56. Salinity Damage

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Hosts

Many native plants, including most forest tree species, are very sensitive to the level of salts in soil and irrigation water. Germinants and young seedlings are particularly sensitive due to their succulent nature and small root systems. Older seedlings and transplants become more tolerant of salinity. Small-seeded or slow-growing species are more susceptible to salt damage because they take longer to grow out of the juvenile succulent stage.

Distribution

Soluble salts are inorganic chemical compounds that release electrically charged particles called ions when they are dissolved in water. The specific compounds present and total salt concentration in soil or water will determine whether soluble salts have a beneficial, neutral, or damaging effect on seedlings. For example, magnesium sulfate ($MgSO_4$) can be used as a fertilizer, but sodium chloride ($NaCl$) is toxic.

Soluble salts in nurseries can originate from several sources. Salts accumulate naturally in the surface soil of arid and semiarid areas with less than 38 cm (15 in) of annual precipitation and in areas where evapotranspiration exceeds precipitation. Groundwater used for irrigation in these areas is often high in salts. In coastal areas, saltwater may intrude into the groundwater. Overfertilization, improper use of fertilizers, soil compaction, naturally calcareous soil, and contaminated mulches can result in excessive salt levels in nursery soils and container media.

Damage

There are four ways that soluble salts can injure seedlings. High concentrations of soluble salts can reduce the amount of water available to seedlings through osmosis, the process that enables plants to absorb water from the soil. High concentrations of sodium ions reduce the permeability and water infiltration rate of the soil. High concentrations of sodium, chloride, and boron are directly toxic to plants. An imbalance of nutrients, such as calcium, will reduce the availability of other essential nutrients such as iron, magnesium, and phosphorus.

Salinity damage can result in mortality of young germinants and growth losses in older stock. Growth losses may be difficult to determine because significant reductions in growth often occur before more visible symptoms become evident. Seedlings that are stunted due to salinity damage may perform poorly after outplanting due to low vigor or poorly developed root systems. High concentrations of salts may also reduce frost hardiness and resistance to some pathogenic fungi. In addition to damaging plants, high concentrations of soluble salts can form deposits that clog sprinkler nozzles and leave unsightly whitish deposits on foliage.

Hot, dry weather increases the potential for salinity damage. Irrigation practices that enable the soil to dry out concentrate salts in the soil. In particular, brief irrigation used for cooling seedlings in hot weather increases salinity at the soil's surface due to evaporation, which pulls salts to the surface where they concentrate. Soil management practices can also lead to accumulation of salts in the seedling root zone, especially in fine-textured soils. Improper or excessive cultivation may break down the soil structure, reducing porosity, inhibiting water infiltration and drainage, and allowing salts to accumulate. Repeated use of heavy equipment in seedbeds causes impermeable hard pans, which can restrict drainage. Application of dry inorganic fertilizers without sufficient irrigation can concentrate salts at the soil surface where the roots of young germinants are present.

Diagnosis

Mortality due to salt damage in germinating seeds and emerging seedlings is often confused with other diseases such as damping-off. The pattern of mortality is often patchy and irregular. In larger seedlings, symptoms vary depending on the species, stock type, and age. Symptoms include chlorosis (fig. 56.1), scorched needle tips and leaf margins (fig. 56.2), bluish leaf color, white

Figure 56.1—*Chlorosis of young needles, a symptom of iron deficiency associated with saline soil.*
Photo by Thomas D. Landis, USDA Forest Service.

Figure 56.2—*Scorched needle tips caused by physiological drought due to high levels of soluble salts.* Photo by Thomas D. Landis, USDA Forest Service.

deposits on foliage (fig. 56.3), stunting (fig. 56.4), lack of roots near the surface, patchy growth patterns (fig. 56.5), and mortality. *S*alt crystals can sometimes be seen on seedling roots when examined under a microscope. Soil characteristics may also provide evidence for salinity damage. Calcareous soils often develop a white crust on the surface (fig. 56.6) that effervesces when tested with a drop of dilute acid. Soil high in sodium salts is blackish with a slick feel.

In most cases, salinity damage is very difficult to identify solely by visual symptoms. Accurate diagnosis requires comprehensive evaluation that should include chemical analysis of the soil or container media, irrigation water, and seedling foliage. Soil samples should be collected at several different depths, but especially from the surface horizons where salts accumulate. An electrical conductivity test of the irrigation water or a saturated paste of the soil is the best way to measure the total soluble salt level. Electrical conductivity can be determined at the nursery using a conductivity meter. Readings of greater than 4,000 microSiemens per centimeter (mS/cm) are considered excessive, and values between 2,500 and 4,000 mS/cm should be of concern (fig. 56.7). Concentrations of individual salts can be measured by laboratory tests of water extracted from the soil. Salinity can be described in terms of total salinity, or concentrations of specific salt ions. High pH may also be an indicator of excessive salt levels.

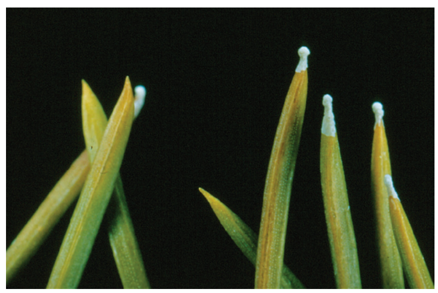

Figure 56.3—*Salt accumulation at the tips of spruce needles.* Photo by Thomas D. Landis, USDA Forest Service.

Control

The best solution for problems with salinity is to avoid them through careful selection of nursery sites. During the site selection process, both the irrigation water and soil should be tested for total soluble salts and the relative concentrations of specific salts. Soil permeability and porosity should also be tested to determine the leaching potential of the soil. In established nurseries, the soil should be mapped to identify problem areas and ensure that sensitive species and stock types are planted on the best soils. Irrigation water should be tested several times a year to monitor changes in salinity.

Figure 56.4—*Stunted seedlings, often in a variable pattern, are a characteristic symptom of saline soil.* Photo by Thomas D. Landis, USDA Forest Service.

Figure 56.5—*Stunting and chlorosis often occur in irregular patches throughout the seedbed.* Photo by Thomas D. Landis, USDA Forest Service.

Figure 56.6—*Salt crust on the surface is an indicator of saline soil.* Photo by Thomas D. Landis, USDA Forest Service.

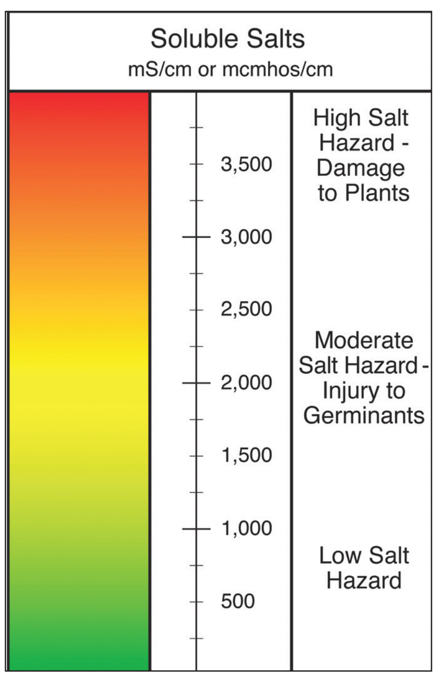

Figure 56.7—*Guidelines for interpreting soluble salt concentrations.* Graphic by Thomas D. Landis, USDA Forest Service.

Cultural

In bareroot nurseries, cultural practices such as deep-ripping, addition of organic matter, and leaching of salts can alleviate the effects of saline water and prevent buildup of salts in the soil. Leaching consists of applying large amounts of water to the soil to dissolve salts and flush them down below the seedling root zone. This treatment should be conducted while fields are fallow and after deep-ripping to break up any impermeable hard pans and promote rapid drainage.

Deep irrigation to decrease the levels of salts in the surface soil during germination and seedling emergence can reduce the potential for damage. It is important, however, to ensure that the soil does not become waterlogged during this treatment or seedlings may become vulnerable to root diseases. It is always best to irrigate during times when the evapotranspiration rate is low to avoid salt buildup in the surface soil.

Mulches are a good way to maintain consistent soil moisture, decrease evaporation from the soil, improve water infiltration, and prevent the formation of salt crusts. Light-colored mulches are recommended to avoid heat damage to seedlings that may occur with the use of dark-colored mulches. A thin layer of fresh sawdust or hydromulch, about 1 cm thick, may be used as mulch on top of newly sown seedbeds or on seedlings after emergence. Sand or grit can also be effective as a mulch but should be tested for salts before use.

Inorganic fertilizers are salts, so it is critical that they be applied carefully because they add to the total salt level. In nurseries with naturally saline soil or water, only products with a low salt index should be used. In container nurseries, use of very dilute liquid fertilizer or controlled-release fertilizer is recommended to keep salts within acceptable limits. Several small fertilizer applications are less likely to cause damage than one large presowing application. Organic fertilizers such as sewage sludge and animal manure should be tested before they are purchased as they may contain high levels of salts, heavy metals, or even poisons.

Chemical

Chemical treatments should be applied only after thorough testing to avoid creating additional problems. Soils with excessive levels of sodium can be treated by adding gypsum at a rate of about 22.4 metric tons per ha (10 tons per acre). Adding gypsum will improve the porosity and infiltration rate of the soil. Soils high in calcium can be treated with elemental sulfur at a rate of 560 to 1,120 kgs per ha (500 to 1,000 lbs per acre). Elemental sulphur converts calcium carbonate to the more soluble calcium sulfate. Sulfur treatments also lower soil pH but, because the process takes time, it should be applied at least 1 year before a crop is sown. A significant lowering of soil pH may take many years to accomplish.

Selected References

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