Soil-Pest Relationships

Robert L. Anderson and Jack R. Sutherland

Site selection is the most important decision made during the establishment of a bareroot nursery. Numerous considerations, such as availability of labor and good-quality water, and proper microclimate, enter into this decision, but probably the most important factor is soil. Many disease, insect, and weed problems are inherently associated with specific soil properties. Thus, in addition to affecting many cultural practices, soil properties frequently dictate the timing, method, and effectiveness of pest management practices.

Although forest nursery conditions vary greatly throughout the United States, several general principles apply to the interrelationships among soils, cultural practices, and seedling pests. These are discussed below.

Texture

Texture (size distribution of soil particles) is the most important soil property affecting occurrence, severity, and management of seedling diseases and insects. The ideal soil texture for most nurseries is either a sandy loam or a loamy sand that contains a maximum of 15 to 20 percent silt-plus-clay particles.

An example of the effect of soil texture occurs with preemergence damping-off. This disease is less severe in coarse-textured than in fine-textured soils because the slower rate of seedling emergence in fine-textured soil extends the time seedlings are exposed to fungus pathogens.

On the other hand, corky root disease of Douglas-fir seedlings is more severe on coarse-textured soils. Both the pathogenic nematode *Xiphinema bakeri* and the corky root disease occur only in nurseries with coarse-textured sandy soils that have pore spaces large enough to allow movement of X. bakeri. In addition, certain soil insects, such as the black vine and strawberry weevils and white grubs, are favored by coarse-textured soils.

Soil texture also affects the type and effectiveness of pest management practices. In general, pest management is more effective on coarse-textured sandy soils because it is easier to control soil temperature and moisture conditions. In addition, soil fumigation is more effective in coarse-textured soils because the fumigant moves more easily through the larger pores.

Moisture

Soil moisture is a major factor affecting the incidence, development, and control of nursery pest problems. Ideally, nursery soils should be well drained; excess moisture-rather than moisture deficiency-is the most common problem. Soil moisture deficiency is rare in modern nurseries equipped with adequate irrigation systems.

Soil-borne pests favored by excess moisture include damping-off and root rots caused by fungi in the genera *Pythium* and *Phytophthora.* Larvae of the marsh crane fly, *Tipula paludosa*, are also more likely to occur and damage seedlings in soils with excessive moisture.

Other types of damping-off and root disease fungi such as Rhizoctonia are favored by moisture-deficient soils, as are Phomopsis canker on Douglas-fir and Cytospora canker on hardwoods.

The success of many pest management practices is highly dependent upon soil moisture levels. For example, the effectiveness of soil fumigation is frequently determined by soil moisture conditions during and following application.

Temperature

Soil temperature affects seed germination, seedling growth, and pest development and survival. Soil temperature is determined primarily by climate, but soil moisture and color also affect it. Dark-colored soils absorb heat and develop higher temperatures than light-colored soils. Irrigation is one of the most commonly used practices for reducing soil and seedling temperatures.

Disease development can be greatly influenced by temperature. Preemergence damping-off, for example, caused by soil and seed-borne fungi such as *Fusarium* spp., is usually most severe during and after extended periods of cool, moist weather. This type of weather also impedes development of woody tissues resistant to the post-emergence form of this disease.

Conversely, Fusarium root rot of Douglas-fir seedlings, charcoal root disease, and black root rot of pine are favored by warm soil temperatures. Likewise, increases in populations of the soil-borne pathogenic nematode X. bakeri coincide with seasonal fluctuation in soil temperatures.

However, insect pests in nursery soils appear to be considerably less affected by short-term alterations in soil temperature than are diseases. The white grubs are the exceptions; the length of their life cycle is affected by prevailing soil temperatures in different climatic zones.

Soil Reaction (pH)

Most conifer and hardwood seedlings grow best in slightly acid soil, with a pH of 5 to 6. Soil-borne disease problems are most severe at pH 6 and above. Reducing soil pH is one way to minimize diseases

without negative effects on seedling growth and quality.

Damping-off is probably the best example of a seedling disease that is affected by soil pH. Acidifying the soil to control this disease has been used for many years and remains an effective and practical cultural practice, especially for alkaline soils. However, before acidifying the soil, make sure that certain acid-tolerant pathogens, *Cylindrocladium* spp. for example, are not present. If they are present, lowering the soil pH may increase disease severity. Several damping-off fungi also cause root rots, and lowering the soil pH can be helpful in controlling them.

Insects apparently are relatively insensitive to soil acidity within the range occurring in most nurseries.

Nutrients

The amount and type of nutrients can affect several diseases. For example, fusiform rust of loblolly and slash pine seedlings is significantly affected by soil fertility. Both host susceptibility to the disease and subsequent damage increase with nitrogen and phosphorus fertilization. This rust fungus appears to infect vigorous, fast-growing trees more readily than slow-growing ones.

Calcium and phosphorus deficiencies contribute to higher damping-off losses, while excess nitrogen results in greater disease severity. The calcium and phosphorus deficiencies probably delay the formation of seedling woody tissues resistant to damping-off. Increased nitrogen most likely promotes formation of succulent, susceptible tissues.

Soil fertility is also important in at least one nematode-caused seedling disease: corky root disease caused by X. bakeri. A comparison of the soil nutrient levels within disease-free and infested areas suggests that disease severity is correlated with low soil fertility.

Soil fertility apparently has little effect on nursery insects.

Organic Matter

Addition of soil organic matter required to maintain proper nutrient and moisture-holding capacities and aeration usually does not affect soil-borne nursery pests. Negative effects of organic matter soil amendments can generally be traced to using too much or the wrong types of organic matter. In one such case, increased damping-off was observed following the use of buckwheat.

Other types of organic amendments, such as sawdust, may provide fungi such as Fusarium spp. and *Cylindrocladium* spp. with food bases for survival. Addition of fresh, non-decayed sawdust may also promote nitrogen deficiencies (yellowing and stunting) of seedlings. This condition is primarily caused by the increased nutrient requirements of the large numbers of soil organisms (primarily bacteria) involved in the decomposition of the sawdust.

Selected References

Armson, K.A.; Sadreika, V. 1979. Forest tree nursery soil management and related practices. Oshawa, ON: Ontario Ministry of Natural Resources. 179 p.

Bloomberg, W.J. 1976. Distribution and pathogenicity of Fusarium oxysporum in a forest nursery soil. Phytopathology. 66: 1090-1092.

Jackson, L.W.R. 1940. Effects of H-ion and Al-ion concentrations on damping-off of conifers and causal fungi. Phytopathology. 30: 563-579.

Riffle, J.W.; Smith, R.S., Jr. 1979. Nursery diseases of western conifers. For. Insect & Dis. Leafl. 157. Washington, DC: U.S. Department of Agriculture, Forest Service. 11 p.

Rowan, S.J.; Steinbeck, K. 1977. Seedling age and fertilization affect the susceptibility of loblolly pine to fusiform rust. Phytopathology. 67: 242-246.

Smith, R.S., Jr. 1975. Charcoal root disease. In: Forest nursery diseases in the United States. Agric. Handb. 470. Washington, DC: U.S. Department of Agriculture: 11-13.

Sutherland, J.R.; Sluggett, L.J. 1973. Corky root disease of Douglas-fir: relation to Xiphinema *bakeri nematodes,* to symptom severity, and observations on seedling tissue and soil nutrients. Canadian Journal of Forest Research. 3: 299-303.

Sutherland, J.R.; Sluggett, L.J. 1975. Corky root disease: population fluctuations of Xiphinemo *bakeri nematodes,* and disease severity in forest nursery soil cropped with different seedling species. Canadian Journal of Forest Research. 5: 97-104.

Sutherland, Jack R.; Van Eerden, Evert. 1980. Diseases and insect pests in British Columbia forest nurseries. Joint Rep. 12. Victoria, BC: British Columbia Ministry of Forests/ Canadian Forestry Service. 55 p.

Tint, H. 1945. Studies of the Fusarium damping-off of conifers, III. Relation of age of host, pH, and some nutritional factors to the pathogenicity of Fusarium. Phytopathology. 35: 440-457.

Wilde, S.A. 1958. Forest soils. New York: The Ronald Press. 537 p.

Williams, R.D.; Hanks, S.H. 1976. Hardwood nurseryman's guide. Agric. Handb. 473. Washington, DC: U.S. Department of Agriculture. 78 p.