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# A Word of Caution on Fertilizing Woody Plants (pg 1 of 6)

It is important that the goals of a planned fertilizing program are to increase health of the tree, and not to over-stimulate top growth, or correct problems caused by plant selection, improper planting techniques, poor soil drainage, soil compaction, or incorrect watering. The purpose of fertilizing is to improve the appearance and condition of plants, and increase vigor to make plants more resistant to stresses.

Many landscape plants are under stress, and it must be taken into account when fertilizing, because response to fertilizer varies with plant and environment. Response can be affected by soil fertility, aeration, and drainage, site exposure, temperature, or proximity to manmade structures.

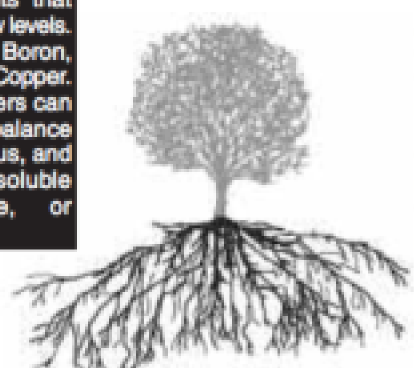
## Plant Nutrition

Plant growth depends on Essential Elements, the absence of which prevents a plant from completing its life cycle. We sometimes refer to supplying plants with these nutrients as 'feeding' but the nutrients act more like vitamins, helping the plant produce energy and grow.

### Micronutrients

Some elements are needed in such small amounts that they become toxic at low levels. These include Boron, Manganese, Zinc, and Copper.

Micronutrient disorders can be caused by the imbalance of Nitrogen, Phosphorus, and Potassium, excess soluble salts, pH balance, or ammonium toxicity.



### DID YOU KNOW?

| If Plant Has Nutrient... | Fertilizing Will |
|---|---|
| ...Deficiency | Increase plant growth |
| ...Adequacy | Not change growth |
| ...Surplus | Decrease plant growth |
| ...Toxicity | Kill plant |

## The Essentials

There are sixteen elements required for plant growth. Carbon, Hydrogen, and Oxygen are provided free, from the environment. Thirteen other elements are provided by the soil and transformed into absorbable forms, then taken up by the roots. Plants will absorb any element from the soil, including non-essential, even toxic substances. Plants can have multiple deficiencies of nutrients at one time, or an excess of one nutrient can cause toxic amounts another.

**N- Nitrogen**

Nitrogen is one of the most abundant elements, and makes up 80% of the atmosphere, but it is in an inert form, and must be fixed (chemically transformed) to be useable by plants. Nitrogen is the critical limiting element for most plants because of its unavailability, and is second only to light and water in importance. Nitrogen is required for growth from seedling or cutting to mature plant, and the need increases as plant growth increases.

Plants acquire Nitrogen from the soil through fertilizer, manure, or mineralization of organic matter, from the atmosphere, through N fixation in the soil or from movement within the plant.

**P- Phosphorus**

Phosphorus is second only to Nitrogen as the limiting element for plant growth, and is an important part of plant cells. Phosphorus is abundant in most soils but mostly unavailable for uptake, because it forms insoluble complexes and is incorporated into organic matter by microbes. Only 20% or less of the Phosphorus applied is used by the current years growth, the rest can be lost to runoff, affecting the health of lakes and rivers. Care must also be taken in phosphorus applications, as excess can interfere with mycorrhizal-forming fungi.

# A Word of Caution on Fertilizing Woody Plants (pg 2 of 6)

## In the Soil-Symbiotic Associations

In healthy soil, many types of tiny living things exist that aid in plant growth and survival. They form symbiotic beneficial relationships with plant roots, where they help the plants obtain water and nutrients, and the microorganisms get energy, vitamins, and amino acids. Water stress not only affects plants, but also affects the ability of symbiotic microorganisms, because less water means less materials transported to make energy that the bacteria or fungi depend on.

## Mycorrhizal-Plant Associations

Certain types of fungi inhabit and colonize the fine non-woody roots of plants, and form root structures called mycorrhizae. These structures extend the roots, and can increase surface area up to 700%, increasing the uptake of water and nutrients. The mycorrhizae are finer than roots so they can extend in soil pores, and they typically grow faster, live longer, are more efficient, and absorb and accumulate nutrients better than roots. With the increased ability to take up Nitrogen and Phosphorus, the most important nutrients, mycorrhizae are credited with the adaptation of land plants to nutrient poor soils.

With the aid of the mycorrhizae, plants have increased tolerance of soil compaction, pH extremes, salinity, drought, heavy metals, organic or inorganic soil toxins, and high soil temperatures, all of which are common characteristics of difficult landscape sites. Plants with mycorrhizae also show increased growth, flowering, and hardiness, and less transplant shock. Mycorrhizae can also deter pathogens and parasites by creating barriers, creating competition, or producing toxins.

Mycorrhizal fungi associate with 80% of land plant species, and occur naturally in soil, but typically not in cultivated nursery fields. Soils that are low in organic matter, in a field rotation, sterilized, or compacted, or have high fertilizer levels, high pH, bad drainage, or frequent irrigation are unfavorable to mycorrhizal fungi. Soil-less container mixes are completely uninhabitable.

## Bacterial-Plant Associations

Rhizobium and other bacteria live in the root nodules of certain families of plants, mostly Legumes, fixing more Nitrogen than free-living bacteria because of the energy and protection from the plant. There are also woody non-legume species of certain families that have root nodule bacteria.

These plants are all adapted to grow in poor soil, and will form nodules even in nursery fields if inoculated with the bacteria:

| | |
|---|---|
| **Alnus glutinosa** *Alder Common Black* | **Carpinus betulus** *Hornbeam European* |
| **Alnus rugosa** *Alder Speckled* | **Carpinus caroliniana** *Hornbeam American* |
| **Betula alleghenensis** *Birch Yellow* | **Carpinus japonica** *Hornbeam Japanese* |
| **Betula Madison** *Birch White Satin* | **Ceanothus americanus** *New Jersey Tea* |
| **Betula nigra** *Birch River* | **Cephalanthus occidentalis** *Buttonbush* |
| **Betula nigra Fox Valley®** *Birch Little King Dwarf* | **Comptonia peregrina** *Sweetfern* |
| **Betula nigra Heritage®** *Birch Heritage® River* | **Corylus americana** *Filbert American* |
| **Betula plat. japonica** *Birch Whitespire* | **Myrica pensylvanica** *Northern Bayberry* |
| **Betula x 'Crimson Frost'** *Birch Crimson Frost* | **Ostrya virginiana** *Hophornbeam American* |

Even though the root nodule bacteria only associate with certain plants, the increased Nitrogen fixed in the soil can benefit other plants nearby. These plants can be used as cover crops or in companion planting.

### Legumes are dependent on mycorrhizae for efficient Phosphorus uptake

Tree legumes inoculated w/ rhizobia and mycorrhizae are often used for reclamation of poor, degraded soils. Two different types of mycorrhizal fungi are endo- and ectomycorrhizal fungi. Endomycorrhizal fungi occur in most plants woody and herbaceous, inside the plant roots. Ectomycorrhizal fungi occur in only woody plants, outside plant roots. About 2,100 species of trees form mycorrhizae including alder, birch, hickory, pecan, walnut, fir, hemlock, pine, spruce, poplar, and willow.

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# Fertilizing Woody Plants (pg 3 of 6)

## Nutrients From the Atmosphere

Nitrogen from the atmosphere is returned to the soil by rain or snow, lightning, volcanoes, industrial byproducts, or leaching from plant leaves.

## Nitrogen Movement within the Plant

Nitrogen is mobile. It moves easily within the plant to where it is needed. Plants can move Nitrogen from old to new leaves if adequate amounts are unavailable. Nitrogen is needed most in the leaves, meristems and seeds of the plant.

Seasonal movement of Nitrogen within a plant also occurs. In Fall and Winter, Nitrogen concentration increases in woody tissue as nutrients and other materials are sent to the branches before the leaves fall. In Spring, Nitrogen is moved back from the woody tissue to the growing leaves and shoots. Nitrogen from stored wood is more readily available for plant growth than external sources.

## Strategies for Correcting Nutrient Deficiencies

### Prevention

To prevent nutrient deficiencies from occurring, first select the right plants for the site conditions. A plant that has its preferred light, water, and soil will be able to use the nutrients available.

One can prevent Nitrogen deficiencies by planting Nitrogen fixing companion species in the landscape.

### Correction – The Last Resort

The last resort is to Fertilize a plant, after careful analysis, because it has a complex effect on the quality of the plants and the quantity of the plant products (flowers, fruits, shoots in shrubs). For example, fertilizing could increase the number of flowers or fruits, but lower the quality of the fruits or the plant.

The best fertilizing results occur if other factors important to the plant are not limited, and the plant is in balance.

**DID YOU KNOW?**

A person's nutritional Nitrogen needs are derived solely from plants.

## Limitations to Plant Response to Fertilizer

### Root/Shoot Ratio Balance

Different plant species have different ratios of roots to shoots, and root/shoot ratio decreases with plant age and size, but no matter what its desired ratio is, a plant will always attempt to return to it no matter what happens to it. Plants have developed this balance to efficiently supply the above ground parts with the water, nutrients, and hormones it needs from the roots, and supply the root system with the energy and products it needs from the leaves. An upset in either part is a problem for the other part.

### Disturbing the balance - Examples

Shading, pruning, defoliation, flowering and fruiting all decrease growth by lowering photosynthesis or using up energy. Heavy Nitrogen fertilization increases shoots, but decrease the ratio.

Injury to either roots or shoots triggers compensation of that part at a rapid rate. When plants are dug in a nursery, roots are cut, and when the plant is back in the ground, hormones and energy are sent to roots for rapid growth to make up for the loss. If the leaves, however, are not getting what they need, they are not able to send the roots what they need to make up for the loss.

**DID YOU KNOW?**

Atmospheric nitrogen fixing is only 1/7 of the amount of that fixed by microbials. The decay of organic matter also releases Nitrogen to the soil, but it can takes up to 50 years to release all the Nitrogen from 1 years worth of plant litter.

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# A Word of Caution on Fertilizing Woody Plants (pg 4 of 6)

## Effects of Fertilizing on Pest and Disease Susceptibility

Any physiological change in a plant, good or bad, attracts some type of pest or disease if it is in the vicinity.

***Examples:***

- Some insects attack trees with low vigor, low energy reserves
- Parasites generally prefer vigorous plants
- Decay fungi prefer woody parts with high Nitrogen concentrations
- Damping off diseases prefer young soft stems
- Rust fungi generally prefer young plants
- Canker diseases generally prefer trees under 20 years old

Fertilizing a plant causes a physiological change in the plant, which can make it healthier and more resistant to some pests or diseases, or it can upset the plant balance and make it more susceptible to other pests or diseases. For example, fertilizing can increase resistance of Elms to Dutch Elm Disease.

***Fertilizing can…***
*…increase susceptibility to sucking insects*
***but***
*provide resistance to leaf diseases and dieback diseases*

**Examples of When Fertilizing Does not work:**

- Drought = decreased plant growth = less water and nutrient uptake
- Waterlogged soil = decrease effectiveness of roots = less water and nutrient uptake
- Root pathogen attack = root injury = less water and nutrient uptake
- Defoliation by pests = decrease Photosynthesis = decrease growth = less energy to roots = less water and nutrient uptake
- Competition from weeds = decrease availability of water/nutrients = less water and nutrient uptake

**Law of Diminishing Return:**
with any plant no matter its nutrient needs, continually increasing fertilizer past the adequate level does not increase growth

## Effects of Excess Fertilizer

Applying excess fertilizer, beyond what a plant can use is not only wasteful of time, money, and resources, and a pollution hazard for ground water, lakes, and rivers, but it can harm the plant more than helping it.

Over fertilizing can cause a buildup of salts which can affect plant cell water pressure, change pH, unbalance the plant, or burn the roots. Any of these changes can decrease water uptake, creating water stress in the plant, and eventually cause injury or death. Root injury from pH change can also be caused by the increased solubility of certain toxic elements in acidic soil, or the decreased availability of Iron and Manganese in alkaline soil.

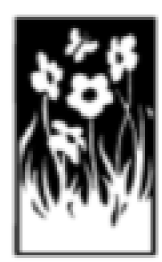
Late season fertilizing prolongs the growing season, and a late flush of growth may not have time to harden before frost, resulting in freezing injury.

Over-stimulating the branching, flowering, fruiting, especially on mature trees uses excess energy, and the plant will be stressed the following season as it tries to replace its energy reserves.

In very young plants, fertilizing that creates overly excessive top growth, creates a low root/shoot ratio, which means poor transplant survival.

The effects of over-fertilizing are different depending on the plant species, but typically, conifers are more sensitive to over-fertilizing because they have about 1/3 of the nutrient need compared to deciduous plants. Conifer roots can be easily damaged by over-fertilizing, or unwanted and excessive growth can occur.

***Fertilizing can…***
*…increase the seriousness of root diseases,*
***but***
*discourage defoliating insects and borers*



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# A Word of Caution on Fertilizing Woody Plants (pg 5 of 6)

## Maximizing Healthy Growth

Overall plant growth increases more if there is little water stress than by increasing fertilizer, and plants in water stress will not use fertilizer.

**In the nursery**

Container grown shrubs are usually given a controlled release fertilizer mixed with the soil, or applied through the irrigation system. Fertilizer is essential in soil-less or nearly soil-less container media, but to get the best landscape plant, the goal of a container nutrient program should be to have a high root to shoot ratio. Plants held above ground should be watered thoroughly every 2-3 days, depending on the weather.

**Digging/Transplanting**

Digging plants in the field, cutting the roots, is the equivalent of surgery to a plant. After transplanting, what they really need is rest, and lots of fluids. So forcing recovery and growth by fertilizing can cause problems and stress the plant. After planting in the landscape, plants should be watered 1" once a week, depending on the weather.

**Maintaining in the landscape**

* The second year after transplanting is the time when fertilizer can be used to increase height, width, and caliper. Once established, plants can be fertilized to maintain health and vigor.
* Fertilizing should be based on plant nutrient needs, which will result in higher uptake efficiency compared to constant and uniform fertilization.
* Uniform fertilizing can cause more problems, because some micronutrients are toxic at low levels. Fertilizer needs also depend on soil organic matter, soil texture, and drainage.

**_Watering transplants_**

*Rule of thumb: Keep roots moist but let the top few inches dry out between waterings (increase oxygen in soil) Newly planted trees need thorough watering after planting and regular watering should be continued over a period of 2-3 years. Slow soaking should take place up to 2-3 inches. As a general rule, trees should receive 1-2 inches of water every 7-10 days throughout growing season (more if temps are extreme). Water slowly, deeply and intermittently, not daily. Use a soil probe as guide.*

## How do you know if a plant needs Fertilizer?

Most plants will begin to show symptoms of a deficiency in a nutrient starting with decreased growth, followed by physical changes, and in extreme cases death. These symptoms can also be caused by many other environmental or cultural factors, so more investigating needs to be done before assuming the plant needs fertilizer.

## General Chlorosis

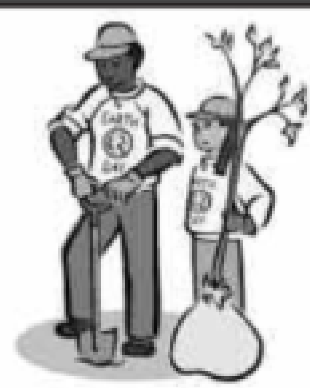
Chlorosis is yellowing of the leaves and is caused by a general disturbance to the plant metabolism. It is usually from a Nitrogen deficiency or lack of other essential element. A plant lacking Nitrogen will also have a lack of chlorophyll production and a decrease in photosynthesis, and a decrease in growth. Chlorosis can also be caused by over or under watering, temperature extremes, toxic substances, excess elements, genetic mutations, or pH of soil.

**Common Physical Signs of Nutrient Deficiency**

No terminal growth
Pale green/yellow leaves (chlorotic)
Mottled or stunted leaves, or early loss of leaves
Dead branches
Decreased General Vigor
Compare the length of twig growth

* Young trees - 9-12" terminal growth per year
* Mature trees - 6-9" terminal growth per year
* Shrubs - 6-9" terminal growth per year

(varies by season, variety, species, size)



**DID YOU KNOW?**

3lbs actual N per 1,000sqft per year is all that is needed for the health of woody plants in most situations

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# A Word of Caution on Fertilizing Woody Plants (pg 6 of 6)

## Determining Nutrient Needs

Generally if foliage color, growth, vigor not normal, plant tissues or soil can be analyzed for deficiencies.
General Calculations for Nutrient Needs

- Measure trunk to edge of branch spread (radius)
- Radius squared x 3.14= surface area
- 3 lbs/1,000 sqft
- Woody plants- 3-1-2 or 3-1-1 ratio

## Fertilizing Efficiency and Timing

Plant leaves can take advantage of the greatest amount of nutrients until September or October, when the plant begins its rapid accumulation of energy and nutrients in the roots and woody stems. The highest Nitrogen recovery efficiency is in late summer/early fall. In the following Spring, half of the Nitrogen stored is remobilized to the leaves, and the whole plant dry weight doubles in April-June.

### Fertilizing Timing

The best time generally to fertilize is in spring and fall. Fall is best, generally after the first hard freeze in September or October. Spring is the next best, but it should be done early, before growth in March to early May. Summer fertilizing can be done up to July 1. Correct fertilizing in the summer can be used to increase flowering, fruit set or fruit size the next year. Fertilizing too late in the growing season promotes a late flush of growth, which is not able to mature before the fall freeze.

## Kinds of Fertilizers

Fertilizer Analysis or Grade refers to minimum amounts of N, $P_2O_5$ and $K_2O$ in fertilizer, and the number is the percent of each in the mix.

**Organic** - from plant/animal source, slow to be available because it must be reduced by microorganisms to usable form

**Chemical -** mixed or manufactured, typically lower cost

**Slow Release Fertilizer -** organic or chemical, slow rate of release, low burn, low water solubility

**Liquid fertilizer -** soluble, applied to leaves or soil, used for deep root feeding of trees/shrubs

## Methods of Fertilizing

The best method to use depends on budget, and site and plant conditions.

- Liquid injection into soil- easy for roots to uptake, water used also helps plants
- Dry fertilizer in drilled holes in soil- helps aerate heavy compacted soils
- Fertilizer on soil surface- the least time and expense, but can increase turf growth
- Liquid Spray on foliage- Does not provide all necessary nutrients for growth, but can correct minor nutrient deficiencies (especially iron)

A Soil Sample should be done before planting to monitor soluble salts and pH, and determine what fertilizer is needed. This should be done at least a year before, and tested every three years after plants are established.

### Resources

Rose, Mary Ann, and Barbara Biermacka, 'Seasonal Patterns of Nutrient and Dry Weight Accumulation in Freeman Maple', HortScience, American Society for Horticultural Science, February 1999 (Vol 34, No 1)

Rose, Mary Ann, Mark Rose and Hao Wand, 'Fertilizer Concentration and Moisture Tension Affect Growth and Foliar N, P, and K Contents of Two Woody Ornamentals', HortScience, American Society for Horticultural Science, April 1999 (Vol 34, No 2)

Vance, Carroll P., 'Symbiotic Nitrogen Fixation and Phosphorus Acquisition. Plant Nutrition in a World of Declining Renewable Resources', Plant Physiology, October 2001 Vol. 127, pp. 390-397. www.plantphysiol.org

'Fertilizing Landscape Plants' Green Tips, Dept of Horticulture- Michigan State University March 1998

'Fertilizing Woody Ornamentals' Texas A&M University Extension Horticulture Information Resource