DETERIORATION OF MYCORRHIZA-FORMING FUNGI AND NURSERY STOCK CAUSED BY PERIODICALLY IMPEDED DRAINAGE

The main cause of poor seedlings was lack of aeration, which was lethal to mycorrhiza-forming fungi.

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In one section of the Lucky Peak Nursery in southern Idaho, near Boise, nursery beds included several "problem patches" on which ponderosa pine seedlings during the second year of their growth exhibited retarded development, yellowing of the foilage, browning of the needle tips and a complete absence of mycorrhizal short roots (figure 1). This deterioration of the stock could have been caused by adverse conditions of chemical, physical, or biotic nature.

The results of soil analyses, given in table 1, failed to indicate any significant fertility difference between soils supporting vigorously growing and impaired stock. Later determinations of the catalytic capacity (*7*), yielded rather unexpected results: soils supporting normally developed trees showed a very high catalytic capacity between 65 and 82 mm Hg, whereas soils supporting inferior trees showed an extremely high catalytic capacity of about 180 mm Hg. The latter level could not have been attained in an old nursery soil due to the influence of enzymatic substances and this suggested the presence of reduced compounds, particularly readily soluble ferrous iron, characteristic of poorly drained soils. Subsequent foliar analyses provided additional indications of the presence of a permanently or periodically impeded drainage. As shown in table 2, the concentration of nutrient elements in the foilage of the inferior stock is markedly below that of the healthy stock with the notable exception of iron.

Table 1. – *Average state of fertility factors in soils supporting vigorously growing and impaired 2-year-old seedlings of ponderosa pine. (Lucky Peak Nursery, Idaho)*

Nature of analyzed stock	Rea. pH	Exch. capacity me/100 g	Total N pct.	Avail. P_2O_5 lbs/a	Avail. K_2O lbs/a	Exch. Ca me/100 g	Exch. Mg me/100 g
Normal	5.3	9.3	0.072	373	398	5.41	1.38
Inferior	5.5	10.3	0.100	337	452	6.08	1.63

Table 2. – *Concentration of nutrient elements in the foliage of average 2-year-old ponderosa pine seedlings. (Kjeldahl and emission spectrometer analyses of oven-dried samples)*

	Foliar constituents								
Nature of analyzed stock	N	P	K	Ca	Mg	B	Cu	Zn	Fe
	Percent					*Parts per million*			
Normal	1.59	.187	.822	.275	.123	19.1	3.74	47.5	227
Inferior	0.90	.150	.535	.218	.102	13.3	2.80	18.2	407

A subsequent examinatin of soil profiles disclosed the presence, in the affected parts of nursery beds, of a clay-enriched substratum which periodically intercepted the seepage from the adjacent land. which sloped at about a 3 percent gradient. A determination of physical properties of the soil supporting deteriorated stock, according to Wilde *et al.* (*5*), yielded the following results:

Property	*Percent*
Bulk density	1.37
Specific gravity	2.54
Porosity	46.8
Field moisture capacity	43.5
Air content at field moisture capacity	3.3

The last figure is of the critical importance; according to the credo of drainage engineers, soils with air content at field moisture capacity below 7 percent are not

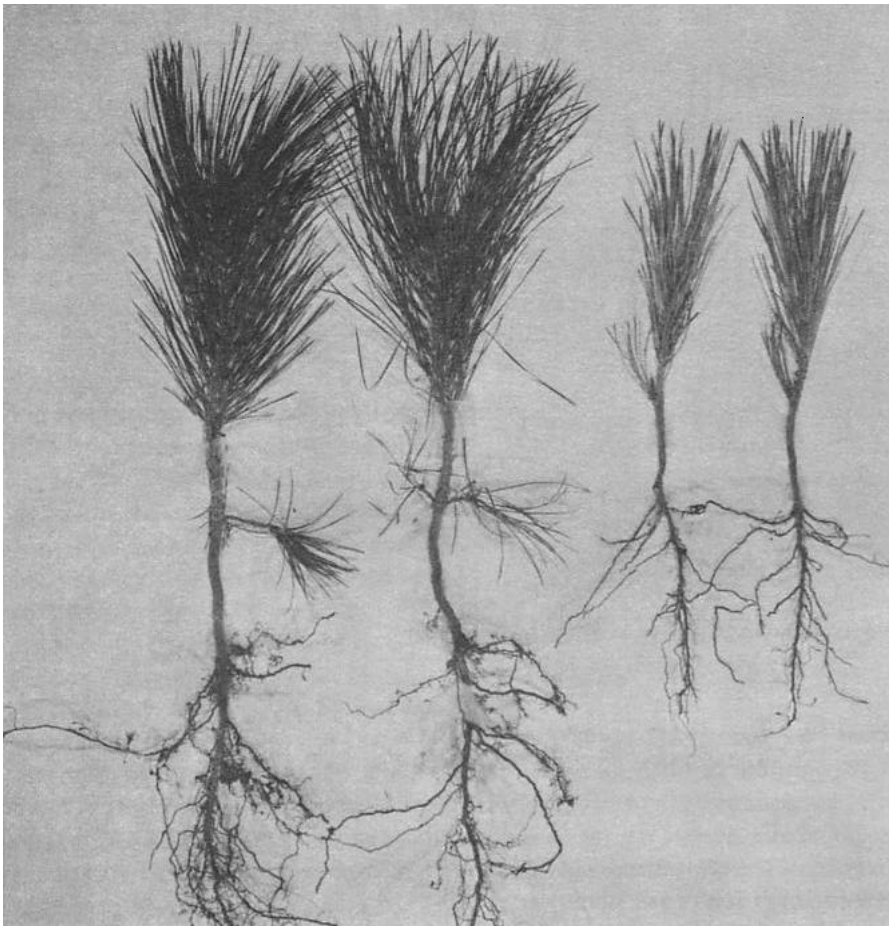

Figure 1. – *Two-year-old ponderosa pine seedlings of normal (left) and depressed development. Note the deteriorated root system and the absence of mycorrhizal short roots.*

capable of supporting farm crops, but only sedges and other marsh vegetation (*2*), (*1*). As suggested by Wilde (*3*), the air content of nursery soils supporting dense stands should not be permitted to decrease below 20 percent for a period exceeding a few hours. It should be remembered that a critically deficient aeration acts as a lethal poison; it kills aerobic organisms much faster than does a lack of water or nourishment.

Very likely the survival of mycorrhiza-forming fungi is also precluded by a minimum air content not too much below 7 percent. The effects of impeded drainage and inadequate aeration on the fate of mycorrhiza-forming fungi are written on the face of the entire United States. In spite of logging, severe forest fires, cultivation and grazing, there is now not 1 square foot of previously deforested land free from mycorrhiza-forming fungi (*4*). The only notable exceptions are lands of abandoned and partly drained beaver flowages in which impounded water eliminated and still precludes the existences of the fungal symbionts of trees (*6*).

Completion of this study justified a request for installation of a partial tile drainage system in the affected area.

Aside from its utilitarian results, this study suggested a rather important plant physiological relationship. With the possible exception of manganese, other reduced compounds of poorly drained soils, especially nitrites and ferrous iron, are probably unjustly accused as to their toxicity or deteriorating influence on the growth of trees and other lignophytes. The major growth-impairing factor is likely to be the deficiency of aeration annihilating the highly aerobic mycorrhiza-forming fungi.

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