SOIL MANAGEMENT

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Nursery soils have been discussed rather thoroughly at previous nursery conferences. Topics discussed within the past few years include:

1-964 The forest nursery and its soils.
Jack T. May.

Soil nutrients and pH in southern hardwood nurseries.
F. T. Bonner and W. M. Broadfoot.

Soil problems in forest nurseries as related to hardwood seedling production.
M. K. Meines.

Pesticide residues in soils.
A. D. Worsham.

Pesticides in forest nursery soils.
John P. Hollis.

1961 Cover crops, other organic amendments, with fertilizer requirements.
Harvey H. Johnson.

Seedling chlorosis.
Al Foster.

1959 Physical and chemical requirements for seedlings.
Jack T. May.

Comparison of chemical analyses of various nurseries.
Sam Lyle.

Chlorosis — What it is and suggestions for control.
Arnold Lewis.

1957 Nursery diseases: Damping—off, black root rot, chlorosis.
Al Foster.

1953 Soil tests for forest tree nurseries.
Jack T. May.

Soil characteristics currently associated with soil problems include:

A. Physical

1. Soil moisture - drainage.
2. Soil structure - crusting and packing.
3. Organic matter
    a. Effects on soil structure.
    b. Effects on fertility.
        (a) Soil fumigants.
        (b) Cation and anion exchange.

B. Chemical

1. Balances among nutrients.
2. Excessive levels of soil reaction and minerals.
    a. pH.
    b. Phosphorus.
    c. Calcium.
    d. Nitrogen.

C. Biotic

1. Nitrogen fixing bacteria.
2. Nematodes.
3. Fungi.
    a. Fusarium Schlerotium complex.
    b. Pythiums, etc.

PHYSICAL CHARACTERISTICS

Drainage

A detailed and effective drainage system is usually included as part of the nursery development. Sometimes, drainage systems are developed gradually over a period of years.

In some older nurseries, there is a tendency to forget that maintenance of drainage systems is a part of soil maintenance. Consequently, depressed areas within and adjacent to seedbeds become reservoirs after rains or irrigation. Seedling production is greatly reduced or becomes nil on the low, wet area. Also, the areas are favorable habitats for pathogenic organisms.

Imperfect drainage results in excessive moisture and poor aeration. Chlorosis, root rots, and poor seedling development are frequently directly related to imperfect drainage.

Imperfect drainage, also, may affect cultural operations such as cultivation, spraying, and lifting of seedlings.

Paths or alleys between seedbeds and drainage ditches adjacent to seedbed areas should be graded so that free water does not remain on the surface longer than 6 to 12 hours after a rain or irrigation.

<u>Structure</u>

The importance of soil structure in nursery soils cannot be overemphasized. In pure sands the structure is single-grained. As texture changes from loamy sands to loamy, silt loamy and sandy clay loamy, a crumb or granular structure should be developed and maintained.

Crusting and compaction develops with the flocculation of soil particles. Poor aeration, imperfect internal drainage and, consequently, poor development of root systems are associated with poor soil structure.

Rototillers and similar pulverizing equipment should be used sparingly; and only rarely for seedbed preparation.

<u>Organic matter</u>

Organic matter has beneficial effects on both light and heavy-textured soils. It influences the development of a crumb or granular structure in all soils. It increases the waterholding capacity of light-textured soils and improves the drainage of heavy-textured soils.

In general, soil fertility increases with an increase in organic matter, through an increase in exchange capacity.

Intensive use of soil fumigants makes the role of organic matter more complex. For example, when soils high in organic matter or humus are fumigated with chemicals, such as methyl bromide, excessive amounts of ammonium nitrogen may accumulate and persist for weeks or months.

CHENICAL CHARACTERISTICS

Quality pine seedlings can be produced uncer a relatively wide range of nutrient levels, as long as balances are maintained among nutrients. Gilmore and Kahler (1965) reported on use for fertilizers and organic additives for loblolly and shortleaf pine (table 1). Sawdust was added at rates of 100 and 200 cubic yards per acre. N, P, and K rates of applications ranged from 300 to 900 pounds of ammonium nitrate, 110 to 660 pounds of superphosphate, and 28 to 166 pounds of muriate of potash per acre. Seedbed treatments did not affect height growth, percent of plantable seedlings, or survival of planted seedlings.

A high percentage of abnormalities in seedling development, growth, or color are associated with a high or low pH, or deficient or excessive concentrations of minerals.

A pH of about 5.5 to 6.0 is considered optimum for production of southern pine seedlings. Soil reactions as low as 4.7 and as high as 7.0 are still found in some nurseries.

Nutrient deficiencies can usually be detected by slow growth, color abnormalities, or soil test; and corrections are relatively easy.

Excessive concentrations of many minerals, especially phophorus, calcium, and some forms of nitrogen produce stunting, chlorosis, and necrosis of shoot and upper needles.

Table 1.--Fertilizers and organic matter additives[1/]

Sawdust (cubic yards per acre)	Fertilizer					
	Nitrogen		Phophorus		Potassium	
	N	NH_4NO_3	P	P_{205}	K	K_{20}
	- - - - - - - -	Pounds per acre	- - - - - - -			
200	300	900	132	660	100	166
200	100	300	44	220	33	55
100	300	900	66	330	50	83
100	100	300	22	110	17	28

1/ Gilmore and Kahler, Tree Planters' Notes No. 73, Oct. 1965.

Carter (1964) and Shoulders and Czabator (1965) discuss causes of and treatments for chlorosis. Carter found that seedlings low in nitrogen develop chlorosis following a heavy application of nitrogen.

Shoulders and Czabator found that chlorosis was associated with a pH of 4.1 to 4.6 and with high levels of available P and K (table 2).

Steinbeck, May, and McCreery (1966) deliberately developed excessive levels of nitrogen, phosphorus, potassium, calcium, and manganese in sand and soil growth media; and observed the resulting symptoms. They found that high and low pHs and excessive levels of N, P, and Ca produced chlorosis, necrosis of plant organs, and stunting.

Optimum balances of nutrients cannot be maintained without periodic soil analysis. It is essential that optimum and workable ranges of nutrient levels be established and maintained.

BIOTIC CHARACTERISTICS

The use of cover crops and organic additives requires a high population of nitrifying bacteria, especially Nitrosomonas and Nitrobacter, and cellulose-decomposers. Nitrosomonas bacteria are concerned with conversion of ammonium nitrogen to nitrites, which are considered toxic to seedlings. Nitrobacter bacteria are responsible for oxidation of nitrites to nitrates. Pine seedlings use nitrogen in NH_4 and NO_3 forms.

Many soil fumigants inhibit activity of nitrifying bacteria and cellulose-decomposers to a higher degree than ammonifiers and denitrifiers. Consequently, with a combination of high organic matter and soil fumigation, an adequate level of nitrates may not always be available; but there may be an excess of other forms of nitrogen.

The conditions that tend to promote nitrate formation in the soil are:

1. A favorable temperature: 80° - 90°F.
2. An abundant supply of air.
3. A proper moisture supply.
4. A favorable soil reaction: 6.0 - 6.5
5. The presence of carbonates or other buffer agents.
6. The absence of large quantities of soluble organic matter.

Zarger (1964) found the most reliable form of nitrogen fertilizer to be ammonium nitrate. He compared nine sources of nitrogen, including five rapidly-available forms and four slowly-available forms.

Other soil organisms that may be beneficial or detrimental include nematodes and parasitic fungi. Control of these parasitic organisms,

Table 2.--Partial analysis of soils from study area in Stuart Nursery, May 1960[1]

Fertilizer and line treatment (per acre)	pH	Total N	Available K_2O	Available P_2O_5	Organic matter	Chlorotic seedlings
		ppm	- Pounds per acre -		- - Percent - -	
No fertilizer, no lime	5.0	784	237	129	2.8	2.0
No fertilizer, 1/2-ton lime	5.5	835	309	37	3.3	1.0
No fertilizer, 2 tons lime	6.2	858	279	6	3.6	2.0
1/2-ton 6-24-24, no lime	5.2	802	519	226	3.1	2.0
1/2-ton 6-24-24, 2 tons lime	6.1	796	489	354	3.2	10.0

1/ Shoulders and Czabator, Tree Planters' Notes 71, May 1965.

although a phase of good soil management, is not an integral part of this discussion. However, all of the interactions resulting from soil fumigation, fertilization, cultivation, drainage, and irrigation must be considered in maintaining a high fertility level at reasonable costs.

Carter, Mason C.
1964. Nitrogen and summer chlorosis in loblolly pine. U. S. Forest Serv. Tree Planters' Notes 64:18-19.

Gilmore, A. R. and L. H. Kahler.
1965. Fertilizers and organic additives in pine nursery seedbeds: Effect on field survival, field growth, and chemical content of foliage. U. S. Forest Serv. Tree Planters' Notes 73:21-27.

Shoulders, Eugene and Felix J. Czabator.
1965. Chlorosis in a southern pine nursery: A case study. U. S. Forest Serv., Tree Planters' Notes 71:19-21.

Steinbeck, Klaus, Jack T. May, and Robert A. McCreery.
1966. Growth and needle color abnormalities of slash pine seedlings caused by nutrient treatments. Ga. Forest Res. Council, Ga. Forest Res. Paper 38.

Zarger, Thomas G.
1964. Comparison of slowly and rapidly available nitrogen fertilizers for nursery production of pine seedlings. U. S. Forest Serve Tree Planters' Notes 66:8-10.