Soil fertility

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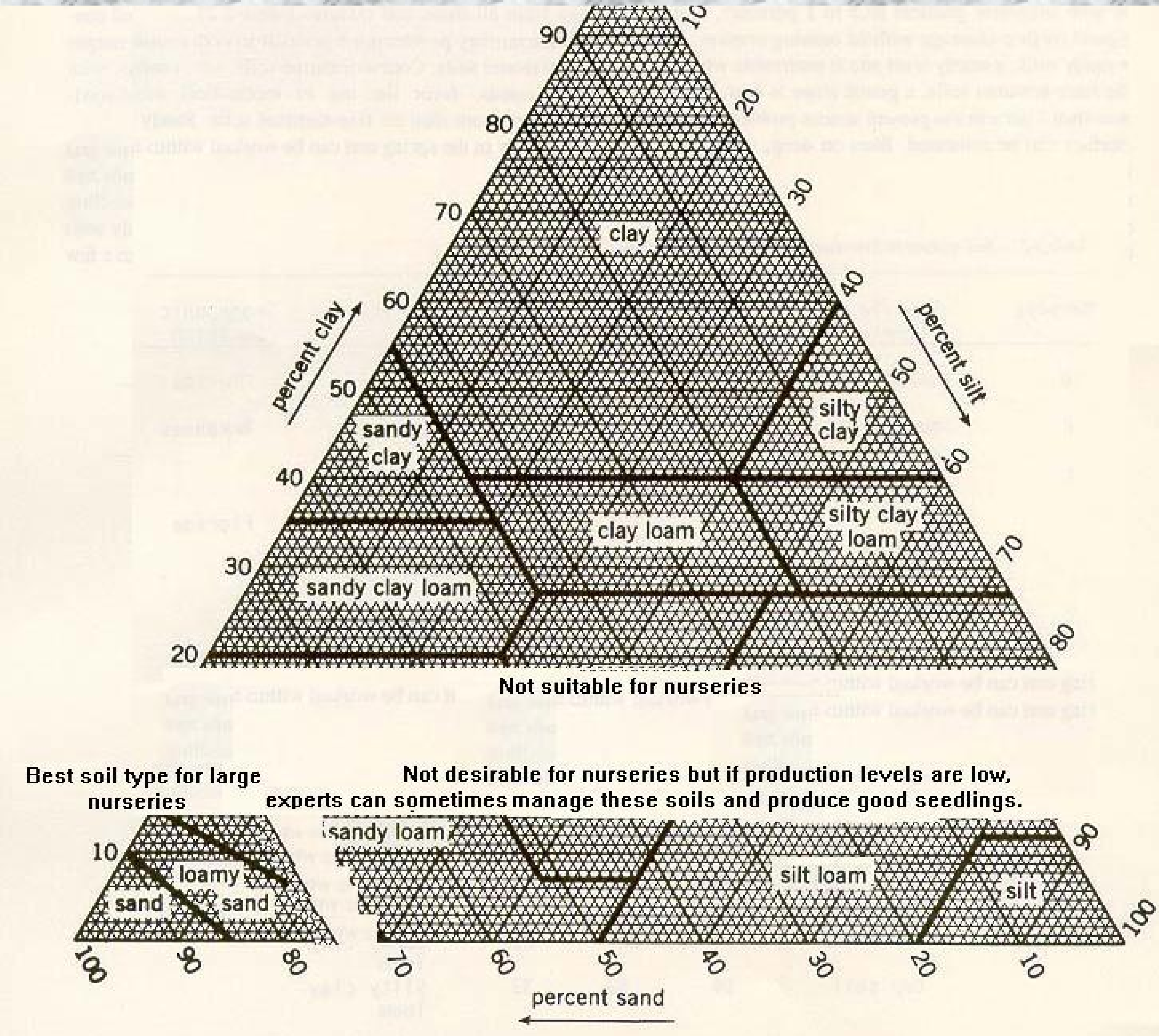
https://midwestlabs.com/resource/agronomy-handbook/


percent clay
percent silt
percent sand
clay
sandy clay
silty clay
clay loam
silty clay loam
sandy clay loam
Not suitable for nurseries
Best soil type for large nurseries
Not desirable for nurseries but if production levels are low, experts can sometimes manage these soils and produce good seedlings.
sand
loamy sand
sandy loam
silt loam
silt
10
20
30
40
50
60
70
80
90
100

SOIL TEST RESULTS FROM SOUTHERN PINE NURSERIES

Data collected from 1977 to 1981

Region	State	%OM	pH	C.E.C.	Sand	Silt	Clay	Texture
Coastal Plain	NC	1.9	5.7	3	93	3	4	sand
Coastal Plain	FL	0.8	5.9	3.1	92	4	4	sand
Coastal Plain	FL	0.7	5.7	1.9	92	2	6	sand
Coastal Plain	VA	1	6.3	2.3	89	4	7	sand
Coastal Plain	GA	1.9	5.5	4.3	88	6	6	loamy sand
Coastal Plain	GA	1.6	5.4	4.4	87	6	7	loamy sand
Coastal Plain	SC	0.9	5.5	3.2	87	8	5	loamy sand
Coastal Plain	OK	0.4	5.3	1.5	86	8	6	loamy sand
Coastal Plain	AL	1.1	6.1	1.5	85	8	7	loamy sand
Coastal Plain	VA	2.1	6	4.5	85	4	11	loamy sand
Coastal Plain	TX	0.9	5.6	3.3	84	11	5	loamy sand
Coastal Plain	GA	0.9	5.5	2.5	83	9	8	loamy sand
Coastal Plain	SC	0.9	5.6	1.9	83	6	11	loamy sand
Coastal Plain	TX	0.8	4.9	3.1	83	10	7	loamy sand
Coastal Plain	AR	0.5	5.6	2.9	82	12	6	loamy sand
Piedmont	SC	1.2	6	3.2	82	11	7	loamy sand
Coastal Plain	SC	1.5	5.3	3.2	82	10	8	loamy sand
Coastal Plain	FL	1.3	5.7	4.5	81	7	12	loamy sand
Coastal Plain	SC	2.3	5.6	5.6	81	7	12	loamy sand
Blue Ridge	NC	0.7	5.7	5.8	78	15	7	loamy sand
Coastal Plain	AL	0.7	5.9	3.6	78	14	8	loamy sand
Coastal Plain	AK	1.2	5.7	3.2	78	14	8	loamy sand
Coastal Plain	NC	1.4	5.1	3.6	74	5	11	sandy loam
Coastal Plain	GA	1.2	5.8	6.1	71	6	13	sandy loam
Coastal Plain	AL	1.7	5.4	4	70	15	15	sandy loam
Coastal Plain	AL	0.8	5.6	4.2	68	21	11	sandy loam
Coastal Plain	AL				67	22	11	sandy loam
Coastal Plain	AL	1.1	5.1	4.9	67	13	20	sandyclayloam
Coastal Plain	LA	1.9	5.7	6	66	23	11	sandy loam

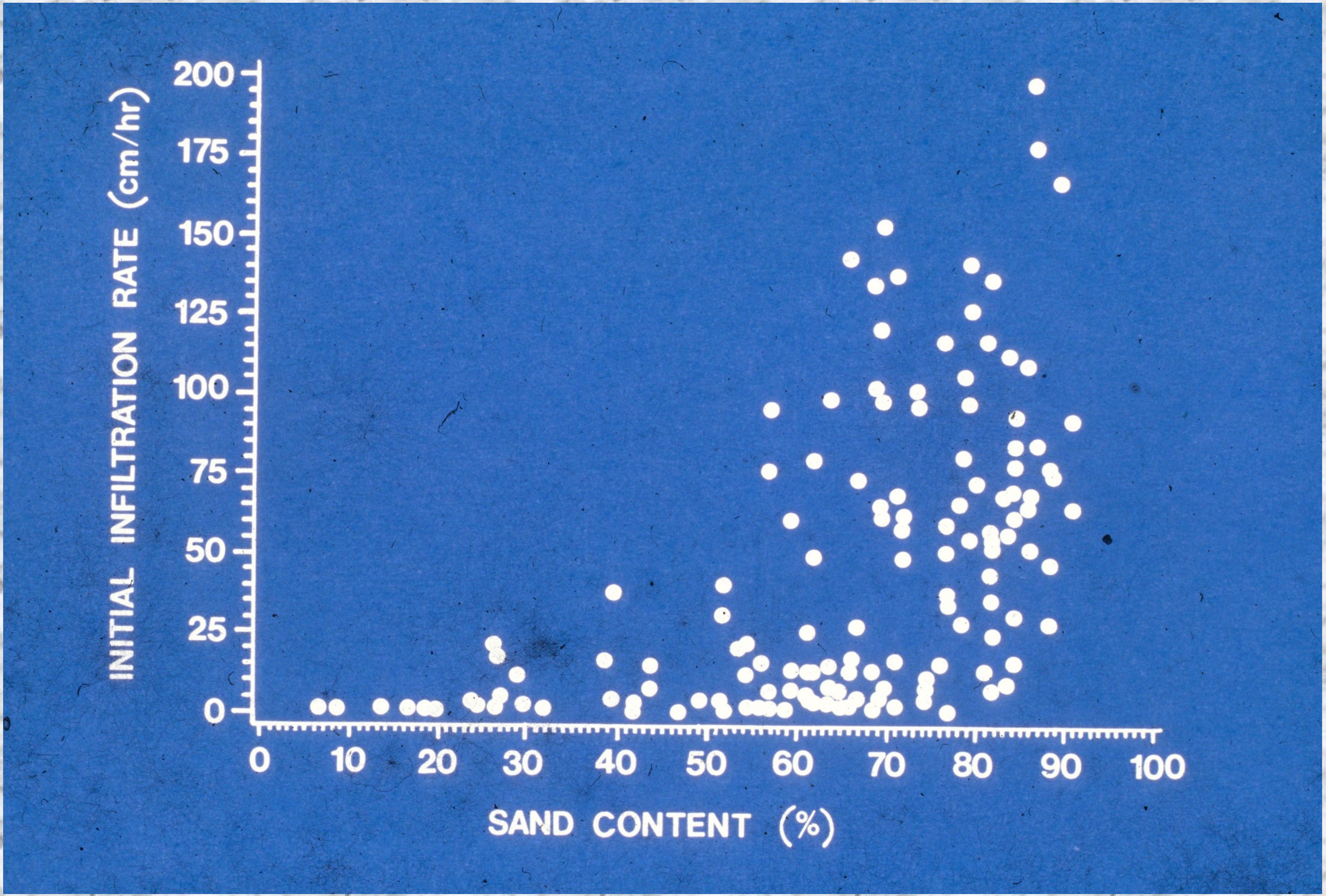
Coastal Plain	NC	1.4	5.1	3.6	74	5	11	sandy loam
Coastal Plain	GA	1.2	5.8	6.1	71	6	13	sandy loam
Coastal Plain	AL	1.7	5.4	4	70	15	15	sandy loam
Coastal Plain	AL	0.8	5.6	4.2	68	21	11	sandy loam
Coastal Plain	AL				67	22	11	sandy loam
Coastal Plain	AL	1.1	5.1	4.9	67	13	20	sandyclayloam
Coastal Plain	LA	1.9	5.7	6	66	23	11	sandy loam
Coastal Plain	AL	1.5	3	5.5	66	18	16	sandy loam
Coastal Plain	MS	1.7	4.9	5.1	64	22	14	sandy loam
Coastal Plain	TX	1.8	4.4	4	61	28	11	sandy loam
Coastal Plain	MS	2.6	5.3	5.4	58	26	16	sandy loam
Blue Ridge	SC	3.1	5.5	6.4	55	25	20	sandy loam
Coastal Plain	AL	2.5	5.5	6	55	20	25	sandyclayloam
Coastal Plain	LA	1.6	5.2	8.8	49	44	7	sandy loam
Coastal Plain	MS	1.2	6.2	5.5	43	45	12	loam
low plateau	KY	1.4	5.4	7.1	41	37	22	loam
valley/ridge	*AL	3.5	5.9		40	40	20	loam
Mississippi	AK	0.8	5.5	5.2	36	47	17	silt loam
Mississippi	MS	1.8	6.3	11.5	29	47	24	loam
Coastal Plain	*TN	2.5	5.3	7.2	26	57	17	silt loam
Mississippi	*LA	1.8	5.7	7	21	67	12	silt loam

Many nurseries with less than 67% sand have closed

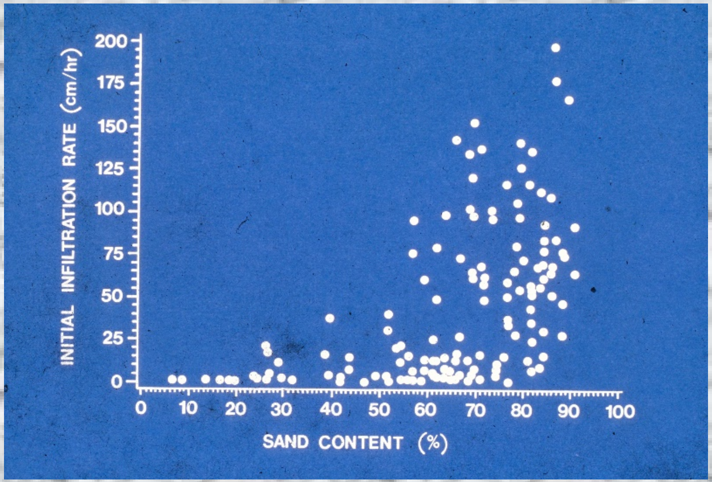
The importance of good seedbed preparation is related to moisture and heat transfer--both of which are important in seed germination. A fine granular structure is ideal
in this respect, as it provides adequate porosity for good infiltration of water and air exchange between the soil and the atmosphere.

This creates an ideal physical medium for plant growth. However, where surface crusting exists, or subsurface claypans or hardpans occur, plant growth is hindered because of restricted porosity, which is the fraction of the bulk volume of the soil not occupied by soil particles. This is the reason that bulk density measurements are important in determining the
total porosity of soils.

Not all sandy soils have good infiltration



Not all sandy soils have good infiltration



Surface crusting - Good infiltration vs poor infiltration

Poor infiltration can result in stunted growth and in some cases will result in conditions that increase seedling mortality

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Poor infiltration can result in stunted growth.

Bulk density levels range from

1.0 to 1.3 for clay soils,
1.1 to 1.4 for clay loams and silt loams, and
1.2 to 1.6 for loams, sandy loams, and sands.

Tillage

"Because of the potential damage to soil structure from overworking the soil and for economic and fuel conservation purposes, the modern approach is to use only as much tillage as is required to produce a good crop."

Soil water

Soil water

Soil water

Soil water

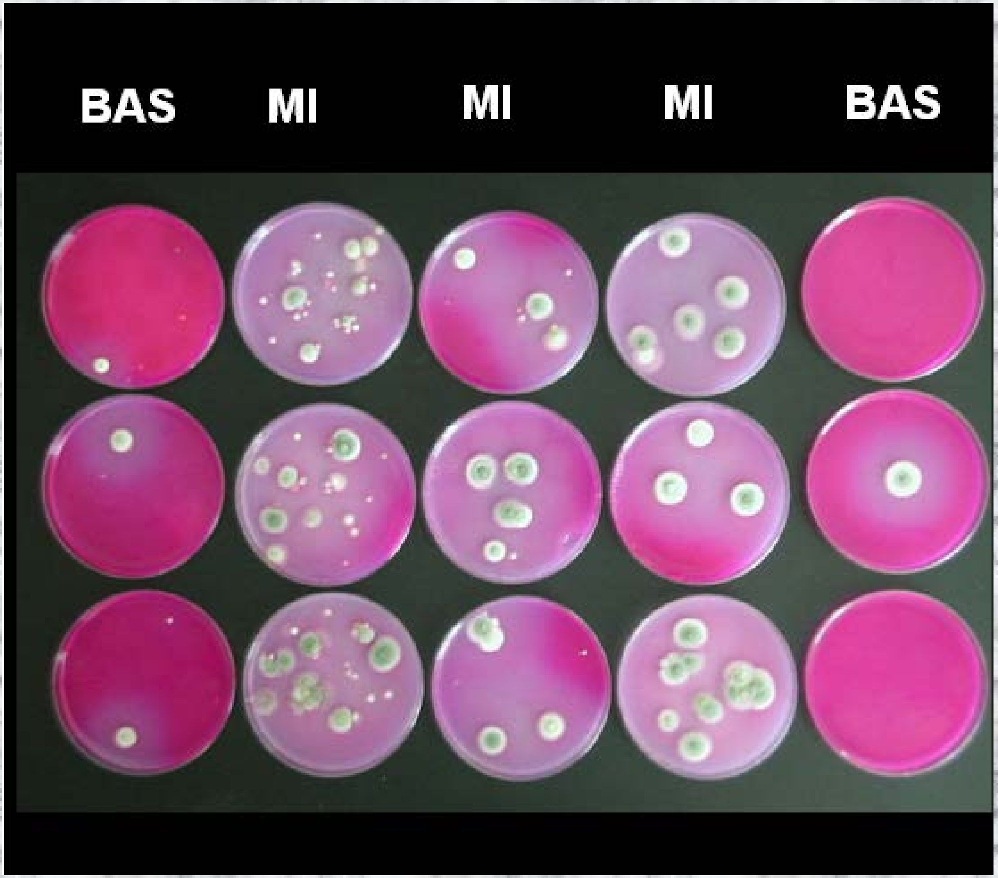
An example of lenticels on the stem

Soil temperature

The killing temperature for a young hypocotyl is about 104° F (40° C). Dying seedlings were noticed after the soil temperatures exceed 106° F during the afternoon on May 11 and 13 (between noon and 5:30 PM). This photo was taken on the morning of May 16th .

Soil microorganisms

Trichoderma



Mycorrhiza

SOIL MICROORGANISMS

Besides their role in soil-forming processes, soil organisms make an important contribution to plant growth through their effect on the fertility level of the soil. *Endomycorrhiza* - *P uptake*

SOIL MICROORGANISMS

Ectomycorrhiza - P uptake

New ground syndrome

SOIL MICROORGANISMS

Ectomycorrhiza

Good development at 60 ppm of Phosphorus

Tillage

"Because of the potential damage to soil structure from overworking the soil and for economic and fuel conservation purposes, the modern approach is to use only as much tillage as is required to produce a good crop."

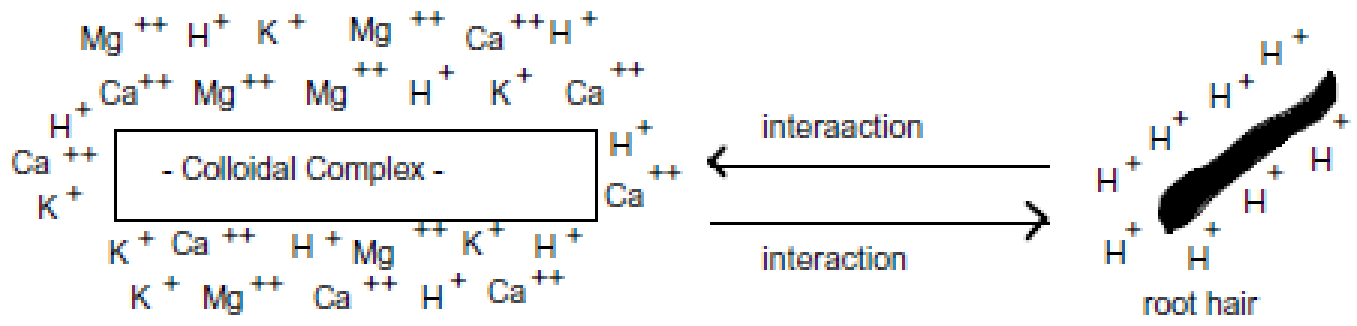
CEC

CATION EXCHANGE CAPACITY

Cation exchange capacity (CEC) is a measure of the capacity of a soil or soil material to hold exchangeable cations.

It can be defined as the amount of negative charges per unit quantity of soil that is neutralized by exchangeable cations.

A cation is an ion carrying a positive charge of electricity, while the soil colloid has a negative charge.



CEC

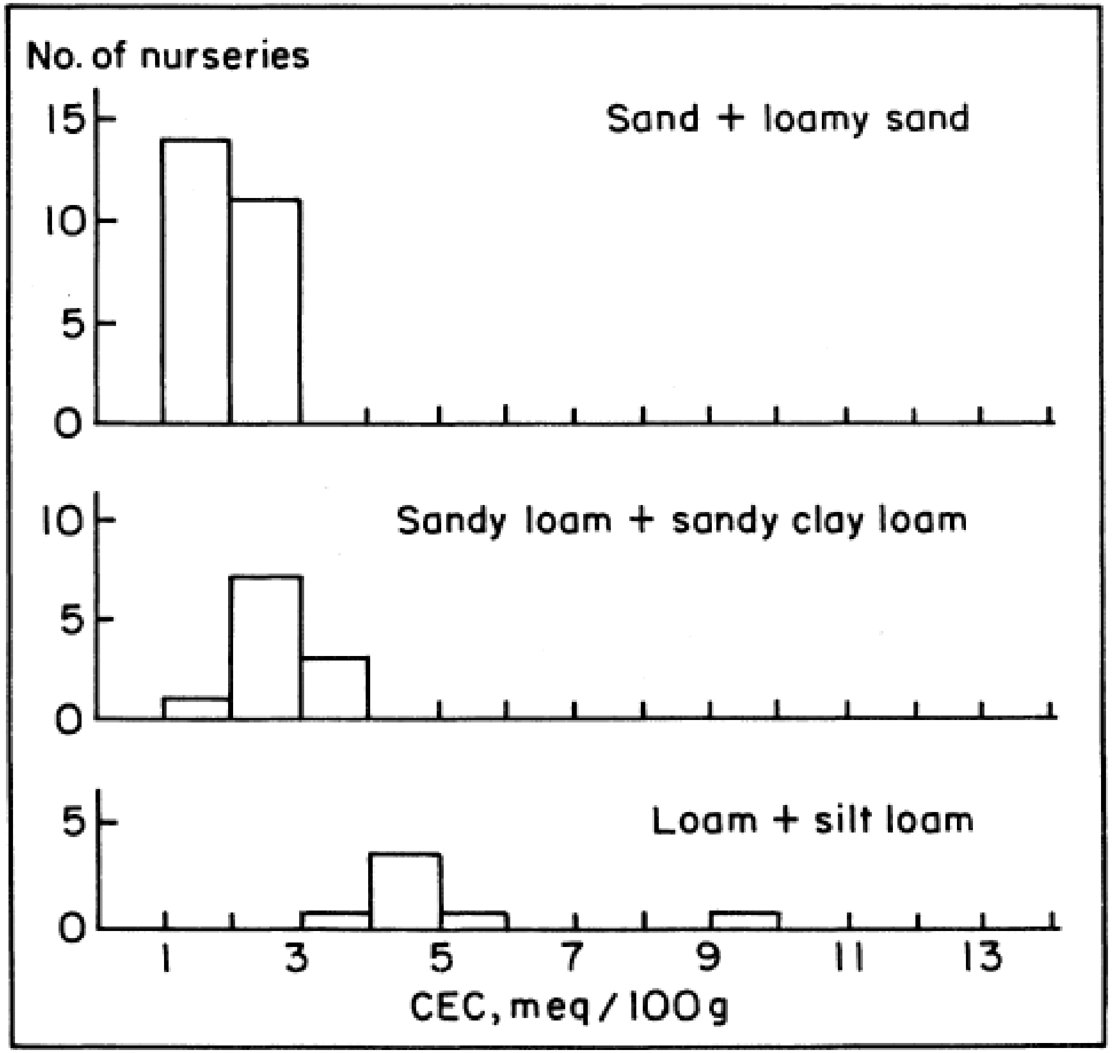


Fig. 9. Cation exchange capacity for 45 southern forest nurseries.

Fertilizer question

When does 10 equal 10 and 4.4 at the same time?

Fertilizer question

When does 10 equal 10 and 4.4 at the same time?

10:10:10 same as 10:4.4:8.3 ?

$N:P_2O_5:K_2O$ **N:P:K**

Remember: a bag of 10:10:10 fertilizer contains

10% **N**itrogen

10% $\mathbf{P_2O_5}$ and 10% $\mathbf{K_2O}$

It **does not** contain 10% K and 10% P

table 32.

CONVERSION FACTORS

Nutrient	Column 1	Column 2	To convert column 1 into column 2 multiply by
Nitrogen	N	NO_3	4.4266
	NO_3	N	0.22591
	N	KNO_3	7.22
	KNO_3	N	0.13855
	KNO_3	NO_3	0.61331
	NO_3	KNO_3	1.63
Phosphorus	P	P_2O_5	2.2951
	P_2O_5	P	0.43646
Potassium	K	K_2O	1.2046
	K_2O	K	0.83013

NITROGEN

No need to apply N prior to sowing tree seed.

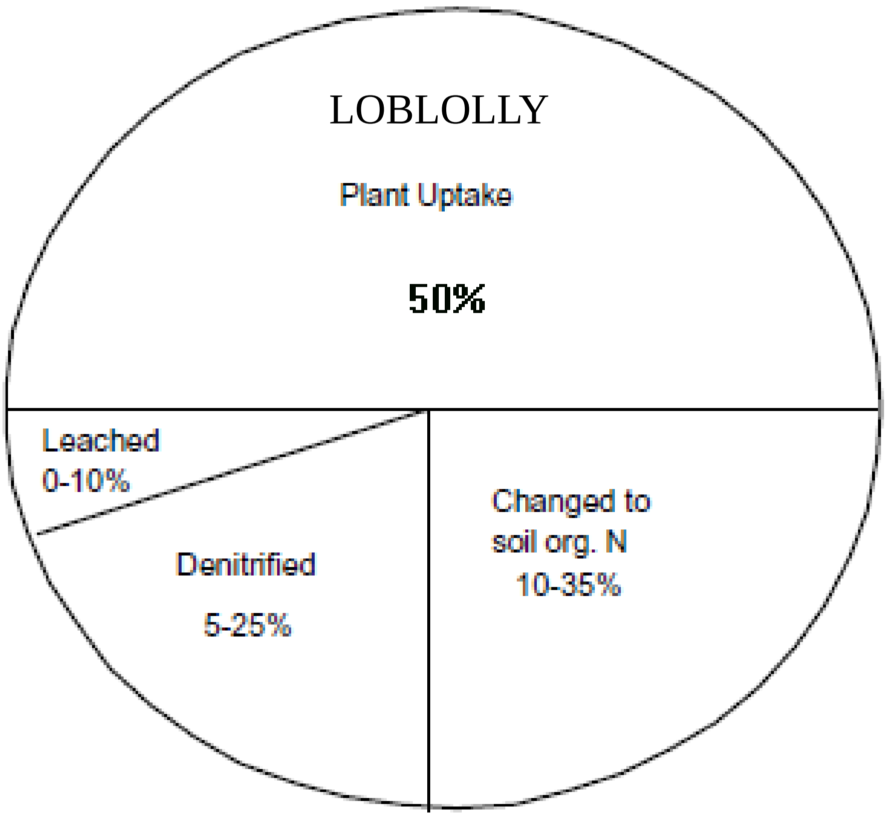
OK to apply N prior to sowing cover-crop.

Advise against growing legumes as cover-crop (IPM).

Adding N as UAN (in tank-mix with herbicides)
is an economical method of applying N.

Deficiency of nitrogen can reduce seed efficiency and RCD.

NITROGEN



. What happens to applied nitrogen?

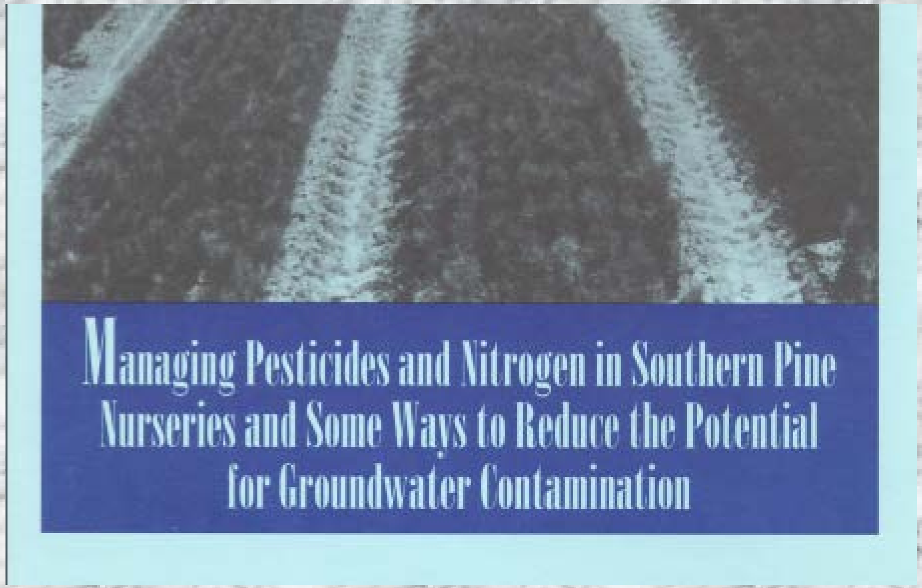
Apply 150 lbs N

Harvest 75 lbs N

6,250 lbs (dry) seedlings/acre at 1.2% N

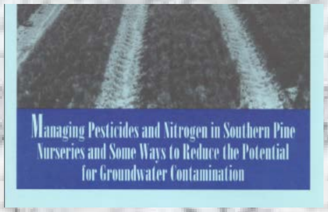
NITROGEN

What is your goal?



Nitrogen is used in nurseries to increase seed efficiency and to increase height growth after outplanting. Although several practices can be used to reduce nitrate leaching, growing legumes as cover-crops or reducing the total amount of N applied to pine seedlings are not recommended. Managers of bare-root nurseries should first consider the following to reduce the potential for leaching nitrates:

NITROGEN



(1) Check irrigation uniformity and make adjustments if the coefficient of uniformity is less than 0.80.
(2) Schedule irrigation during the "growing" phase to avoid saturating the soil. At some nurseries, managers may not need to water until the soil tension reaches 30 kPa – 4”zone.
(3) Avoid applying N to tractor paths.
(4) Increase nutrient use efficiency by applying N on a frequent basis.
(5) Apply ammonium sulfate when soil acidification is needed. (instead of using ammonium nitriate)
(6) When feasible, reduce the amounts of N applied to cover-crops.
(7) Where tile drainage exists, consider building a reservoir to store effluent to use as an irrigation source.

Phosphorus

Phosphorus does not leach easily from the soil.
Leaching is possible on well fertilized sandy soils
(that are low in phosphorus fixation capacity).

Pine seedlings on “new ground” might need an early June
application of DAP (in years with a dry spring).

Hardwoods like maple and sweeetgum might benefit from
an early application of DAP (when endomycorrhiza is absent)

Phosphorus

In pure sand, a lack of P stunted shortleaf pine more than no added nitrogen. (Clinton Hobbs 1944)

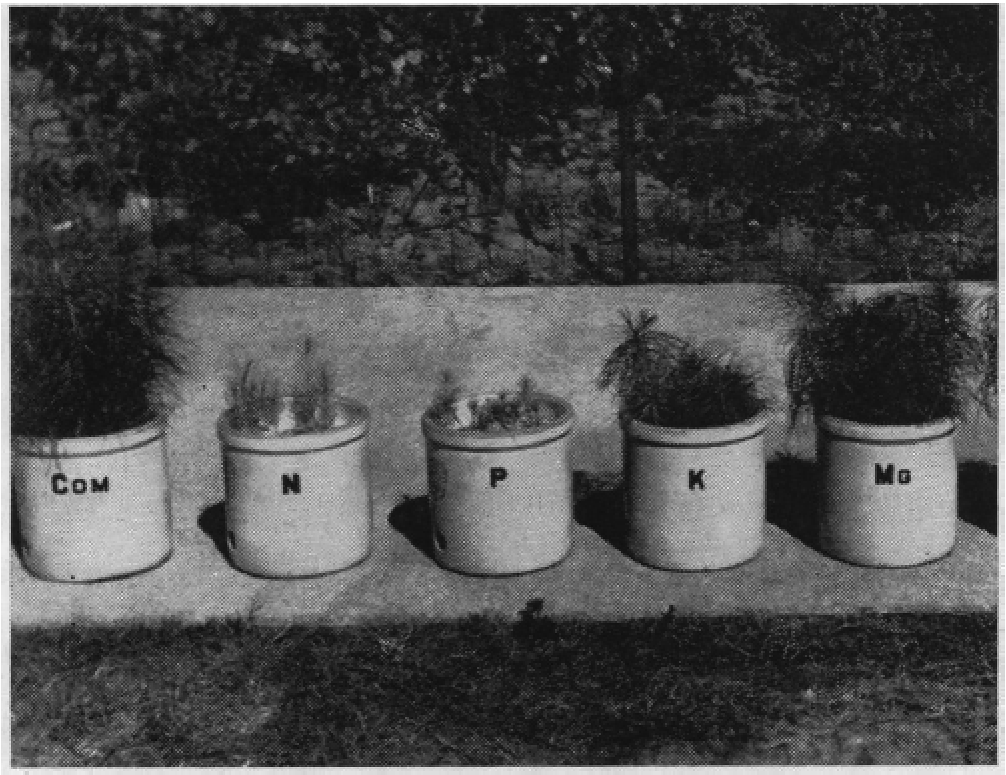


FIG. 6. Photograph of representative shortleaf pine cultures.

Phosphorus

Bray P_1 levels

Rating		ppm P
Very Low	(VL)	0 - 8
Low	(L)	9 - 17
Medium	(M)	18 - 26
High	(H)	27 - 39
Very High	(VH)	40+

Minimum for weak Bray is 40 ppm for pine

Some say 75 to 100 ppm for hardwoods

Double-acid minimum should be 25 ppm for pine

SULFUR

At least 3 nurseries with S deficiency (AL, OK, VA)

Excessive available N on low organic soils may bring on a sulfur deficiency.

Also, use of fertilizers with no sulfur might result in a deficiency.

Needle chlorosis is the symptom.

Where OM is low, may need to apply ammonium sulfate or other S containing fertilizers

Calcium deficiency induced by low soil Ca, low pH, and high soil Mn

Resin exudation on chlorotic, stunted loblolly pine

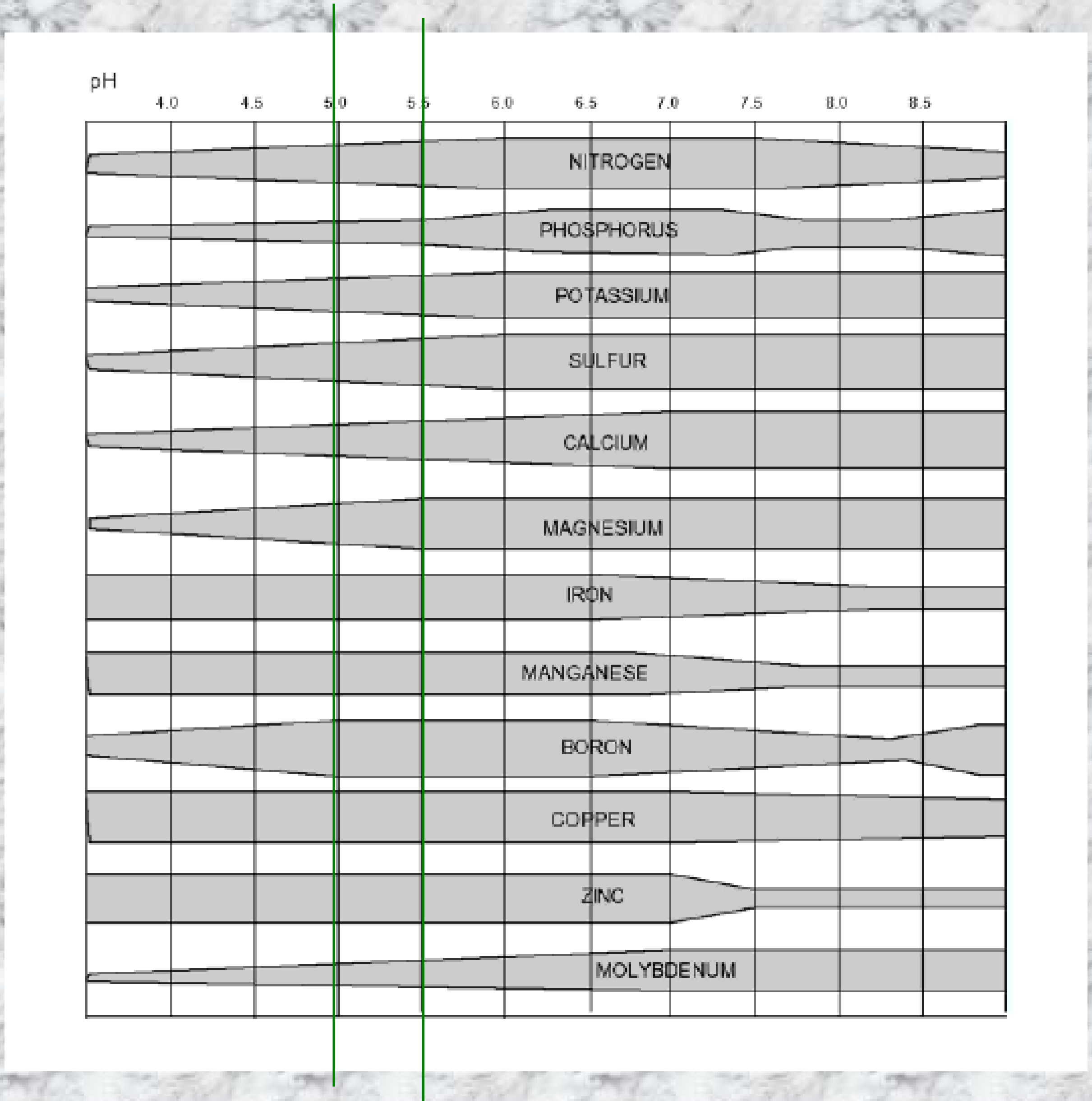
Sodium

This nursery was closed, in part, due to the high level of sodium in the irrigation water

"Soft water makes hard ground"

Soil pH

The pH value reflects the relative number of hydrogen ions (H+) in the soil solution.



Target soil pH (5-5.5) can be the same for both pine and hardwoods

Hardwood seedlings may be grown over a wide range of pH with proper fertilization

Soil pH

TABLE 1. Soil fertility standards for raising hardwood seedlings.[1]

Species	pH range
Acer nigrum	5.5-7.3
saccharum	5.5-7.3
Alnus glutinosa	5.0
Betula alleghaniensis	5.0-6.0
nigra	5.0
Carya illinoensis	5.5-7.3
Fraxinus americana	5.5-7.3
Juglans cinerea	5.5-7.3
nigra	5.5-7.3
Liriodendron tulipifera	5.5-7.3
Populus tremuloides	5.0-6.0
Prunus serotina	5.0-6.0
Quercus alba	5.5-7.3
macrocarpa	5.5-7.3
palustris	5.0-6.0
rubra	5.0-6.0
velutina	5.0-6.0
Tilia americana	5.5-7.3
Ulmus americana	5.5-7.3

[1] Source: Wilde, S. A. Forest soils. 537 pp. New York:

Target soil pH (5-5.5) can be the same for both pine and hardwoods

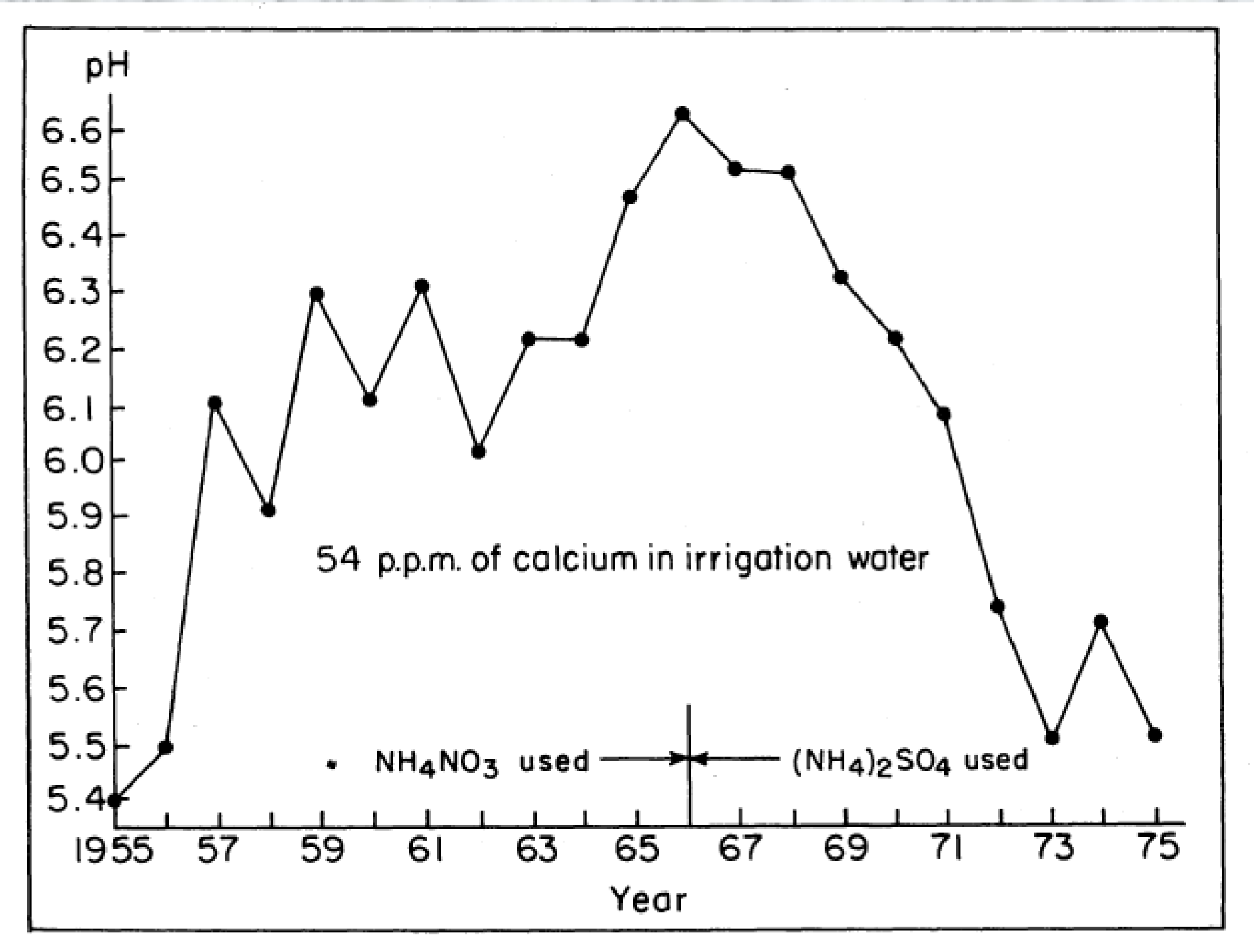
Hardwood seedlings may be grown over a wide range of pH with proper fertilization

Soil pH

Chlorosis when pH at 6 or above

Soil pH

Calcium in irrigation water can increase soil pH
Apply ammonium sulfate when pH is too high.



Soil pH

When soil has pH less than 4.9, then consider applying lime prior to sowing next cover-crop.

Apply about 1,000 lbs of limestone per acre.

Table 1. Approximate Amount of Finely Ground Limestone Needed to Raise the pH of a 7-inch Layer of Soil

Lime Requirements (Tons per Acre)	
Soil Texture	**From pH 4.5 to 5.5**
Sand and loamy sand	0.5
Sandy loam	0.8

Soil pH

Ignore this table for bareroot nurseries

pH of seedbeds can be the same for both pine and hardwoods

table 12. (continued)

Ornamental Shrubs and Trees

Abelia	6.0-7.0	Hydrangea (blue flower)	4.5-5.5
Althea (Rose of Sharon)	6.0-7.0	Hydrangea (pink flower)	6.0-7.0
Annual Flowers (various)	5.5-6.5	Juniper	5.0-7.5
Ash (Green)	6.0-7.0	Locust	6.0-7.0
Azalea	4.5-5.5	Magnolia (deciduous)	5.0-6.0
Beech	6.0-7.0	Maple (Silver, Sugar, Red)	6.0-7.0
Birch	5.0-6.0	Mimosa	5.5-6.5
Boxwood	6.0-7.0	Mulberry	6.0-7.0
Camellia	4.5-5.5	Oak (Scarlet or Red)	6.0-7.0
Cedar (Red)	5.0-7.0	Oak (White)	5.5-6.5
Cherry (Flowering)	5.0-7.0	Pine	5.0-6.5
Cottonwood	5.5-7.0	Poplar	6.0-7.0
Crab apple (Flowering)	6.0-7.0	Rhododendron	5.0-6.0
Crape myrtle	5.0-6.0	Roses	5.5-7.0
Cypress (Bald)	5.0-6.5	Spirea	6.0-7.0
Dogwood	5.0-6.5	Spruce (Norway)	5.0-6.5
Elm	6.0-7.0	Sweet Gum	6.0-7.0
Gardenia	5.0-6.0	Viburnum	6.0-7.5
Honeysuckle	6.0-7.0	Willow	6.0-7.0
Holly (American)	4.0-6.0	Yew	6.0-7.0
Holly (Japanese)	5.0-6.5		

Soil pH

pH of 5.5 ok for millet, Milo, sorghum

Field Crops and Forages	Range
Alfalfa	6.5-7.5
Barley	6.0-7.0
Clover (Alsike)	6.0-7.5
Clover (Arrowleaf)	5.5-7.0
Clover (Crimson)	5.5-7.0
Clover (Red)	6.0-7.0
Clover (Sweet)	6.5-7.5
Clover (White)	6.0-7.0
Coastal Bermuda	5.5-7.0
Corn	6.0-7.0
Cotton	5.5-7.0
Fescue	6.0-7.5
Grass (Orchard)	6.0-7.0
Grass (Sudan)	5.5-6.5
Lespedeza	6.0-7.0
Millet	5.5-6.5
Milo	5.5-7.0
Oats	5.5-7.5
Peanuts	5.5-7.0
Rice	5.5-6.5
Rye	5.5-6.5
Sorghum	5.5-7.0
Soybeans	6.0-7.5
Sugarcane	5.5-7.0
Sunflower	6.0-7.5
Tobacco	5.5-7.5
Vetch (Hairy)	5.5-7.0
Velvet beans	5.5-6.5
Wheat	6.0-7.0

Do not adjust
pH up due to cover crops

Avoid using legumes
as cover-crops

BORON

Boron Deficiency in a Southern Pine Nursery

E. L. Stone, C. A. Hollis and E. L. Barnard

1 NURSERY IN 50 YEARS

Boron deficiency should be a non-problem in nurseries because it is easily avoided by use of soil additions or foliar sprays. Including appropriate amounts of B in the preplant fertilizer application is a useful precaution.

POTASSIUM

Potassium does leach in sandy soils

I know of no evidence that applying potassium in the fall increases cold tolerance

Potassium is thought to improve the winter survival of trees (Levitt 1956). However, potassium does not seem to have a clear effect on the cold hardiness of Scots pine needles (Christersson 1975; Aronsson 1980; Sarjala et al. 1997). No effect of potassium (foliage range 3-12 mg g^{-1}) was found in first-year seedlings in the initial phase of hardening (LT_{50} -11°C) and the effect was even negative after a hardening period of 9 weeks (Sarjala et al. 1997). Christersson (1973, 1975, 1976) suggests that the better winter survival of seedlings well-supplied with potassium is mainly a consequence of better tolerance of winter desiccation.

Many researchers emphasise that it is the balance between nutrients that is important to cold hardiness, not the concentration of a single nutrient. For example, differences in damage among trees of high nitrogen status may be related to their poor boron status (Aronsson 1980). Hulten (1976) also noted that it had not been possible to demonstrate a decline in cold hardiness when the fertilization period was extended to autumn, if the plant was in optimal nutritional status. Thus it seems that both a low or high nitrogen concentration connected to an imbalance with other nutrients may impair the cold and winter hardiness of Scots pine.

IRON

Most common nutrient deficiency in loblolly/slash pine

Results in “chlorosis” in terminal needles
often on South side of seedbed.

Iron availability decreases as the pH increases so it typically does not occur when soil pH is less than 5.6.

Iron deficiency is the main reason why loblolly pine does not grow well when planted on alkaline soils.

Foliar tests may not be helpful in diagnosing Fe deficiency.

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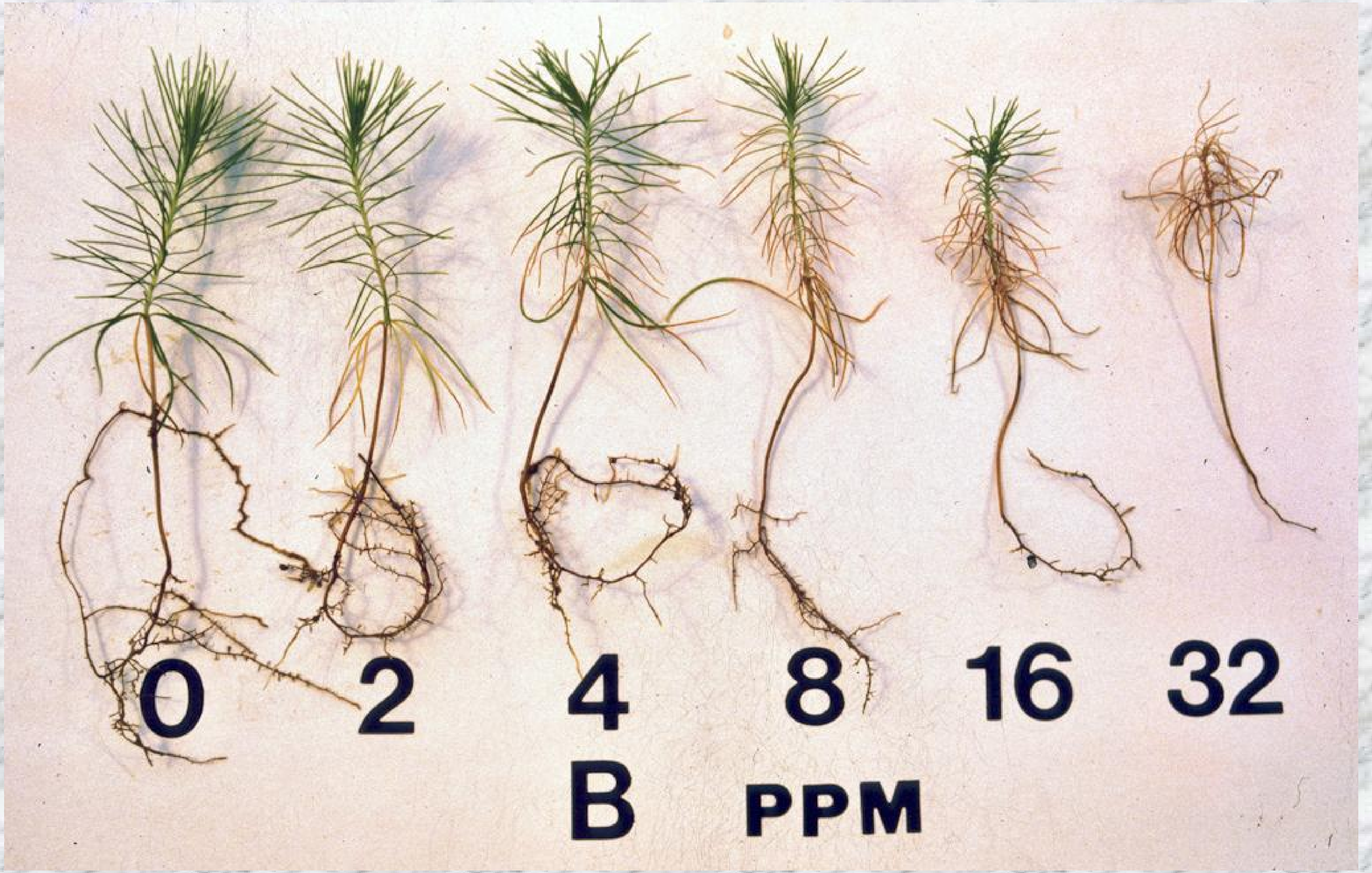
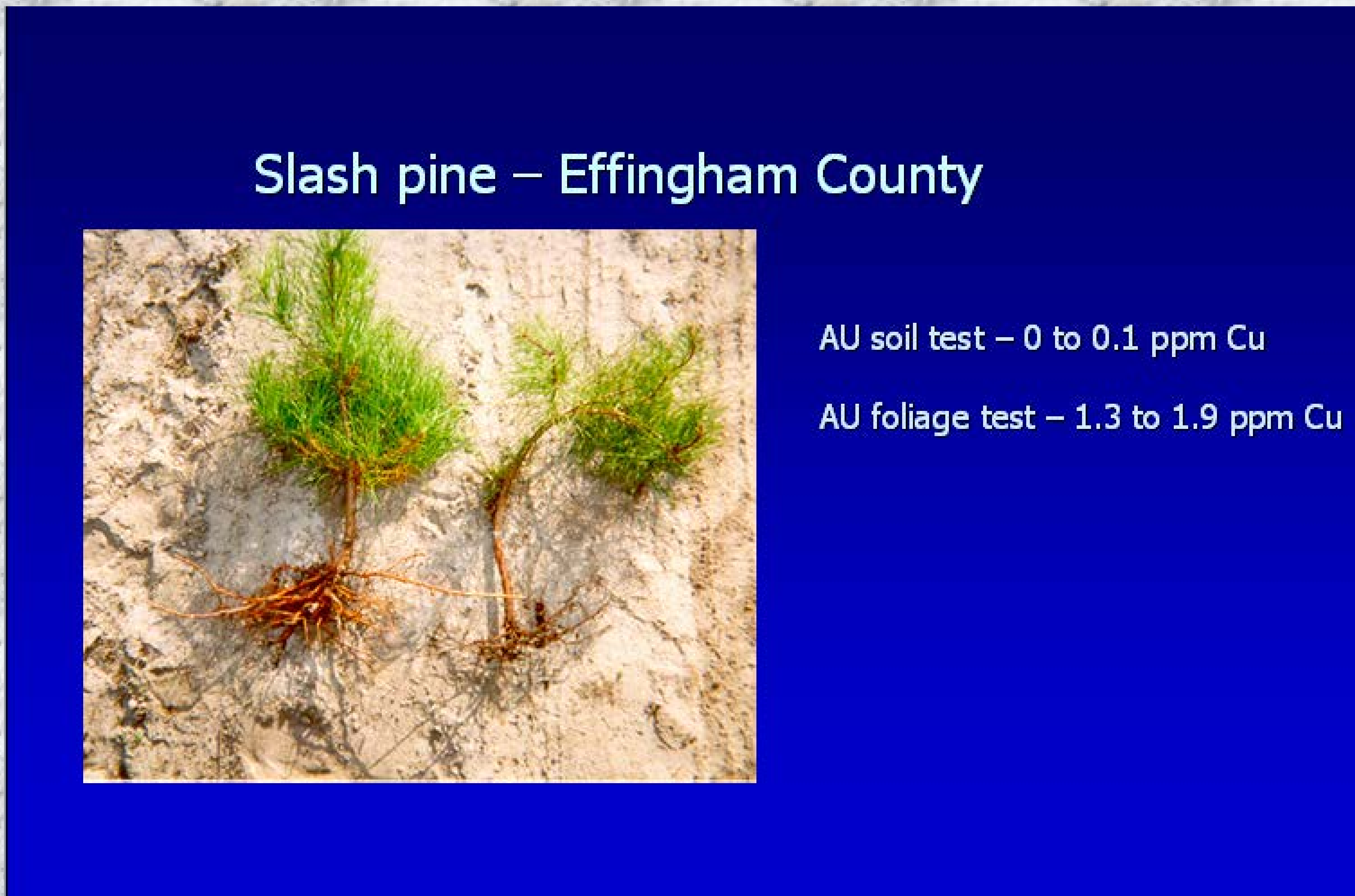
BORON



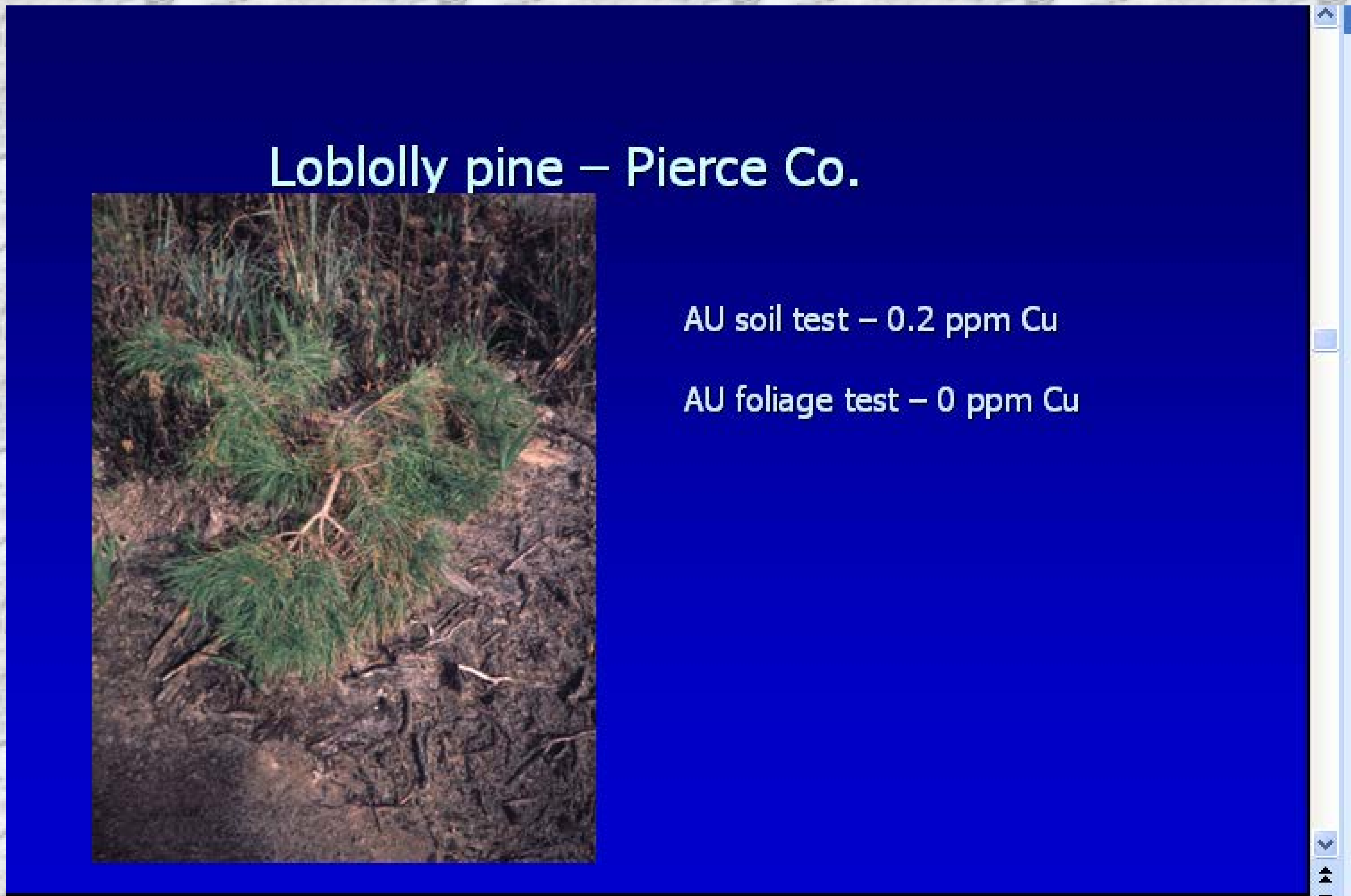
In as much as excess B is highly toxic, however, especially in acid sandy soils, additions should be small.

Copper

Zero reported cases of Cu deficiency in southern pine nurseries



Copper


Loblolly pine – Pierce Co.
AU soil test – 0.2 ppm Cu
AU foliage test – 0 ppm Cu

Copper

Loblolly pine – Echols Co.

Waters foliage test – 3 ppm Cu

Photo by Scott Cameron

Questions?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