequate. A fertilizer containing magnesium may be needed if plants often exhibit magnesium deficiency symptoms and for soils with inadequate magnesium.

Water soluble fertilizer is less expensive than products that provide extended release, but the components of the water soluble fertilizer may leach quickly through the soil. In sandy soils, the soluble fertilizer may move past the root system after only a few inches of rainfall or irrigation. In finer textured marl, clay or muck soils leaching will be slower, but runoff may be greater.

Remember that no more than 1/2 to .7 lb./1000 ft^2 of the readily available nitrogen should be in quick release form.

Micronutrients

Micronutrients should be applied as needed and, depending on the situation, possibly more frequently in south Florida. They may be applied as part of a fertilizer or applied separately as a special mix. Micronutrients should be applied singularly to the soil only in the case of severe deficiencies because of the danger of applying excessive amounts.

Micronutrient deficiencies can be corrected with foliar sprays if deficiencies are not severe; however, correction is usually temporary. Persistent deficiencies may be prevented by applying a fertilizer with micronutrient supplements. Maintenance of recommended pH will minimize micronutrient deficiencies. Specific micronutrient recommendations are available for various pH problems and for specific plant groups.

Figure III-10: Target pH, and recommended nitrogen, phosphorus pentoxide, and potassium oxide fertilizer rates for ornamentals in the landscape.

CROP DESCRIPTION	TARGET pH	If soil test results indicate that: Phosphorous pentoxide is VL	LO	MED	H	VH	Potassium oxide is VL	LO	MED	H	VH
		Then apply (pounds per 1000 square feet per year)									
Woody Ornamentals or Trees in the Landscape	6.0	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	0.3	0.3	0.2	0	0	0.7	0.7	0.3	0	0

VL = very low LO = low MED = medium H = high VH = very high

*Phosphorus and potassium rates are based on interpretation of a Mehlich-1 soil test.

Fertilizer Amounts

For each fertilizer application, apply a maximum of one pound of nitrogen per 1000 ft^2. This rate is easy to calculate from the information given on the fertilizer bag. Simply divide the nitrogen percentage (the first number of the analysis) into 100.

For example:

You have purchased a 15-5-10 fertilizer, divide 15 into 100 (i.e. 100 / 15 = 6.6). Therefore, 6.6 pounds of 15-5-10 will supply one pound nitrogen to be distributed over 1000 square feet of landscape area.

If the soil tests high for phosphorus and potassium, these don't need to be applied (See Figure III-10). Soils low in phosphorous and potassium should receive the equivalent of 0.7 and 1.4 pounds of phosphorus pentoxide (P_2O_5) and potassium oxide (K_2O) respectively, per 1000 ft^2 per year. Phosphorus can be applied in one application; however, the total amount of potassium should be divided into three applications per year.

Other Considerations

Too much nitrogen promotes excessive growth which increases maintenance costs and time. Disposing of excess growth as yard wastes is an additional problem and expense. Application of too much soluble nitrogen causes environmental concerns, i.e. nitrogen leaching into water supplies or polluting surface waters such as lakes, rivers, bays and retention ponds. Additionally, nitrogen is not used efficiently by unthrifty plants. Diseased or damaged roots, improper soil pH, water logged sites and plantings that are too deep can result in inefficient nutrient absorption and nutrient deficiency symptoms.

Too much nitrogen can also contribute to disease development. It is one of the environmental stresses that can lead to increased disease or insect problems which are often treated chemically without changing the cultural practices that initially caused the problem. In Chapter IV, cultural control practices are discussed to reduce susceptibility to pests.

Fertilizer Timing

Trees, shrubs and ground covers can be fertilized four to six weeks after planting. Most established landscape plants grow well with two or three fertilizer applications per year. One application is normally scheduled around February (south Florida) or March (north Florida) and another in September (north) or October (south). The third application can be made during the summer. Fall applications facilitate nutrient utilization during the cool months and are very important for growth flushes in the spring.

Grasses and other plants that are actively growing throughout the year need three to six applications of fertilizer per year, while mature plants need two to three feedings per year. If you plan to fertilize only twice per year, applications would be best in early spring and early fall. Three applications per year would be best in early spring, early summer and early fall, and four applications per year would be applied in late winter, late spring, summer and fall.

Be sure to avoid fertilizing during times when heavy rains are anticipated, including during tropical storm or flood watches or warnings.

Fertilizer Recommendations for Landscape Plantings

When it has been determined that fertilization is necessary, most established landscape plants should be fertilized at rates within ranges listed in Figure III-11. The number of pounds of various nitrogen-containing fertilizers to apply per 1000 square feet of bed area per year is presented in Figure III-12.

Phosphorus content of the fertilizer should be 0 - 2% P_2O_5. Historically, the ratio of nitrogen (N) to potassium (K_2O) for landscape plants has been in the range of 1:1 to 2:1. A 15-0-15 is an example of a fertilizer utilizing the 1:1 ratio. Due to the prevalence of magnesium (Mg) deficiency on certain landscape plants in many parts of the state, up to 2.5 pounds Mg/1000 ft/year may be applied to address this problem. Micronutrients can be

Type	WIN%	N-Release	Description
Urea Formaldehyde 38% N	65-71	Biological/ Microbial	Rate influenced by soil temperature Less effective in cool seasons. Maybe found in liquid forms
Methylene Urea 40% N	36	Biological/ Microbial	Provides better performance in cool temps than UF. It is typically marketed as Nutralene.
Isobutylidene Diurea - IBDU 31% N	90%	Hydrolysis	Fertilizer performs better than many others at low temps. Fastest in low pH and High Temps

Type	N-Release	Description
Sulfur Coated Urea 32-38% N	Coating Thickness Biological Soil Temp	Increasing thickness lowers the N content. The release rate quickens as coating thickness decreases and as temperature increases.
Polymer Coated Variable % N	Coating Thickness Soil Temp Osmotic Diffusion Rate	Polymer coats provide a much more uniform release rate than sulfur coats. This technology provides good response in either warm or cool temps (faster release in warm temps). These are usually more expensive.

applied at specified rates and timing to achieve fertilization objectives.

Water-soluble fertilizers should be applied at no more than 1/2 pound of actual nitrogen per 1000 square feet per application. Application rates of controlled-release fertilizers depend on release rates of the product.

Ground cover plantings and other areas where plants more or less cover the entire surface area can be fertilized with 1 pound of nitrogen per 1000 ft^2 of surface area, per application, two to four times per year.

Areas that need to be fertilized before planting, such as areas to be sodded, planted with ground covers or bedding plants, planted with vegetables, or planted as a landscape, can be fertilized at a rate of 1.5 to 2 pounds of nitrogen per 1000 ft^2 of surface area.

Special Recommendations

Some recommendations are specific for certain groups of plants that require a different pH or special culture. Three examples are roses, azaleas, and citrus. These recommendations vary from the generalized recommendations above. Fact sheets on many plants are available through UF/IFAS and should be referenced when producing or managing these crops.

Fertilizer Recommendations for Palms

Palms are among the most important ornamental plants in Florida landscapes and production nurseries, and have different nutritional requirements than other landscape plants. Palms suffer quickly and conspicuously from improper mineral nutrition, whether due to insufficient or incorrect fertilization. They also may exhibit certain nutritional disorders in unique ways compared to other ornamental plants. Some nutritional problems in palms are difficult to diagnose accurately because symptoms of several different mineral deficiencies may overlap. Nutritional disorders common on palms in the landscape, production field, and container nursery are

Figure III-12: Number of Pounds of Fertilizer (per 1000 ft^2/yr) to Use for Fertilizer Containing Various Percentages of N at 7 Rates

	Rate (lbs N/1000 ft^2/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 III-11: Amounts of Nitrogen Fertilizer vs. the Level of Maintenance

Level of Maintenance	Amount of Nitrogen Fertilizer
Basic	0-2 pounds N/1000 ft^2/year
Moderate	2-4 pounds N/1000 ft^2/year
High	4-6 pounds N/1000 ft^2/year

briefly discussed below. Fertilization recommendations for palms in these situations are also provided. More information about palm production and management can be found in the Palm Nutrition Guide (see Bibliography).

Nutritional Disorders

Nitrogen. Nitrogen (N) deficiency is fairly common in Florida palms and typically the most limiting element in container production. However, other elements such as K (potassium), Mg (magnesium) and Mn (manganese) are much more prevalent and serious in the landscape. Symptoms of N deficiency include an overall light green color and decreased vigor of the palm. It is easily corrected by applying any N fertilizer to the soil. Leaf color quickly darkens in response to either soil or foliar fertilization.

Potassium. Potassium deficiency is perhaps the most widespread and serious of all disorders in Florida palms. Symptoms occur first on oldest leaves and affects progressively 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 in color instead of green in some species.

Magnesium. Magnesium deficiency is also quite common in Florida palms, 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 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 deficiency or "frizzletop" is a common problem in palms growing in the alkaline soils that cover much of south Florida. 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.

Manganese deficiency is primarily caused by the element's insolubility in high pH situations. In some palms such as coconut, which are not normally affected by the problem, 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 up 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 deficiency usually appears on palms growing in poorly aerated soils or those that have been planted too deeply. Water-logged soils and deep planting effectively suffocate the roots. Symptoms appear first on the new leaves and in most palms 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.

Diagnosis of nutrient deficiencies by visual symptoms alone can be difficult, since some of the symptoms overlap considerably in some species. For instance, Mn and late-stage K deficiencies are easily confused on 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

Field nurseries. Fertilization rates for field-grown palms will vary with the soil type and size of the palms. Granular fertilizers are typically applied to the soil at rates starting at 1/2 to 1 lb. for small, recently planted palms to 5 lb. or more for large royal or coconut palms spaced 8' or more apart.

Fertilizers should be applied 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. It is a rather inefficient method for providing macronutrient elements such as N, K and Mg, but 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 for a normal soil fertilization program, particularly for micronutrients, and can be performed in conjunction with regular fungicide applications.

Liquid fertilization programs are not the most efficient 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.

Container nurseries. For containerized palms, a fertilizer with a N-P_2O_5-K_2O 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 7 to 10 lb. per cubic yard. Dibbling of slow release fertilizers (as opposed to surface application) is recommended over surface application and even incorporation. The extra labor costs will be offset by the added longevity of the container soil and, consequently, better growth of the crop. Additionally, one and a half to three pounds of a micronutrient amendment (rate depends on product), should also be incorporated per cubic yard of planting medium. Approximately 7 lb. of dolomite per cubic yard incorporated into the mix will adjust the pH of most media to 6-6.5 and provide calcium and magnesium.

If constant liquid fertilization programs will be used instead, approximately 150 ppm of both N and K (and 1/3 to 1/2 as much 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 degrees F fertilization rates should be reduced.

Landscape. Mature palms in the landscape should optimally receive a complete granular fertilizer formulated for palms (“palm special”), four times per year at a rate of 5-8 lb. each application. Dropping below a minimum of two applications, even for the most budget conscious maintenance schedules, is not recommended. On fill soils, even two applications may not be enough. For palms under eight feet tall, 2-5 lb. should be adequate. Newly planted palms can receive even less (1/2 to 2 lb., dependent on size). Special palm fertilizers contain additional Mg and a complete micronutrient amendment. N and K rates in the formulation should be equivalent, and all or at least some of both elements should be available in slow release form. 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.

Fertilizer Recommendations for Turfgrass

Turfgrasses commonly require higher rates and more frequent applications of N source fertilizers than other nutrient sources. In most cases, slow-release N sources can be used to reduce the potential for leaching losses of applied N. In order to obtain the desired growth and color response, a 50/50 mixture of soluble and slow-release N sources is recommended for use on turfgrasses. No more than one half (0.5) pounds of nitrogen in each application should be in the soluble form.

It should be pointed out that turfgrasses are one of the most N absorbing efficient ground covers that one can use. When fertilized at the recommended rate and frequency N leaches very sparingly, if at all, from the turfgrass system. Poor quality, slow-growing and improperly fertilized turfgrasses actually leach much more N than do turfgrasses growing at optimum levels. 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 that is growing at excessive rates which will require more frequent mowing and possibly result in contamination of the ground water with nitrate nitrogen.

For Florida lawns, the best yearly fertilization program usually includes a combination of one or two applications of a complete fertilizer and supplemental applications of a nitrogen fertilizer and iron. One of the recommendations of the Florida Yards and Neighborhoods (FYN) program is to use less fertilizer, especially nitrogen, to help reduce luxuriant growth during the summer and to reduce evapotranspiration water losses. A conservative approach to nitrogen applications also aids the landscape manager by reducing some pests, e.g., chinch bugs in St. Augustinegrass.

The rate of nutrient application, particularly nitrogen, depends on a number of factors: turfgrass species, turfgrass maintenance level goals, the location in the state where the turfgrass is being grown, time of year, and type of fertilizer source being used (soluble or slow release). Thus a single rate of application cannot be recommended. Maximum applications of nitrogen and phosphate are established by rule.

Nitrogen fertilization is often based on the desired growth rate and type of turfgrass being grown. Due to past fertilization and the inherent nature of some Florida soils, P fertilization is not always required. One should depend on a recent soil test to determine if P is required for optimum turfgrass growth. If your soil test indicates an adequate level of extractable soil P, choose a fertilizer blend that does not contain P as one of the supplied nutrients. That blend would be represented by an X-O-X, such as a 15-0-15.

The off-site transport of P is often associated with soil erosion from unvegetated and thin turfgrass areas. Another source of P is in reclaimed water. Turf irrigated with reclaimed water may receive an excess 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 N in total fertilization requirement is K. Potassium influences root growth and water and stress tolerance relationships in turfgrasses and should be maintained at adequate levels for optimum growth. In most turfgrass growth systems, the potassium

Figure IV-13: Fertilization guidelines for established turfgrass lawns in three regions of Florida.

	Nitrogen recommendations (lbs N/1000 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	3-5	3-6	4-6

*Homeowner preferences for lawn quality and maintenance will vary, so a range of fertility rates for each grass species and location is recommended.

fertilization program should be based on a recent soil test. Potassium is highly mobile in most of Florida's sandy soils, but an annual soil test is adequate for determining the K fertilization requirement of most turfgrasses grown in the State.

Nitrogen is the nutrient that is most likely to be deficient; therefore, fertilizer application rates are usually based on the amount of nitrogen applied. See Figure IV-13 for fertilizer guidelines for established turfgrass lawns in the three regions of Florida.

Fertilizers labeled as urban turf or lawn fertilizer have a maximum application rate of 0.7 pounds of readily available nitrogen per 1,000 sq. ft. per single application. For those fertilizers containing sources of slowly available nitrogen, the maximum single application rate is 1 lb. of nitrogen per 1,000 sq. ft., provided that the rate of readily available nitrogen does not exceed 0.7 pounds per 1,000 sq. ft. The maximum annual loading of nitrogen is 5 pounds per 1,000 sq. ft., regardless of the nitrogen source.

Concerning phosphate applications, no phosphate fertilizers contain no more than 0.5% of available phosphate expressed at P_2O_5. Low phosphate fertilizers have directions for use for a maximum application rate of 0.25 lbs P_2O_5/1000 ft^2 per application and not to exceed 0.50 lbs of P_2O_5/1000 ft^2 per year.

Fertilizers labeled as "starter fertilizers", have a maximum application rate of no greater than 1.0 lb of P_2O_5/1000 sq. ft. and subsequent applications shall be either low or no phosphate fertilizers. Starter Fertilizer is formulated for a one-time application at planting or near that time to encourage root growth and enhance the initial establishment.

Fertilizing turfgrass for establishment and recovery is a special situation. New sod should not be fertilized with nitrogen for the first 30 days, until it has firmly rooted into the soil. However, plugs can be fertilized at the time of installation to encourage the runners to spread. In addition, newly seeded areas should not receive nitrogen fertilization in the first 30 days until a cover has been established.

Fertilizer Application Precautions

The following precautions and procedures need to be followed when applying fertilizers to insure that no injury occurs to the plants or the environment.

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. Over fertilization is a major cause of plant injury. Excess fertilizer also leaches and may cause water pollution.

Be sure that the 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 fertilization should be evenly dispersed over the entire area. If fertilizer is injected into holes drilled into the soil, then the holes should be evenly spaced with the same amount of fertilizer applied in each hole. Individual plant fertilization should have the same amount for the same size and type of plant. Row fertilization and side dressing should be evenly distributed within the row.

Avoid getting dry fertilizer on the leaves and green stems of plants. In situations where fertilizer does get on the leaves, remove as much as possible prior to watering. Watering after the 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 you have applied a foliar application of liquid fertilizer, the plants should not be watered immediately after application.

Always leave a "ring of responsibility" 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

A Guide to Rate of Fertilizer Materials to Use on Florida Lawns

Nitrogen Fertilizers	% N	Pounds needed to supply 0.5 lb. actual nitrogen/1000 sq. ft.
Rapid Release or Soluble N Sources (Inorganics)		
Ammonium Nitrate	33.5	1.5
Ammonium Sulfate	20	2.5
Calcium Nitrate	15.5	3.2
Diammonium Phosphate	18-46-0	2.8 also 1.3# P_20_5
Mono-ammonium Phosphate	11-48-0	4.5 also 2.2# P_20_5
Nitrate of Soda-Potash	15-0-16	3.3 also 0.5# K_20
Potassium Nitrate	13-0-44	3.8 also 1.7# K_20
Sodium Nitrate	16	3.1
Rapid Release or Soluble N Sources (Organics)		
Calcium Cyanamid	21	2.4
Urea	45	1.1
Slow Release N Sources (Natural Organics)		
Alfalfa Meal	6	8.3
Blood Meal	3-22-0	16 also 3.7# P_20_5
Cottonseed Meal	7	7.1
Cow Manure	2-0-0	25
Garbage Tankages	2-3 (varies)	20 to 15
Poultry Manure	4-0-0	12.5
Processed Tankages	5-10 (varies)	10 to 5
Sewage Sludge	6-2-0	8.3 also 0.2# P_20_5
Slow Release N Sources (Synthetics)		
(IBDU) Isobutylidene diurea	31	1.6
Nutralene	40	1.25
Polyon	42	1.2
Sulfur Coated Urea (SCU)	38	1.3
Ureaform/Nitroform	38	1.3

Common potassium and phosphorus fertilizers:	Pounds Commercial to Supply 0.5 lb. K_2O or 0.25 lb. P_2O_5 /1000 sq. ft.
Concentrated Superphosphate (46% P_2O_5)	1
Muriate of Potash (60% K_2O)	0.83
Potassium Nitrate (44% K_2O)	1.1 also 0.1# N
Sulfate of Potash (50% K_2O)	1
Sulfate of Potash-Magnesia (22% K_2O)	2.2 also 0.2# Mg & S
Superphosphate (20% P_2O_5)	2.5

CAUTION: Practically all inorganic fertilizers can burn grass foliage. These materials should be watered off the turf immediately after application. If using organic N sources (slow release), up to 1 pound of N can be applied per 1000 sq. ft. per application providing that the rate of readily available nitrogen does not exceed 0.7 pounds per 1,000 sq. ft.

General Recommendations for Fertilization of Turfgrasses on Florida Soils

Fertilization guide for turfgrasses 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**													
	Basic	--	--	C	--	--	--	--	--	C	--	--	--
Bahiagrass	Moderate	--	--	C	--	SRN	--	--	--	C	--	--	--
	High	--	--	C	--	SRN	--	Fe	--	C	--	--	--
	Basic	--	--	C	--	SRN	--	--	--	C	--	--	--
Bermudagrass	Moderate	--	--	C	--	SRN	--	SRN	--	C	--	--	--
	High	--	--	C	SRN	C	--	SRN	Fe	C	--	--	--
	Basic	--	--	--	C	--	--	--	--	--	--	--	--
Centipedegrass	Moderate	--	--	--	C	Fe	--	--	--	--	--	--	--
	High	--	--	--	C	SRN	--	Fe	--	--	--	--	--
	Basic	--	--	C	--	--	Fe	--	--	C	--	--	--
St. Augustinegrass	Moderate	--	--	C	--	SRN	--	Fe	--	C	--	--	--
	High	--	--	C	--	SRN	Fe	SRN	--	C	--	--	--
	Basic	--	--	C	--	SRN	--	--	--	C	--	--	--
Zoysiagrass	Moderate	--	--	C	--	SRN	--	SRN	--	C	--	--	--
	High	--	--	C	N	SRN	--	SRN	--	C	--	--	--
Central Florida													
	Basic	--	--	C	--	N	--	--	--	C	--	--	--
Bahiagrass	Moderate	--	--	C	--	N	--	Fe	--	--	C	--	--
	High	--	--	C	N	--	SRN	--	Fe	--	C	--	--
	Basic	--	--	C	--	N	--	SRN	--	C	--	--	--
Bermudagrass	Moderate	--	--	C	--	N	--	SRN	--	SRN	--	C	--
	High	--	--	C	N	SRN	--	C	Fe	SRN	--	C	--
	Basic	--	--	C	--	SRN	--	--	--	--	--	--	--
Centipedegrass	Moderate	--	--	C	--	SRN	--	--	Fe	--	--	--	--
	High	--	--	C	--	SRN	--	--	--	C	--	--	--
	Basic	--	--	C	--	--	--	Fe	--	C	--	--	--
St. Augustinegrass	Moderate	--	--	C	--	SRN	--	Fe	SRN	--	C	--	--
	High	--	C	--	N	SRN	--	Fe	SRN	--	C	--	--
	Basic	--	--	C	--	SRN	--	--	--	C	--	--	--
Zoysiagrass	Moderate	--	--	C	--	SRN	--	--	SRN	--	--	C	--
	High	--	C	--	N	SRN	--	SRN	--	N	--	C	--

General Recommendations for Fertilization of Turfgrasses on Florida Soils

Fertilization guide for turfgrasses maintained without the benefit of a soil test.*

Turfgrass	Maintenance Level	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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	--	SRN	--	--	C	--	--
	Moderate	--	C	--	N	--	SRN	--	SRN	--	--	C	--
	High	--	C	--	N	SRN	--	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 soil test.

**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 lbs N/1000 sq ft containing 50% soluble and 50% slow-release N.

N = Soluble N applied at 0.5 lbs N/1000 sq ft.

SRN = Slow-release N applied at 1.0 lbs N/1000 sq ft.

Fe = Apply Fe to provide dark green color without stimulating excessive growth. For foliar application use ferrous sulfate (2 oz /3-5 gal water/1000 sq ft). If the Fe is applied to an acidic soil, use one pound of iron sulfate per 1000 square feet. If the soil is calcareous, use the container label recommended rate of an iron chelate.

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. More information is provided in Chapter VII Landscape Management.

Fertilizer Spreader Calibration

Fertilizer application is only effective if you ensure uniform coverage. Dry fertilizers can be applied with either a drop (gravity) spreader or a rotary (centrifugal) spreader.

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

The cyclone (also known as rotary or centrifugal) spreader generally has a wider pattern of distribution compared to a drop spreader and thus can cover a larger area in a short 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.

A recent improvement in fertilizer spreader technology is the use of air to apply the material (like the cyclone spreader) that is somewhat exact (like the drop spreader) without damaging the granules or slinging heavier particles farther. Wind and rain effects also are reduced using the technology but initial equipment expense and application expertise are higher.

Spreader calibration involves measurement of the fertilizer output as the spreader is operated over a known area. One way to ensure uniform application of material is to divide the material into two equal portions. Use a spreader calibration which will deliver one-half the correct amount of material. Make an application over the entire area, turn the spreader direction ninety degrees from the initial application, and make a second application. This eliminates skips in the coverage. Accordingly, calibration of the spreader should be based on one-half desired application rates. A flat surface, a method of collecting the material, and a scale for weighing the material is needed for calibration.

For detailed information on calibration of a fertilizer spreader, refer to UF/IFAS publication How to Calibrate Your Fertilizer Spreader (see Bibliography).

Water

Do not overwater!

Water is essential for plant growth and is probably the greatest regulator of how well or how poorly a plant grows. Water is absorbed and used as a transport medium for sugars, minerals, and hormones within the plant, and in the process of transpiration to help control plant temperatures.

The main factors that influence the amount of water used by a plant are: plant species, size, age, stage of growth, temperature, relative humidity and wind. Some plant species require large amounts of water to grow, while others, such as cactus, possess features to conserve water. Actively growing plants require more water than dormant plants. Plant size is also an important factor of water use because a large plant has a higher water use potential. Younger plants require more water in relation to size than older plants, probably because of active growth.

Temperature affects the rate of water use, both directly by affecting evaporation and transpiration, and indirectly by affecting other plant processes. Warm temperatures tend to increase water loss while cool temperatures decrease water loss. Relative humidity directly affects the rate of transpiration and evaporation. When relative humidity is high, the amount of moisture in the air and the moisture level at the leaf surface differs little; therefore, water loss due to transpiration is decreased. With low relative humidity, transpiration increases as does water use by the plant. Wind can also increase evaporation and transpiration. All of these factors combine to determine the water use status of the plant.

Water Stress Symptoms

Water is lost both by plants (transpiration) and by soil (evaporation); the combined loss is evapotranspiration. When these losses exceed the amount of soil moisture, the water deficit is called drought. A plant is stressed when water loss exceeds the ability to absorb soil moisture.

Water stress symptoms can be observed in most plants, and are used to gauge when a plant needs water. One of the first symptoms of water stress is when soft leaves and stem tissue become limp or begin to wilt. This may occur first during the hottest, driest part of the day; however, within another day or two the symptom may be present most of the day. If the plant continues without water, it may remain wilted throughout the day. In some plants, such as grasses, the foliage color is distinctly different (a bluish-green) when the plant is in the early stages of water stress.

Plants need water when they begin to show water stress symptoms. If a plant is not watered, wilting can be followed by yellowing and dropping of older leaves and browning of tips or margins. If water deprivation continues, the entire leaf may turn brown and die, which can lead to the eventual death of the plant. Undetected symptoms may occur when a plant is getting only marginal amounts of water. Plant growth may slow down or stop due to water stress; however, the decreased growth may be blamed incorrectly on fertilization or pests. Water stress symptoms vary according to the plant.

Symptoms of Excess Water

Excess water symptoms often are similar to symptoms of not enough water. Under conditions of excess water, the soil lacks oxygen needed for root survival. As the root system deteriorates, the plant takes up less water. Often the decline of the root system is followed by invasion of root diseases. If plants with adequate moisture in the soil show what appear to be water stress systems, the root system should be examined.

Irrigation

A good method for determining when to water is to observe your plants for water stress symptoms. Indicator plants, which show stress a day or two before others, can usually be found. Then, observe plants regularly and water whenever the indicator plants show stress symptoms. This requires keen observation to be sure that the indicator plants are in fact representative of the needs of the majority of plants being grown. Keep in mind that either species or the containers in which they are growing may differ. Small containers typically need water more frequently than large containers.

Another method of determining need is to monitor the moisture level in the soil with a reliable moisture meter or by feel. Judging soil moisture by feel should be done an inch or so under the soil surface, as the surface will dry out before there is a need to water. Watering by need, rather than an arbitrary schedule, often results in healthier plants.

Irrigation systems should be designed to achieve optimal uniformity. Checking uniformity close to the pump and far away from the pump and in each zone representing different irrigation infrastructures or delivery systems is recommended annually. Non-uniform systems may contribute to leaching and runoff, hence potential contamination of ground water.

Uniformity of water application with overhead sprinkler irrigation systems is often reported as Distribution Uniformity (DU). It is an indicator of how equal (or unequal) the application rates are in the nursery. A low DU (below 60%) indicates that application rates are very different, while a high DU (80% or higher) indicates that application rates over the area are similar in value and that the water is distributed evenly to all the plants. Distribution Uniformity is based on the low quarter of the irrigated area. The calculation of DU requires that the catch can test be performed in the irrigation

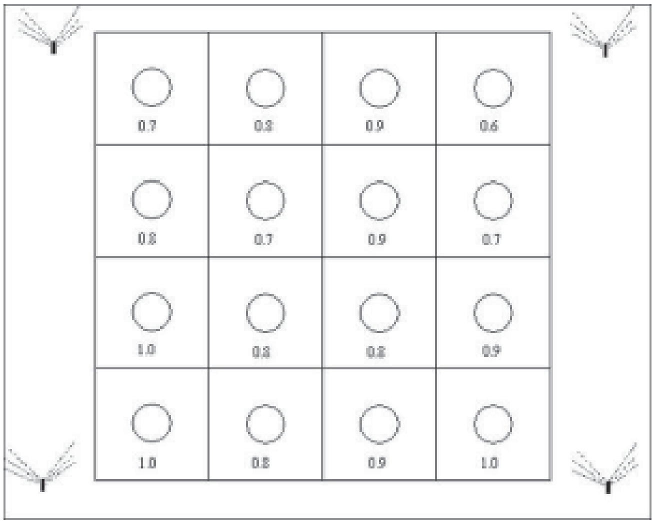


Figure IV-14: The distribution of catch cans between four sprinklers spaced in a square grid pattern. The number below each circle represents the depth of water caught in one hour at that location.

zone. Figure IV-14 is an example of the catch can test.

In Figure IV-14 , 16 straight-sided catch cans have been placed in the irrigation zone. The depth of water collected in these cans after running the system for one hour is presented below each can. The average application rate in this zone is the average depth collected in the cans and is equal to 0.8 in/hr.

(0.7 + 0.8 + 0.9 + 0.6 + 0.8 + 0.7 + 0.9 + 0.7 + 1.0 + 0.8 + 0.8 + 0.9 + 1.0 + 0.8 + 0.9 + 1.0) / 16 = 0.8 in/hr

Now, in order to calculate Distribution Uniformity, the lowest one-fourth or quarter of the measurements from our example are selected. The other value we must know is the average depth of application during the test, which was calculated above.

DU = (average low quarter depth / overall average depth) x 100%

For the application rates presented in Figure IV-13, average low quarter depth = (0.6 + 0.7 + 0.7 + 0.7) / 4 = 0.7 in/hr.

DU = 0.7 / 0.8 x 100% = 87.5%

Emission Uniformity is used for micro irrigation systems rather than Distribution Uniformity. It is calculated by comparing the volume of water from the emitters to the statistical differences in the total volume. An Emission Uniformity of 90% or higher is considered excellent.

Additional information regarding irrigation frequency and amount is presented in Chapter VI Irrigation.

Water Quality

Chemicals, living organisms and particulate matter affect water quality. Chemicals may injure plants, deposit undesirable residues on plants, or clog irrigation systems. Living organisms may also clog irrigation systems or spread plant diseases through irrigation water. Particulate matter may clog irrigation systems, especially low volume drip type systems. Water pH may adversely affect the pH of growing media and may cause problems with applications of chemicals for pest control or fertilization.

Irrigation water should be tested for soluble salts and pH. Soil and water management practices may have to be changed based on results. If water is high in soluble salts, fertilization procedures may have to be changed. If water is high in certain dissolved minerals, it may be necessary to avoid foliar application on some plants because of undesirable deposits on leaves, which spoil the appearance.

Surface water has the potential to be contaminated with chemicals and disease-causing organisms. If it is necessary to use surface water, care must be used to avoid contamination. Contamination problems can include herbicides, algae or other particulate matter, which may clog automatic controllers and drip irrigation. Filtering can remove much of the particulate matter. Water that has been softened by a sodium ion replacement system should not be used for plant irrigation.

Reclaimed water nutrient levels can vary by a factor of 10 or more, so be sure to contact the supplier to get information on nutrient content. When applying fertilizers to a site that irrigates with reclaimed water, consider the amount of nutrients in the water and reduce fertilzation appropriately. In addition to possible nutrient pollution bu over-irrigating, reclaimed water may contain high levels of chloride, leading to salt accumulations in the soil.

Light

Light influences many aspects of plant growth and development; it is required for photosynthesis, the sole process for sustaining life. Light level is a primary consideration when deciding what plants to use for a specific location. Some plants require full sun to grow satisfactorily and will not grow well in partial sun or shade. Plants adapted to shady environments need less light than plants adapted to full sun. Plants requiring partial shade can be used in sunny areas, if shade is provided during the higher intensity of the afternoon sun.

Reduce both irrigation and fertilization levels for plants in the shade to avoid fungal growth and stress.

In addition to light intensity (levels), light duration also influences certain aspects of plant growth and development. Day length controls flowering in many species. The relationship of the length between day and night is known as photoperiod. A chemical in plants (phytochrome) changes forms during light and darkness. This change signals the plant if days are short or long, thereby triggering flowering at the appropriate time.

Flowering is initiated in some plants when the nights get longer. These “short day” plants include chrysanthemum and poinsettia. Placing these plants under a light disrupts their perceived day length, and they won’t bloom properly. Other plants bloom in the spring with flower initiation triggered by nights getting shorter (long day plants), while another large group of plants are not affected by the relationship of day/night hours (day neutral plants).

For plants to survive successfully indoors, they must be able to adapt to low light levels. Field grown foliage plants in Florida are placed under shade cloth to be better adapted (acclimated) to the low light of interiors. Plants that can withstand low light levels must be acclimatized if they are moved from an area with higher light. Conversely, sunscald occurs in plants that are exposed to bright sunlight after being in an area with lower light levels. This happens when a plant is moved or when a plant is pruned and lower leaves are exposed to full sun.

Temperature

Every plant has a temperature range at which it grows best, although certain plants can survive at much lower and somewhat higher extremes. Changes in temperature influence growth and development processes, such as photosynthesis and respiration. When temperatures go above or below the optimal range, growth slows and can eventually stop. Temperatures more extreme from the optimal range can result in death of the plant. These are not absolute temperatures; rather, they involve relationships between temperature and time. A plant might withstand freezing temperatures for a few hours, but when exposed for 24 hours, it can die.

Optimum temperature ranges vary greatly among species. The situation becomes very complex as one considers that the optimal temperatures for a particular species vary not only with cultivar but also with the stage of development, the tissue involved, the length of exposure, and environmental factors such as radiation received from the sun and water stress. With many plants, the daytime optimum is higher than the optimum temperature at night.

Some plants slow down or stop growing in the summer simply because the temperatures have exceeded their optimal temperature range. This phenomenon is called “heat stall”. As temperatures decrease, the plants will resume growth.

Minimal winter temperatures also determine the northern and southern limits of plants, the former in terms of hardiness to cold (winter survival) and the latter in terms of chilling requirements needed to break dormancy so growth and reproduction can resume. The length of high summer temperature periods also influences plant species adaptation to a region. Both factors influence the natural distribution of plants. We cannot grow a number of plants successfully in Florida because summer temperatures are too high. For this reason, annuals such as pansies, petunias and snapdragons that are grown in the North during the spring and summer are grown as winter annuals in Florida.

Hardiness zone and heat zone maps aid in the selection of plants appropriate to a given geographic region.

Sample Questions - Plant Growth Chapter III

True-False:

21. Fertilizer application rates are usually based on the amount of nitrogen to apply.

22. The chemical symbol for potassium is P.

23. Fertilizer mixtures containing pesticides must have a yellow label.

24. Evapotranspiration is the combined loss of water by both plants and soil.

25. Lime is used to lower the pH of the soil (make it more acidic).

Multiple Choice. Choose the best answer and mark the appropriate answer on your answer sheet. Be sure to match the question number with the answer:

26. If you want to apply one pound of actual nitrogen per 1,000 sq. ft., how much 15-5-10 fertilizer is required?

    A. 3.3 pounds
    B. 1 pound
    C. 6.6 pounds
    D. 5.0 pounds
    E. None of the above

27. The Florida Fertilizer Label Law:

    A. Was designed to protect consumers
    B. Requires that a fertilizer label appear on each bag, package, container or lot of fertilizer sold in Florida
    C. Requires the name and address of the manufacturer or registrant of the fertilizer appear on the label
    D. All of the above
    E. None of the above

28. The pH of a soil with limerock or shells present would probably be:

A. High and easily changed
B. High and difficult to change
C. Low and easily changed
D. Low and difficult to change
E. Variable

29. Plants require ______ essential elements to live.

A. 12
B. 13
C. 16
D. 24
E. None of the above answers are correct

30. Fertilizers sold at retail must have a conspicuous label that says

A. Nitrogen shall not be applied at an application rate of more than 0.7 lbs per 1,000 sq. ft.
B. Do not apply near water, storm drains or drainage ditches
C. Soil tests are required to determine nutrient deficiencies
D. Before using, read the Florida Green Industries Best Management Practices Manual
E. None of the above

Note: A number of the questions from this chapter may be included in the Open Book section of the exam. These questions will involve the correct use of terms using your manual as a reference.