NURSERY SOIL MANAGEMENT FOR HARDWOODS

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My remarks on soil management at previous nurserymen's conferences were particularly directed towards conifer seedlings. The reasons were threefold; one, most nurserymen were concerned with growing far more conifers than hardwood seedlings; second, there was more information available for conifers; and third, most nursery sites were selected for conifer production rather than for hardwoods.

I have stated that there is generally no excuse for not producing a high percentage of grades 1 and 2 pine seedlings. Unfortunately, we do not have sufficient knowledge regarding seedling quality, nutrient requirements or soil-plant relationships to produce continuing crops of quality hardwood seedlings.

The size of the end product; i.e., grades 1 plantable seedlings, is determined by the rate of growth per unit time and the length of time during which growth takes place. The period of growth should be known, and in southern nurseries is approximately 9 to 15 months. The rate of growth per unit time is a function of inherent (genetic) properties, environmental factors such as light, temperature, oxygen supply, water, nutrients; and biotic influences, some of which may affect the immediate environment, e.g. sulphur bacteria, parasitic nematodes, mycorrhizal fungi, etc.

Soil management in hardwood nurseries involves: (1) a maximum degree of sanitation, (2) an intensive mapping of critical areas in the nursery, (3) maintenance of soil physical properties, and (4) maintenance of an adequate and balanced ratio of nutrients.

SANITATION

Some of the major avenues of concern have already been thoroughly discussed but let's stress them again.

1. Weeds - Weed pests compete with seedlings for moisture, nutrients, and growing space. They also harbor insects, fungi, and other pests.

2. Parasitic fungi and insects - Soil inhabiting parasitic fungi, nematodes and some insects can create symptoms similar to nutrient deficiencies. Fumigation of the soils and washing-down of equipment may be required as standard practices.

Biocide residues - The introduction of toxic substances into a biological system can temporarily unbalance the soil microbiology and cause abnormal growth of seedlings. Some materials are cumulative in the soil and may persist for years. Concentrations of copper carbonate, used as a rabbit repellant, have persisted for years and resulted in malformed roots. Others are metabolized by microorganisms.

Drainage - There should be no standing water within the seedbed area. The soil should be well-drained to imperfectly-drained.

MAPPING OF CRITICAL OR UNUSUAL AREAS

Most nurseries in the southern states are located on light-textured soils. There may be blocks or patches where the tree stand and quality are quite different from other areas. These differences may be due to filling, grading, or leveling with soil material varying in silt-plus-clay content, organic matter and nutrient level. The more fertile parts of the nursery should be set aside for the more nutrient demanding hardwoods. The soil samples should be kept separate by areas of good and poor growth or by apparent texture differences within a working unit.

SOIL PHYSICAL PROPERITES

Soil fertility and the growth patterns of seedling roots depend on the physical condition of the soil. Soil texture is something we are pretty much stuck with as we generally have to live with conditions as we find them.

Soil structure or the aggregation of primary soil particles (sand, silt, and clay) into compound particles can be influenced by cultural practices, such as addition of organic matter, liming, tillage operations and traffic.

Structure modifies the influence of texture in regard to moisture and air relationships, availability of plant nutrients, actions of micro-organisms and root growth.

Organic Matter - The productive capacity of any soil, especially for hardwood seedlings, is intimately associated with the supply of organic matter. Organic matter improves structure (aggregation); aids water penetration, retention and tillage; reduces erosion and lifting damage to roots; retards nutrient leaching; is a reservoir for N and P, chelates some nutrients; and improves buffering action.

These are three major ways in which organic matter is lost from the nursery soils.

1. Removal with seedlings - When a crop of tree seedlings is harvested a certain amount of soil and organic matter are removed with the roots.

2. Oxidation - High soil temperatures and frequent cultivation together with micro-organisms in the soil cause a destruction and/or oxidation of organic matter.

3. Erosion - Regular tillage combined with high intensity rainfall causes an organic matter loss through removal by erosion.

There are essentially only two sources of soil organic matter.

1. Organic material which is grown on the soil. A desirable cover crop or green manure should produce a heavy cover of course fiber.

2. Organic matter brought to the soil. This may include organic material incorporated directly into the soil or composted material added to the soil.

One percent organic matter in an eight inch plow layer of sandy soil means about 12 or 13 tons dry weight per acre. When a heavy cover crop of five to six tons of dry matter per acre is plowed under three to four tons is promptly decomposed, leaving about two tons of slowly decaying humus remaining to be added to the organic matter content of the soil in following years. Such small net additions may not even offset normal decomposition. Thus, cover crops or moderate applications (10 tons per acre) of sawdust or compost applied one year out of two or three simply can not increase soil organic matter content.

Organic matter levels of 2 to 4 percent are considered minimum for production of normally developed hardwood seedlings possessing a high survival and growth potential.

The adjustment of organic matter levels to the desired optimum cannot be accomplished by single cover crops or applications of organic additives. A 2-1 rotation, i.e. two years in cover crops with organic additives is recommended for hardwood production areas.

SOIL CHEMICAL PROPERTIES

Soil reaction - The more exacting hardwoods such as black walnut, white and cherrybark oak, black locust, yellow poplar, sycamore, white ash, catalpa, and basswood grow best within a soil reaction range of about 5.8 - 6.5. This compares with an optimum of about 5.2 - 5.8 for conifers.

The addition of lime improves both physical and chemical properties of the soil.

Over a period of years, a good liming program improves the physical condition of the soil by: (a) decreasing bulk density, (b) increasing its infiltration capacity and (c) increasing the rate of percolation of water.

Dolomitic limestone furnishes calcium and magnesium for plant nutrition.

Lime reduces the loss of nitrogen from soils.

Lime increases the availability of nitrogen by hastening the decomposition of organic matter.

5. Lime makes phosphorus more available.

Lime makes potassium more efficient in plant nutrition by reducing the excessive intake of potassium.

Aluminum, maganese and iron are rendered less soluble when a soil is well supplied with lime.

Beneficial soil bacteria are encouraged by adequate supplies of lime in the soil.

Lime monitors the physiological balance of plant nutrients in the soil.

Nutrient Levels - Optimum levels of essential elements and micronutrients have not been determined for the southern hardwoods. The will be different for each soil type and for each species. Wilde suggests the following standards of nursery fertility for some of the Central States hardwoods. 1/

STANDARDS OF NURSERY FERTILITY

SPECIES	pH	EX. CAP. M.E./100 GM	TOTAL N %	AVAILABLE N	P	K	Ca
				LBS. PER AC.			
YELLOW BIRCH	5.3	12.0	.16	35	26	145	2000
MAPLE, ELM BASSWOOD	5.8	14.0	.20	45	66	228	3500
W. ASH	6.2	16.0	.22	55	81	249	4500

1/ FROM WILDE . 1941. BETTER CROPS WITH PLANT FOOD MAG . 25 (6) : 14-16; 40-42.

The table shows a wide range in levels of availability for three species. This suggests that the nursery manager must adjust fertility levels for each species or develop a high fertility level that will meet the requirements of the more exacting species.

The nursery manager must know the function of each of the essential elements, the symptoms associated with nutrient deficiencies and finally the relative nutrient levels and ratios needed for his particular soil.

GENERAL NUTRIENT FUNCTIONS AND DEFICIENCY SYMPTOMS FOR HARDWOODS

Nitrogen

Function:
1. Constituent of chlorophyll, enzymes, proteins and protoplasm.
2. Stimulates rapid vegetative growth.

Def. symptoms:
1. Leaves develop light green to cream color; may change to red or purple; varies with species, soils and temperature.
2. A general reduction in leaf size and in the number of leaflets.
3. Stems slender
4. Roots stunted.

Phosphorus

Function:
1. Constituent of cell nucleus.
2. Essential for cell division and development of meristematic tissue; seed germination; root development.
3. Synthesis and respiration of carbohydrates; protein metabolism; energy relationships.

Def. symptoms:
1. Stems are slow growing; stunted.
2. Leaves dark green color; may turn yellow, brown, purple or bronze.
3. Purplish or reddish tints on twigs and petioles of leaves.
4. Overall appearance variegated.

Potassium

Function: 1. Catalytic effects on protein synthesis, translocation, and enzyme activity.

2. Favors drought and cold hardiness; regulation of cell water and transpiration.

Def. symptoms: 1. Leaves become chlorotic or mottled from margin toward veins; with bronze, scorched or necrotic spots; smaller than normal.

2. Shoots and stems slender; tend to die back.

3. Roots small.

Calcium

Function: 1. Constituent of cell walls as calcium pectate.

2. Nitrogen metabolism.

3. Essential for the structural and functional integrity of plant cell membranes.

Def. symptoms: 1. Stems and roots stunted and stubby.

2. Leaves distorted or malformed; chlorotic; mottling or brown scorching along margins.

3. Injury of meristems; disintegration of terminal buds and associated tissue.

Magnesium

Function: 1. Constituent of chlorophyll.

2. Synthesis of phosphorus, fats and oils.

Def. symptoms: 1. Older leaves develop mottled interveinal chlorosis followed by reddening and necrosis.

2. Roots stunted; sparsely branched.

Iron

Function: 1. Chlorophyll formation.

2. Synthesis of chloroplast proteins.

3. In respiratory enzymes.

Def. symptoms: 1. Interveinal chlorosis of terminal leaves.

2. Marginal and tip scorching; necrotic areas.

3. Reduction in leaf size.

Sulphur

Function: 1. Constituent of amino acids.

2. Synthesis of proteins.

3. Influences enzyme action, oxidation and reduction.

Def. symptoms: 1. Pale green to yellow young leaves.

2. Leaf size may be reduced.

3. Stems slender.

Boron

Function: 1. Synthesis and translocation of sugars.

2. Involved in respiration, and water relations of cells.

Def. symptoms: 1. Leaves small, malformed, burned or mottled.

2. Apical meristems blacken and die.

3. Root branches short, stubby and brownish.

Manganese

Function: 1. Activation of enzyme systems.

2. Essential for synthesis of chlorophyll.

Def. symptoms: 1. Interveinal chlorosis or spotting on younger leaves; necrosis and early leaf drop.

2. Differential chlorosis between growing tip and older leaves.

3. Leaves may be rolled, cupped or wrinkled.

Zinc

Function: 1. Constituent of some enzymes.

Def. symptoms: 1. Interveinal or complete chlorosis.

2. Leaf malformation.

Molybdenum

Function: 1. Involved in nitrogen fixation.

2. Essential constituent of nitrate reductose systems.

Def. symptoms: 1. Interveinal chlorosis in young leaves.

2. Marginal burning of old leaves.

3. Reduction in leaf size and number of leaflets.

Copper

Function: 1. Constituent of some enzymes.

2. Associated with chloroplasts and proteins.

Def. symptoms: 1. Interveinal chlorosis.

2. Possible malformation of leaves.

3. Necrosis of leaf tissue.

MAINTENANCE OF NUTRIENT LEVELS

A nursery manager has four guides that can be used to regulate nutrient levels. The judicial use of each is essential in determining soil management practices for growing not only high quantity of stock but also high quality stock.

Morphological Measurements - Numerous morphological measurements of seedlings may be useful, e.g. height, color, diameter, leaf size, root size or system, top weight, root weight; and any number of ratios. Mr. Weber has already described the desirable seedling.

Deficiency Symptoms - These have already been discussed.

Soil Analysis - Most nurseries are already involved in a testing program for pH, P, K, Ca, and O.M. The analyses should also include Mg, Fe, Mn, An, and B at least on three year intervals.

Tissue Analysis - Nutrient deficiencies often produce characteristic visual symptoms. Sometimes, however, symptoms for two or more elements are so similar that it is difficult to distinguish between them. In these cases, chemical analyses of the plant tissue can often identify the deficient element.

The Soil Testing and Plant Analyses Laboratory of the University of Georgia and similar labs in other states will make soil and plant tissue analysis for a small processing fee.

GENERAL RECOMMENDATIONS

1. Maintain a sanitary nursery.

2. Maintain a high level of organic mater; i.e. from 2 to 4 percent.

3. Maintain a pH within the range of 5.8 - 6.5.

4. Make annual analysis of soils.

5. Use micronutrient fertilizers such as Ferro's FTE or Chevron's Ortho nutrient D to supplement regular fertilizer treatments.

6. Use foliage analysis to pinpoint specific problems.

A list of selected references is provided. Each of these include some information that could be useful in developing soil management practices.

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