TRANSPORTATION, CARE AND STORAGE OF SEEDLINGS

Presented by:
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at the 1986 Windbreak Management Workshops.

The basic principles of seedling growth and photosynthesis are related to the seedling environment. The rate of photosynthesis is influenced by the intensity or level of moisture, temperature, light and nutrition. Moisture and temperature, usually in combination, are most often limiting to seedling establishment. Nutrition seldom limits seedling growth, at least during the first two years after planting.

Seedling growth after planting also depends upon physiological vigor and dormancy. Physiological vigor must be managed and maximized in the nursery. Maintaining seedling vigor after stock leaves the nursery bed requires lifting stock only when it is in a dormant condition.

Between lifting and planting, seedling roots are exposed and vulnerable to environmental stress, particularly temperature and moisture extremes (fish out of water). Seedling management during this period requires attention to date of lifting, proper packing methods and storage conditions, and systematic monitoring of seedlings to maintain optimum moisture levels.

Temperature affects photosynthesis:

Temperature controls the rate of chemical reactions such as photosynthesis. Below 40 degrees F., little metabolic activity occurs in conifers.

In a laboratory study with Douglas-fir seedlings optimum growth occurred when daytime air temperature was 86 degrees F. and soil temperature was 68 degrees F. In contrast, seedlings grown at 59 degrees F. air temperature and 50 degrees F. soil temperature showed only half of the optimum growth.

Temperature extremes:

Temperature extremes limit growth and can cause seedling mortality. Conifer seedlings can tolerate temperatures up to 29 degrees F. at ground level. Small seedlings are more susceptible than larger, thicker barked ones.

Temperatures below 32 degrees F. (freezing) can damage or even kill non-dormant seedlings. Seedlings become increasingly resistant (hardened) to environmental stress as they become dormant in the fall. They gradually lose this resistance in the spring in their post-dormancy period.

Dormancy and Plant Hormones:

Seedlings do not grow throughout the year. They require a period of rest called dormancy. Under natural conditions most seedlings begin the dormancy cycle in mid-summer, primarily in response to moisture stress. Shoot elongation generally stops until the following spring, but diameter and root growth continue. The period of dormancy is a series of different physiological phases, each with distinct characteristics and requirements. Failure to complete the requirements of each phase of dormancy results in decreased seedling vigor and probably death after outplanting.

Four phases of dormancy for Douglas-fir: (cold hardiness or acclimation)

1. Dormancy induction: Period from mid-July to late September when winter-resting bud are initiated and develop in response to moderate moisture stress. Excessive watering or nitrogen at this time may interfere with this process.

2. Dormancy deepening: Period from September to mid-November when buds are well formed and metabolic changes slowly induce frost hardiness. Seedlings are still susceptible to damage from desiccation or hard freezing. Short photo-periods and mild temperatures are required to complete this phase. The seedlings will not resume growth in response to favorable conditions. The metabolic changes or freezing mechanisms include:

   a. Decrease starch and increase sugar.
   b. Lower overall plant water.
   c. Low "in cell water" and high "outside cell water"
   d. Outside cell water freezes first giving off heat that protects in cell. (When water freezes it releases heat--80 calories per gram of water)

3. Dormant: Period from November to March when seedlings have maximum resistance to environmental stress. Seedlings require a minimum time span of below 40 degrees F. temperature to complete this phase and cannot resume growth. (Time required varies for different species; for example, Douglas-fir takes at least six weeks.) If a chinook starts plant out, it can still regain dormancy if refrozen slowly, but a quick freeze is what does damage.

4. Post-dormancy: Period from thawing out to bud burst. Seedlings gradually lose their resistance to frost damage and other environmental stress. The length of this transition phase depends upon temperature and photo-period; the more favorable the conditions for growth, the sooner buds will burst.

Plant Hormones:

During the 1930s scientists discovered that plant growth was controlled by hormones. A lot of literature on the subject has evolved since then, and new hormones are frequently reported. Four classes of naturally-occurring plant hormones have been identified:

1. Auxins, which are involved in a variety of plant processes including cell elongation, fruit ripening, abscission, and root initiation.

2. Gibberellins (over 40 different ones identified) control cell elongation, flowering, and dormancy.

3. Cytokinins control cell division.

4. Inhibitors cause reduction of cell elongation and appear to control stomata.

Although many of these hormones are known to control certain plant growth processes, when these same hormones are applied to intact plants, there is usually no response.

Plants produce their own hormones, and their growth and development are seldom limited by lack of hormones.

People have tried applying different hormones to the roots and shoots of seedlings, but no hormone treatment yet has proved beneficial to forest seedlings, either in terms of growth or survival. The best treatment that can be applied to a seedling is to lift it at the proper time, minimize PMS, and plant at the proper time of year. Any hormone, fertilizer, or "magic dip" treatment prior to planting is more likely to harm the seedling than to encourage its survival and growth. There may be situations where soil tests indicate a need for fertilizer.

Seedling Handling

Between lifting and planting, seedling roots are exposed and vulnerable to environmental stress. Seedlings are particularly sensitive to temperature and moisture extremes during this time. Exposure of roots to drying conditions significantly decreases seedling survival. The critical length of exposure varies by seedling condition and the severity of the surrounding environment. (Warm, dry or windy conditions are the worst.)

Dormant seedlings can tolerate longer periods of root exposure than non-dormant seedlings. Short exposures (a few minutes) usually are not critical unless seedlings are not dormant, or if conditions are extremely droughty. In general, exposure of roots kills seedlings or decreases growth. Tolerance varies greatly depending on species also. The rule-of-thumb for conifers is "if the root surface dries enough to take on a gray color rather than the normal shiny wet look, the tree has suffered and is probably dead." Hardwoods, on the other hand, are much more forgiving, and often can come through a half day's exposure with no noticeable effects.

Packing for storage

A widely used treatment in packing seedlings is in completely sealed bags or cartons. Sealed containers are most effective in reducing water loss. Polyethylene film or coatings are used as sealants because they are impermeable to water, but permeable to carbon dioxide. The use of moss or other moisture-retaining packing material is helpful for long-term storage but not considered necessary for routine storage in sealed containers.

The State Nursery previously used a 2-ply coated paper sack for most conifer production. We are now using a cardboard box with a plastic liner as they are more durable.

The enclosed sacks or boxes work very well for the reforestation projects in Western Montana where a minimum of handling, refrigeration, and quick transportation to the planting site are the rule.

You will see large orders of bareroot conifers delivered in plastic-lined boxes. Be especially careful not to let these get heated up. You will see all of our containerized conifers shipped in the same boxes but without the plastic liner. There will be some air circulation through the hand holes, so heating up may not be the worst problem here, rather you should be concerned about the containers drying out.

The bulk of trees delivered to counties in the state are still being wrapped in open-end bales with poly-lined burlap or plastic wrap. Although this system is subject to drying out faster than a closed sack, it is more durable, provides better air circulation, and is less subject to overheating when not in cold storage. If storage is necessary and drying becomes a problem, the open-end bales can be tipped on end and water added with a hose.

Storage Facilities:

Storage facilities include the heel-in bed, cool garages, root cellars, and various refrigerated units.

The heel-in bed is used regularly at the State Nursery for over-winter storage of dormant hardwood seedlings with very good results. Use of the heel-in bed in spring can only be a short term solution because higher temperatures and longer day length will be affecting the seedlings.

Ideal storage conditions can be found in refrigerated units that range from 33 degrees to 35 degrees F. with a 95 percent relative humidity. Seedling respiration increases rapidly above 40 degrees F., depleting valuable reserves of moisture and carbohydrates.

Freezing temperatures for over-winter storage is being used successfully for some species. This practice is something for us to consider at the nursery, but probably has no application at the field end of the process as frozen trees must not be roughly handled and must be thawed slowly.

Moisture stress retards growth in storage and is used in some nurseries to keep fruit trees dormant. This is also why soaking the roots of this type stock overnight sometimes helps. This is not practical with our stock, nor is it necessary.

Some districts in North Dakota have handled the storage problem by freezing ice on the floor of a building during winter and covering it with straw. The trees are placed in the building in the spring, and the melting ice keeps it cool.

Mold on trees can sometimes be a problem when storage conditions hve been less than adequate. Cold storage usually prevents severe mold problems; but once molds have started in tree bundles, they should be opened to better air circulation immediately, such as in a heel-in bed or planting. Moderate amount of white mold on the surface can be washed free of the trees; but once the black molds have penetrated the tissue, the trees probably will not recover. Closed containers used for tree shipments can sometimes develop inside temperatures 12 degrees higher than the outside of the bags. This is particularly true with active trees and storage temperatures above 40 degrees F. Close attention should be given to temperature and possible mold development.

Duration of Storage:

Fall-lifted dormant hardwoods can be successfully stored over winter for up to eight months.

Stock taken from the field or heel-in bed in the spring while still dormant can be stored for up to three months if storage conditions are ideal.

Stock lifted during a warm spring that has started to become active can be safely stored for less than one month with ideal storage conditions.

This same stock will suffer within days when no special storage conditions are provided. As this often is the case, getting the trees planted as soon as possible is extremely important.

Transportation:

The same principles of seedling care during storage apply to transporting seedlings. The seedlings should be protected from heat and drying. In the absence of referigerated trucks for delivery from the nursery cold storage unit to the planting site, several precautions need to be taken:

1. Move the trees as fast as possible, planning trips so weekend layovers are avoided.

2. Use tarps to prevent drying.

3. Use a ventilated truck to prevent heat buildup.

4. Park in shade when possible.

The nursery has been using a variety of trucks for tree delivery each spring, some open and, the last two years, a refrigerated van. The ideal process would involve stock lifted when dormant, packed and refrigerated at the nursery, loaded on refrigerated truck for delivery,a nd planted within a day of delivery.

Of course, things never work that perfectly all the time. When planting cannot be geared to delivery time for whatever reason, we now have another alternative. This is delivery directly to landowner by U.P.S. Keep in mind that U.P.S. delivery is not refrigerated, but this may be better than our refrigerated delivery when planting is delayed several weeks.

PLANTING

Planting is one of the several very important steps necessary for establishment and needs to be performed as though everything in the success of the project were dependent upon it.

Let's assume our site has been prepared and staked out, the crew is lined up and our equipment is all ready. We have our seedlings on hand, and we know the seedlings are always deteriorating during storage (But we're keeping the rate of deterioration slow). We want to observe the same principles of tree care as we did in storage, (i.e. the fish out of water).

SOME INFLUENCING FACTORS TO KEEP IN MIND:

Hand out

Exposure of Scotch Pine.

Weather

Ideal day for tree planting is cold, wet, and miserable for the planting crew. The worst situation is hot, sunny, and windy. In fact, if you are working with conifers, planting should be stopped when temperature gets up to 65 degrees F., and the wind is over 20 m.p.h. Plant the most sensitive species in the morning if you can.

Root Regeneration

The sooner a seedling's root system establishes contact with soil moisture and nutrients, the greater the probability of survival and growth.

Photosynthesis

If a seedling is going to become established, it must manufacture food to expand its root system. A seedling poorly planted or otherwise in shock has its moisture transpiration system shut down. When the stomata are closed, diffusion of carbon dioxide slows, photosynthesis is halted, and root growth is interfered with.

PLANTING GOALS:

Care of Seedling

Keep seedlings wet. If hand planting a few at a time, carry them in a pail of water. If machine planting a lot of trees, use wet burlap or moss to protect roots and expose as few trees at a time as possible.

Root Placement

Seedlings should be planted with roots fully extended downward. Avoid the J rooted planting. It may be better to trim long roots than to have them distorted at the bottom of a shallow hole. Keep them natural, i.e., if you are in a situation where you are considering cutting a 12 inch root system back to 10 inches for ease of planting, you should consider the consequences. By root

pruning, you are limiting the plants capacity to function. If this is a dryland planting site, you may have to haul five gallons of water to each plant later in the season to compensate for 2 inches of depth (not a tested figure). Considering the work involved in watering, maybe making the hold deep enough in the first place doesn't sound so bad.

Planting Depth

The deeper roots reach into the ground, the longer they have moisture available as the soil moisture is depleted during the year. Bareroot stock should be planted with root collar at or just slightly below ground line. Containerized stock should be planted about 1/2 inch below ground line so that dirt covers the soil mix on the root ball. If this root ball is exposed, it could act as a wick which dries the plant out.

Soil Compaction

When hand planting, the root system should be placed on the straight edge of the hole, and the dirt should be packed in with your foot. The idea here is to get all the air pockets out and have all the roots in contact with soil. To test your planting job, grasp the tree with thumb and one finger and pull up firmly--the tree should not move. When machine planting, it may also be necessary to follow the planter and compact each tree. This depends on how well the planter is doing and on soil conditions at the time. Compaction can sometimes also be a problem. In heavy clay soil when using a dibble or auger just big enough for a container, we could be creating a compacted cavity that roots have a hard time penetrating--like a pot-bound house plant. I'm assuming that in any of our plantings, this problem has been handled by site preparation that loosened the soil.

EQUIPMENT:

There are a wide variety of tools available for hand planting.

> Dibbles are tools that force a container size hole in the ground without removing any soil.
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> Mattocks, Hoedads, tree planting bars, and tree planting hoes were developed for various soil types for planting conifer stock in a reforestation situation. I don't think any of these tools would make a wide enough or big enough slot for a lot of the hardwood stock we are working with. Most of the blades are only about 3 inches wide.
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> Tree planting spades and shovels have a straight blade 5 inches or 6 inches wide and 12 inches to 16 inches deep. Most hardware stores have tools called tile spades or post hole shovels that have the straight, narrow, and deep blade that are similar. A standard shovel can also get the job done, and probably is the most common tool used in our situations.
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> Tree planting augers that make a 4 inch or 6 inch hole and operate off a chainsaw engine are available. They are expensive and probably not needed on prepared sites; but when getting root systems planted deep is a problem, they provide one solution.

Tree planting machines are the fastest way to plant a lot of trees. There are several different ones around the state, and I cannot tell you which ones are best.

They are manufactured all over the country, usually in small machine shops and have a variety of features.

The basic idea is the pointed shear to open the planting furrow. This should be able to operate at least 12 inches deep. Three-point or pull types are available. There should be packing wheels on the back. Single-seated or double-seated models are available. The double-seated ones have a real advantage when planting a close-spaced row of shrubs. It may even be impossible for some tractors to move slowly enough for a single planter to do a good job when spacing is close.

Maintenance and adjustment is very important in making any planter work properly. The point on the shear needs replacement at times just to stay in the ground. The depth and angle has to be worked out every time a different tractor is used. The packing wheels may need adjustment for different planting conditions.

Percent mortality of bareroot Scotch pine seedlings
due to exposure of roots before planting.

Weather	Hour	Air Temperature (Degrees F)	Minutes of exposure						
			0	2	5	10	20	40	80
			- Percent mortality -						
Cloudy	9-11 am	48.2	12	50	62	64	69	73	88
Cloudy	12-2 pm	50.0	12	49	64	66	69	83	93
Cloudy	3-5 pm	53.6	23	54	65	75	83	94	99
Rainy	9-11 am	60.8	8	40	42	46	56	63	66
Hot, clear	11 am-1 pm	73.4	55	80	88	90	94	100	100