

Types of Overwinter Injury

Winter has arrived, and so it is time to start thinking about protecting your precious seedlings from overwinter injury. As you know, the weather has really been erratic over the past decade and that big "blue norther" could be just around the corner.

Before you can properly protect seedlings, however, you should have a good understanding of the different types of overwinter injury. Some authors distinguish many different types of cold injury, including some that are not prevalent in forest nurseries, such as frost smothering and frost cankers. I consider only three types of cold weather injury to be significant: cold injury, winter drying, and frost heaving. Although the types are listed separately, seedlings are often damaged by a combination of cold temperature stresses.

Table 1 - Comparison of three types of overwinter injury in nurseries

	Caused By	Symptoms	Related to Seedling Hardiness or Dormancy	Stock Types Affected BR= Bareroot C= Container
Cold Injury	Unseasonably cold air temperatures	Meristems most affected: shoot tips, cambium, roots	Yes	BR & C
Winter Burn	Frozen soils and drying winds	Exposed foliage affected	No	BR & C, especially small plants
Frost Heaving	Repeated soil freezing and thawing	Root system exposed and seedling toppling	No	BR, especially small seedlings and transplants

1. Cold injury. This category concerns injuries caused by direct freezing of seedling tissue. When seedlings are actively growing, cold damage rarely occurs until the temperature of plant tissues reaches approximately 30°F (-1°C). At lower temperatures, however, the degree of cold injury depends on the hardiness of the different seedling tissues. *Cold injury is directly related to seedling dormancy and cold hardiness* (Table 1).

Hosts - All species are susceptible to cold injury when succulent, but species and seed sources from low elevations, coastal areas, and southern latitudes are particularly vulnerable.

Symptoms/Damage - Foliar cold injury is initially expressed as pale, water-soaked tissue that eventually turns from straw-colored to brown or bright red, depending on the seedling species and degree of injury. Symptoms develop relatively quickly after exposure to freezing temperatures, usually within a couple of weeks, and meristematic tissues such as shoot tips show damage first (Table 1). This characteristic helps distinguish cold injury from winter desiccation, which usually affects all exposed foliage and develops over a longer time period. Buds can sometimes be killed by frosts that do not injure hardier foliage. The most insidious form of cold injury is cambial damage, which can easily be overlooked because the bark must be removed to expose the symptoms. Cold-damaged cambial tissue turns varying shades of brown within a few days, and this damage may occur in intermittent patches along the stem. Roots are particularly susceptible to cold injury because they do not harden as much as the shoots - this is crucially important for container seedlings that are stored outside.

Pattern of injury - Cold injury can develop from a single frost event or during an extended period of cold weather. Damage is most common in the fall or early spring, when seedlings are entering or coming out of dormancy. Some species show wide individual variation in cold tolerance, and so damage can be scattered. Symptom expression may be delayed during an extended period of cold weather but can be accelerated by bringing the seedlings into a warm environment. Cambial or root injury may be expressed as delayed bud break or foliar

wilting after the seedlings are returned to a growth-promoting environment. wilting after the seedlings are returned to a growth-promoting environment.

Management - Losses to cold injury can be significantly reduced by carefully planned and executed cultural practices:

- Only raise species and seed sources that are adapted to the local environment, especially in bareroot nurseries. Exotics will require special handling and protection.
- Develop growing schedules that include an adequate hardening period. Late summer applications of nitrogen fertilizer and heavy irrigation prolong seedling succulence, whereas moderate nutrient and drought stressing promote hardening.
- Avoid moving container seedlings out of enclosed growing structures until they are adequately cold hardy or all danger of frost has passed.
- Utilize thermal mass to protect seedling roots by grouping container stock on the ground with some sort of insulating material around the perimeter.
- Protect non-hardy seedlings with irrigation (**Figure 1**), supplemental heat, or protective coverings.
- Monitor seedling hardiness with cold hardiness tests to determine when frost protection should begin.



Figure 1—Frost protection with irrigation can be effective, but the weight of ice and oversaturated soils can cause problems.

desiccation injury, which occurs whenever seedlings are exposed to drying conditions, generally wind or direct sunlight. Damage is most severe when the soil or growing medium remains frozen for extended periods while the foliage is still losing water through transpiration. Seedlings can even become desiccated when they are stored under refrigeration without proper

packaging. *Winter drying is not directly related to seedling dormancy or cold hardiness* (Table 1).

Hosts - Conifer seedlings are most susceptible, although hardwoods can become damaged in extreme circumstances. Container seedlings are more susceptible than bareroot stock, because of the limited amount of moisture reserves in small containers (Table 1).

Symptoms/Damage - Winter drying is sometimes referred to as "winter burn" because affected foliage often turns bright red and appears scorched. All exposed foliage is susceptible, but generally the needle tips are most commonly injured; buds within symptomatic foliage may not be damaged and generally produce normal shoots after outplanting. Tip dieback or even seedling mortality can occur in extreme cases. Winter drying can be distinguished from cold injury by foliage color and timing of symptom expression.

Pattern of injury - Winter drying is slower to develop than cold injury, usually requiring weeks rather than days. Desiccation is most severe wherever seedling foliage is exposed to direct sunlight or drying winds, and so bareroot seedlings on the south side of the seedbed are most at risk. Container seedlings that are exposed around the perimeter of the storage area are often severely damaged, especially when the root systems are not properly insulated. In areas with snow cover, shoots that protrude above the snow often show winter burn.

Management - Preventative cultural practices and protective structures can reduce winter drying losses:

- Protect seedlings from direct exposure to sun and wind with sheltering structures. Container seedlings should be stored in a shadehouse, and bareroot stock can be protected with windbreaks or shade frames.
- Orient windbreaks perpendicular to prevailing winter wind, and shade seedlings if possible. Of course, the most effective protection is refrigerated storage as long as the storage containers contain a moisture barrier.
- Cover seedling foliage with mulches or sheeting material, but these must be removed in the early spring to prevent heat buildup or mold damage to covered seedlings. Complete snow cover provides an ideal type of protection; some nurseries have had success with snow-making equipment.
- If possible, irrigate seedlings during periods of mild mid-winter weather.
- Anti-desiccant foliar sprays may provide some degree of protection, but more tests are needed.

3. Frost heaving. This third type of cold damage is

unique to bareroot seedlings and transplants, in particular (Table 1). Frost heaving is a purely mechanical phenomenon that results from repeated freezing and thawing of the soil surface.

Hosts - Small first-year seedlings and newly established transplants are most susceptible, especially plug+one stock. Slow growing species, such as spruces and true firs, and seedlings with a shallow root system are particularly vulnerable (Table 1).

Symptoms/Damage - Frost-heaved seedlings appear to have been pulled from the soil, and often have fallen over on the soil surface with the upper part of the root system exposed. Seedling foliage usually appears desiccated.

Pattern of injury - Damage can occur at any time during the winter, but is particularly severe when the ground surface is exposed during periods of alternately warm and cold weather. Due to the repetitive nature of the frost heaving action, the degree of injury is a function of the exposure period, but eventually seedlings are lifted out of the ground and topple over. Damage often occurs in patches and is most common in wet, fine-textured soils.

Management - Prevention is the only management option as seedlings that have been even partially heaved will not develop normally.

- Seedling growing schedules should encourage root growth on small first-year seedlings.
- Select coarse-textured, well-drained soils and level before forming seedbeds; raised beds are recommended.
- Schedule root wrenching or undercutting to allow adequate time for new root establishment before winter.
- Use thick mulches, shade frames, or fabric coverings to insulate seedbeds and to reduce frost action.

