Virginia Cooperative Extension Service
Publication 430-018
1990

Fertilizing Landscape Trees and Shrubs

Virginia Tech and Virginia State • Virginia's Land-grant Universities

FERTILIZING LANDSCAPE TREES AND SHRUBS

by Bonnie L. Appleton
Extension Horticulturist and Assistant Professor
Department of Horticulture
Hampton Roads Agricultural Experiment Station
Virginia Polytechnic Institute and State University

TABLE OF CONTENTS

The author thanks Ron Walden and Joe Eakes, of Virginia Tech's Department of Horticulture, for their help with technical information.

INTRODUCTION

Trees and shrubs in both residential and commercial landscapes should have maintenance programs developed for them. A good maintenance program will include monitoring and controlling insect and disease problems, suppressing competitive weed growth, and making timely applications of water, mulch, and fertilizer.

Tree and shrub fertilization is especially important in the expanding urban and suburban areas of Virginia where soils have been altered. For example, soils on or adjacent to construction sites tend to be heavily compacted, poorly aerated and drained, and low in organic matter. This is especially true of subsoils left after topsoil has been removed and not replaced. These conditions will impede both root growth and nutrient availability and uptake. The recycling of nutrients from leaf litter and other organic matter that is natural in a forested situation does not occur in such landscapes.

However, trees and shrubs in established landscapes on unaltered soils will also benefit from proper maintenance programs, of which suitable fertilization should be a principal objective.

FERTILIZATION OBJECTIVES

How and when landscape plants are fertilized depends on maintenance objectives combined with the ages of the trees and shrubs involved. While everyone wants healthy landscape plants, the objective with mature trees and shrubs should be to maintain the existing growth without over stimulating new growth. Consequently, trees not in lawn areas may need to be fertilized every two to four years; but those in lawn areas may not need supplimental fertilization if the turf is regularly fertilized.

With newly transplanted and young trees and shrubs the objective should be to accelerate growth, especially root growth, in order to successfully establish the plants in the landscape. This means feeding every year for the first two to three years; though, again, over stimulation is not desirable. Excessive fertilization can lead to weak growth that will be more susceptible to cold, drought, pests, and breakage. It can also lead to an increase in maintenance activities such as pruning. Care should always be taken to avoid applying more fertilizer than a young or a mature plant needs, not only because of the wasted fertilizer and time but, more importantly, because of possible groundwater contamination as excess fertilizer runs off or leaches away.

Keep in mind that a plant has a particular order in which it "feeds" itself (distributes manufactured food) - fruits and flowers first, leaves and stems next, and roots last. Even though the roots absorb the water and nutrients needed for photosynthesis (food manufacture by the leaves), they are the last to benefit. If a plant is stressed by improper planting or care or poor site conditions, the roots are typically the first to go unfed and deteriorate. Good root growth is necessary for good top growth.

DETERMINING THE NEED TO FERTILIZE

While the age of a tree or shrub is one of the factors to use in developing a fertilization program, other factors should also be considered.

Analysis of the soil can be helpful, giving an idea of what nutrients are present. This does not, however, guarantee that the nutrients present will be available for plant uptake.

Analysis of the foliage (tissue analysis) can also be helpful, but comparison standards are needed for interpretation. Although general nutrient ranges for healthy plant growth have been established for broad categories of plants, specific nutrient-level standards are available for only a few nursery crops. In addition, foliar analysis is expensive and not readily available to the public.

When making fertilization decisions, the best overall factor to use is probably a visual inspection of the plants. Look for such things as poor or chlorotic leaf color (pale green to yellow), reduced leaf size and retention, premature fall coloration and leaf drop, reduced twig and branch elongation and retention, and overall reduced plant growth and vigor. See Table 1 for help in identifying particular nutrient deficiencies. Keep in mind that biotic stresses such as insects, diseases, and weeds, and abiotic stresses such as soil compaction, improper chemical use, and adverse weather, can either cause symptoms similar to nutrient deficiences or contribute to nutrient stress.

Many people prefer to simply set up regular fertilizing schedules rather than use the various diagnostic tools. Perhaps a calendar schedule combined with plant monitoring is best, but a planned schedule alone is far better than simply fertilizing when it's convenient or remembered. Keep in mind that plants in a lawn situation, where the lawn is regularly fertilized, should be approached differently than trees and shrubs in separate mulched landscape beds. Street tree and parking lot plantings, and trees and shrubs in other nonturf areas, will also have different fertilizer needs.

Table 1. A guide to nutrient deficiences by foliar symptoms.

Symptoms appear in older leaves first:

- General chlorosis followed by necrosis (tissue death) and leaf drop; overall growth stunted .... **NITROGEN**
- Marginal chlorosis followed by interveinal chlorosis; tips and margins may become brittle, curl upward, and die. .... **MAGNESIUM**
- General then marginal then interveinal chlorosis; leaf margins may curl or roll, then die .... **MOLYBDENUM**
- Interveinal tip chlorosis, then necrosis; leaf margins may become brown and curl downward .... **POTASSIUM**
- Leaves develop blue-green or red-purple coloration, possibly yellowing .... **PHOSPHORUS**

Symptoms appear in youngest leaves first:

- Light green to yellowing, interveinal area even lighter .... **SULFUR**
- Veins green, distinctive interveinal chlorosis yellow or white; leaf drop if severe .... **IRON**
- Smallest veins green, interveinal chlorosis beginning at margins, progressing to midribs, followed by interveinal necrotic spots. .... **MANGANESE**
- Very small, stiff, chlorotic or mottled leaves; shortened internodes causing rosetting .... **ZINC**
- Terminal wilting, chlorosis, rosetting and death; veins lighter than interveinal areas .... **COPPER**

Terminal buds die:

- Lateral buds and root tips also die, or lateral growth has few leaves that are chlorotic or necrotic, small, brittle, thick and cupped downward .... **BORON**
- Tips distorted or die back; young leaves chlorotic, hard, stiff, margins distorted .... **CALCIUM**

INTERVEINAL CHLOROSIS

While plants will express each nutrient deficiency with different symptoms, one that is common is interveinal chlorosis. This symptom is often seen on pin oaks in Virginia landscapes. Though this chlorosis is generally due to an iron deficiency, limited iron uptake is generally only part of the problem.

Although adequate iron may be present in the soil, often a pH imbalance (usually 7.0 or above) caused by over-liming a lawn for turf purposes reduces iron uptake or mobility within the plant. In addition, an excess of phosphorus (P), potassium (K), or magnesium (Mg) may induce iron chlorosis as well as induce deficiencies of manganese (Mn) and zinc (Zn) (excesses of Mn and Zn can also induce iron chlorosis). Excessive use of complete (N-P-K) lawn fertilizers around trees and shrubs can aggrevate the situation if the nitrogen forms used cause basic soil reactions (raise pH) and if P and K levels build to excess. Most Virginia soils have adequate levels of P and K, and, therefore, these probably do not need to be regularly added unless indicated by a soil test.

FERTILIZER SELECTION

The major way in which trees and shrubs obtain nutrients is by absorbing them via the soil solution. Nutrients dissolved in the soil solution come from organic matter decomposition, weathering of the soil's silt and clay particles, and applied fertilizers. When selecting a fertilizer, there are many factors to consider, including:

- visual plant symptoms
- soil and tissue analyses
- target plant species and surrounding plants (pH preference, salt sensitivity, etc.)
- growth rate or response desired
- cost
- application equipment available
- soil type (sandy vs. clayey - fertilizers will leach through sandy soils faster)
- effect on soil pH (using an ammonia form of nitrogen fertilizer such as ammonium nitrate or sulfate will increase acidity; using a nitrate form such as calcium or potassium nitrate will increase alkalinity or cause a basic reaction)
- effect of a change in soil pH on other nutrient availability (the desirable pH range is 5.5 to 6.5); below this desired range, N, P, K, Ca, Mg become less available, leading to possible deficiencies, and B, Cu, Fe, Mn, Zn, and Al more available, which leads to possible excesses and toxicity; above the desired range, the reverse generally occurs

Complete fertilizers (such as 10-10-10) that contain nitrogen (N), phosphorus (P), and potassium (K) may be used if a need is indicated, or single-source fertilizers (such as 33-0-0) can be used if only one of these nutrients is needed. Since most Virginia soils, especially those that have been in fertilized turf or agricultural use, have adequate supplies of phosphorus and potassium, the nutrient generally needed the most is nitrogen. In addition, nitrogen is readily leached (washed through the soil), but phosphorus and potassium are not, meaning they require less frequent application.

If any of the secondary nutrients -- calcium (Ca), magnesium (Mg), sulfur (S) -- or minor (trace) nutrients -- iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo) -- are needed, various fertilizer sources can supply them. Within Virginia soils, secondary and minor nutrient deficiencies are rare, with the exception of the iron chlorosis situation mentioned earlier.

Once the choice between either a complete or a specific nutrient fertilizer has been made, the options remaining relate to types of fertilizer products. These options include organic vs. inorganic, fast- vs. slow-release, and dry vs. liquid.

Organic fertilizers include compost, sewage sludge, processed tankage, animal manures, fish scrap, dried blood, and linseed meal. Inorganic forms range from ammonium nitrate to sulfur-coated urea.

While organic sources are mainly slow-release, inorganic sources may be either fast-release or slow-release (see Table 2). Slow- release fertilizers are prepared by several methods, including the use of water-insoluble nitrogen and coating with sulfur or plastic resins. Examples of slow-release inorganic fertilizers to consider include urea formaldehyde (UF), isobutylidene diurea (IBDU), sulfur-coated urea (SCU), and plastic-coated fertilizers such as Osmocote. Slow-release inorganic fertilizers are gaining in popularity because their nutrient content is higher than most organic sources and their potential for wasteful leaching and groundwater contamination is less than fast-release inorganics.

Many of the inorganic fertilizers can be applied in a variety of dry forms (pulverized, granular, tablet, stake or spike, encapsulated), but also can be applied in liquid form. Use the list of fertilizer selection factors to help you choose the right form for a particular landscape situation.

Table 2. Chemical fertilizers, analysis, speed of reaction, effect on soil pH, and salt index.

Fertilizer	Analysis	Speed of Reaction	Soil Reaction	Salt Index
Ammonium nitrate	33-0-0	Rapid	Acid	104.7
Ammonium sulfate	20-0-0	Rapid	Very acid	69.0
Urea	46-0-0	Rapid	Slightly acid	75.4
Ureaformaldehyde	38-0-0	Slow	Slightly acid	-
Sulfur-coated urea	36-0-0	Slow	Acid	-
Di-ammonium phosphate	18-46-0	Rapid	Acid	34.2
Calcium nitrate	15-0-0	Rapid	Alkaline	52.5
Potassium nitrate	13-0-44	Rapid	Neutral	73.6
10-10-10	10-10-10	Rapid	Varies with N source	-
Osmocote	18-6-12	Slow	Acid	-
Dried blood	12-0-0	Moderate	Acid	-
Linseed Meal	5-2-2	Slow	Acid	-

APPLICATION METHODS

Fertilizers can be applied to trees and shrubs by both indirect and direct methods. The major indirect method is via lawn fertilization for those trees and shrubs located in a turf area. This type of fertilization is generally adequate for mature plants. See Figure 1.

Figure 1. When fertilizers are applied to lawns, trees and shrubs growing in the lawn are fertilized as well.

One method for directly applying fertilizer involves incorporating fertilizer when the trees and shrubs are planted. Old recommendations caution against this, but that is mainly because the fertilizers previously available were fast-acting agronomic fertilizers that had the potential to dehydrate the root system, which would "burn" the plant.

With the development for the nursery industry of several types of dry, slow-release fertilizers (preferably with at least 25%-50% water-insoluable nitrogen (WIN)), there are now fertilizers that can be safely incorporated into the backfill soil or placed in the planting hole at planting time (see Figure 2). Also, fertilizers with low adjusted salt indexes, and therefore reduced potential to burn, can be selected (see Table 2). If a soil test reveals that phosphorus and/or potassium should be added, or that the pH needs to be altered, the appropriate fertilizers can be incorporated into the entire landscape area prior to any planting.

The most common form of direct fertilizer application, broadcasting, is the application method that recent research has shown to be generally the most effective, especially relative to cost.

Figure 2. Slow-release forms of fertilizer, such as these compressed briquettes (top) and plastic coated granules (bottom), are safe to put into the planting hole or mix into the backfill soil at planting time.

Simply broadcasting the desired fertilizer on the soil or turf surface under the trees and shrubs and watering it in is usually adequate, although compacted soil should first be aerated or at least raked. See Figure 3.

Figure 3. The easiest and most inexpensive way to fertilize trees and shrubs is to broadcast a fertilizer on the soil surface or over the grass.

Both slow- and fast-release formulations can be used as long as rate recommendations are carefully followed. Again, fertilizers high in WIN or with low adjusted salt indexes should be selected, as with the subsurface application mentioned below. Care must be taken to not adversely affect lawn areas by overfertilizing.

Four other methods of direct fertilizer application exist: subsurface application or soil injection (see Figure 4), foliar application (see Figure 5), root or trunk injection and implantation (see Figure 6), and fertigation. Subsurface or soil injection application involves applying dry, liquid, or liquid-suspended fertilizers beneath the soil surface, generally by injection or drilling holes.

Figure 4. Subsurface fertilizer application involves injecting liquids (left) and drilling holes to be filled (right) with granular fertilizers.

Figure 5. Foliar fertilizer applications should only be used to temporarily correct deficiences of micronutrients.

Figure 6. Fertilizer injected under pressure into holes drilled into trees.

Subsurface application can be helpful in alleviating soil compaction by aerating the soil. A problem, however, is that often the fertilizer is placed too deep (down two to three feet), below the zone where most of the fibrous roots grow. Where recommendations have been changed so that the fertilizer is applied at the six- to eight-inch depth, subsurface applications can be effective, although special fertilizer and equipment, to drill holes or inject under high pressure, is often needed.

A major disadvantage to subsurface application is labor costs because a grid pattern for individual hole placement must be followed. In addition, concentrating fertilizer in individual holes can lead to turf overstimulation or burning near the holes if rates are too high.

A subsurface application method popular with homeowners uses fertilizer that has been compressed and shaped into stakes or spikes that are pounded into the ground (see Figure 7). While these may be convenient to use, cost per unit of fertilizer will be higher because of the manufacturing process. In addition, the spacing of the stakes may not produce adequate fertilization due to the limited number of roots that will be contacted by the dissolved fertilizer.

Foliar application involves spraying the desired fertilizer in liquid form on the leaves of target trees and shrubs. While this method can give relief from nutrient deficiency symptoms (generally only micronutrients such as iron), it is temporary relief at best, only effecting the existing leaves, and only giving good results if applied in spring.

In addition, foliar application does not address the underlying cause of the deficiency, which is generally an imbalance of soil pH or nutrient availability. Once a foliar fertilizer is applied, measures should be undertaken to correct the real cause of the deficiency. If underlying causes are not remedied, then foliar application will constantly need repeating.

Injection and implantation fertilizer applications involve drilling holes in the roots or trunks of trees and either injecting a liquid or implanting a solid capsule in the application hole. As with foliar fertilization, this application method is also remedial at best. It, too, is generally limited to alleviating micronutrient deficiencies, although it may be a more effective temporary remedy than foliar feeding. Injecting and implanting should be done in spring when wound closure will be most rapid. As with foliar fertilization, the underlying soil problem should be corrected.

The major objection to injection and implantation is the wound that is created by drilling the application hole. The wound, even though it is generally plugged following injection or implantation, can be a site for disease or insect entry.

Fertigation involves applying fertilizer, either a liquid or a dissolved dry formulation, via an irrigation source. While this will place the nutrients in the upper soil zone where most of the absorbing roots are, care must be used to get even coverage and the proper dilution rate.

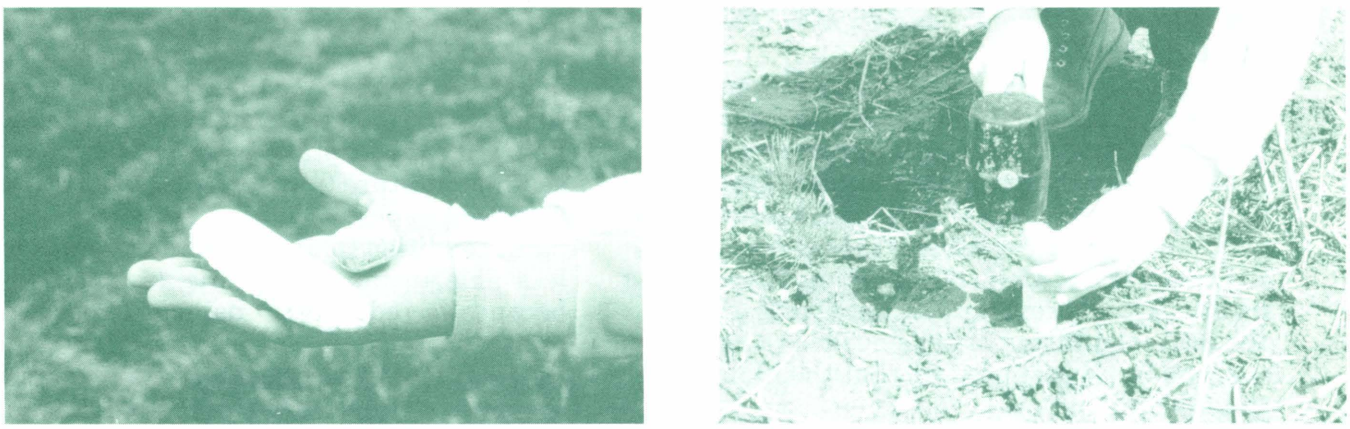

Figure 7. Various compressed forms of slow-release fertilizers can be pounded into the ground for subsurface fertilization.

FERTILIZER PLACEMENT

Not only is it important that fertilizer be placed at the correct depth (shallow, not deep), but it also must be placed in the correct area under trees and shrubs. Old fertilization guidelines, which recommended placing fertilizer from the plant's stem or trunk out to the drip line (the outer edge of a tree's or shrub's crown spread), are no longer considered adequate.

The crown-spread or drip-line area has been shown to be too limited because most of the absorbing feeder roots are out beyond the drip line (see Figure 8). Most tree roots extend an average of at least the radius of the crown out beyond the drip line. A tree with a twenty-foot crown diameter, or a ten-foot crown radius, might therefore have roots out at least twenty feet from the trunk. As much as possible of this entire root zone should be fertilized.

Figure 8. Most tree roots are very shallow (left) and extend far beyond the dripline or spread of the crown (shown here, right, as the area in shadow).

FACTORS AFFECTING FERTILIZER UPTAKE

There are numerous factors that will affect how easily and well trees and shrubs will take up fertilizers. The most important of these are:

- fertilizer form (inorganic, fast-release, or liquid forms are faster than organic, slow-release, or dry forms)
- soil composition (clay particles and organic matter will adsorb (bind to their surfaces) more nutrients than sand, therefore nutrients leach (wash through) sandy soil faster)
- soil microorganisms (fungi and bacteria may "tie up" or use nutrients themselves as they decompose materials, making the nutrients initially unavailable for plants, but the microorganisms may be needed to convert the fertilizer to a form that the plants can take up and use)
- nutrient availability (nutrients may be present but may first require conversion to an "available" form that the plant is capable of taking up)
- soil moisture content (most nutrients are taken up via the soil solution, so soil water is needed to dissolve them, but not to total saturation, which removes soil oxygen which is needed by roots for the uptake process)
- soil aeration (oxygen is needed in the soil to help with root uptake processes)
- soil temperature (nutrient uptake is faster in warmer soils)
- plant condition (plants under stress will be less able to take up nutrients, generally because of reduced or damaged root systems)
- competition (if the roots of many plants occupy a confined area, a reduced amount of nutrients will be available for each)

FERTILIZER RATES

Previous recommendations about how to determine the rate of fertilizer to use have also changed. Recommendations are now based on total root-system spread (as discussed previously under placement), with actual tree trunk diameter or caliper, the old calculation basis, no longer being used to calculate rates. The number of square feet covered by a tree's roots should be calculated, and this root-zone area used to determine the amount of product needed. Generally, the root-zone area will be circular. And remember, the radius of the root-zone area is probably at least twice the radius of the crown.

The formula used to determine the area of a circle is: 3.14 x radius ^{2}. For example, if a tree has a crown spread (diameter) of 30 feet, the radius of the crown spread is 15 feet. Then the radius of the root zone is 2x15, which is 30 feet. Therefore, the area of the root zone is 3.14 x 30^2, which is 2,826 square feet.

The current recommendation is to use one to six pounds of actual nitrogen (N) per thousand square feet of root zone per year for trees that have shown a need for fertilization. Generally, use the lower part of the range (1-3 lbs) for evergreens (more for broadleaves, less for needle) and the higher part of the range (3-6 lbs) for deciduous trees and shrubs. For example, for evergreens this equates to 10-30 lbs of the fast-release granular fertilizer 10-10-10, or 5.6-16.7 lbs of the slow-release encapsulated product 18-6-12 per 1,000 square feet (see Table 3).

If a root system is restricted by paving, a building, or the like, or has been partially removed by construction, the same fertilization rates should be used but the root zone area should be reduced

Table 3. Tree fertilization rate for various tree sizes based on 2 pounds actual N/1000 sq. ft. root spread*

		Fertilizer		
Crown spread	Root spread*	10-10-10	18-6-12	33-0-0
Feet	Square feet		Pounds	
1	13	0.3	0.1	0.8
5	314	6.3	3.5	1.0
10	1,256	25.1	14.0	7.6
15	2,826	56.5	31.4	17.1
20	5,024	100.5	55.8	30.4
25	7,850	157.0	87.2	47.6

* Assumes doubling crown spread (dripline) radius to arrive at root spread (for 5' crown radius, 3.14 x10^2 = 314 sq. ft. area covered by roots)

by the amount of root zone restricted or removed. In addition, mature plants will not need as much as newly planted trees and shrubs. Under shady conditions, cut the rate in half as recommended for turf in shade.

Do not increase the rate where root systems of trees and shrubs overlap (do not count the overlapping areas twice). Simply calculate the entire area containing multiple plants' roots and use this as the total root zone area.

Also reduce the rate if turf or ground covers are beneath the trees or shrubs. More than two pounds per thousand square feet at one time may burn turf or ground covers. Multiple applications at six- to ten-week intervals may be necessary to apply the total amount desired unless a fertilizer high in WIN is used.

If a soil test shows that phosphorus and/or potassium is needed, they are generally applied at the rate of one to two-and-one-quarter pounds and two to four pounds per thousand square feet respectively (1-2 1/4 lbs P and 2-4 lbs K/1,000 sq.ft.). If a complete fertilizer is used, the ratio of N-P-K should be 3-1-2 or 3-1-1 unless the P and/or K are shown by a soil test to be particularly low, in which case additional P and/or K should be added.

FERTILIZER APPLICATION TIMING

The best time to fertilize is when trees and shrubs need the nutrients or when new growth is desired, coupled with when conditions are conducive to fertilizer uptake. Since most people prefer a more specific calendar recommendation, generally the best time to fertilize is in late fall.

In the fall, wait until the deciduous trees and shrubs begin to drop their leaves. This signals dormancy, when no new top growth will be stimulated that might not harden off prior to cold temperatures. At this time the soil is still relatively warm and fertilizer will be easily taken up. Plants can generally absorb fertilizer until the soil temperature drops below 40° F. Do not fertilize frozen ground because the fertilizer will probably just be washed away.

Research has shown that a split application can also be beneficial, applying half of the yearly rate in early spring (February to early April), the rest in the fall (October to December). Again, these calendar guides are better to use than simply fertilizing when it is convenient.

If the trees and shrubs are not in separate beds but are growing in a lawn area, be guided by the best times to fertilize the particular grass species. Cool-season grasses are generally fertilized during the fall and winter, and warm-season grasses are fertilized during the spring and summer. Remember that for trees in a lawn area, if the rate of fertilizer (N) needed exceeds the safe amount for a one-time application to turf, apply the fertilizer in split applications.

Always be sure that adequate moisture (supplied either by rainfall or irrigation or both) is available when fertilizing so that the fertilizer will be dissolved into the soil solution for root uptake, and to avoid burning the grass or shallow plant roots. Do not fertilize during a drought.

SUMMARY

Tree and shrub fertilization decisions should be based on a number of factors: plant age, visual condition, soil analyses, etc. Fall fertilization over the entire root zone with a rate based on the root system's entire spread is generally the best recommendation for Virginia. While numerous types of fertilizers can be used, use them at recommended rates, and place them either on the soil surface or to a shallow depth in the soil. Be sure not to overfertilize, both to avoid damage to turf in lawn areas, and to reduce the possibility of groundwater contamination.

Keep in mind that tree and shrub fertilization is only a part of total plant care. Fertilization may not benefit the plant if it is under stress from poor soil aeration or drainage, saturated soil, insufficient light or space, or excessive pest problems. All of the factors influencing plant growth should be kept at adequate levels to insure good plant growth.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, and September 30, 1977 , in cooperation with the U. S. Department of Agriculture. James F. Johnson, Acting Director, Virginia Cooperative Extension Service, and Acting Vice Provost for Extension, Virginia Polytechnic Institute and State University, Blacksburg, Virginia; Clinton V. Turner, Administrator, 1890 Extension Program, Virginia State University, Petersburg, Virginia.