The Effect of Elevated Post-Cold-Storage Temperatures and Physiology Survival of Boxed White Spruce Seedlings: Field Results – FRDA Project 1.30

Successful establishment and growth of conifer seedlings after planting depends upon their physiological state at the time of planting, and upon prevailing site conditions. Seedlings are subjected to a number of potentially vigour-reducing operations between lifting and planting. After lifting, seedlings are usually counted, boxed, cold-stored, loaded in and out of transporters, thawed and sometimes stored in the field before finally being planted. During these operations, the trees may be exposed to a range of stresses, including excessive heating.

Temperature is only one environmental factor, but it exerts a controlling influence over every life process. Injury may occur at high or low temperature extremes. Heating may kill a tree very quickly, by direct heat stress. Or, death of the seedling may take longer, caused by gradual reduction of vigour through depletion of food reserves as a result of increased respiration and disruption of other physiological processes. As well, heat stress may cause physiological changes such as loss of cold hardiness or change in dormancy state.

According to Levitt (1980) heat injury may be divided into primary and secondary injury. Secondary injury is due to desiccation. Depending on the temperature, primary injury may be either direct or indirect. Direct injury is caused by very brief exposure to temperatures in the range of 45 - 60°C, with the plant responding during actual heating or immediately after. It is characterized by the leakage of amino acids and ions due to membrane damage. Indirect injury, on the other hand, is observed at temperatures around 40°C or lower and usually is not apparent for many days or weeks.

The extent of primary indirect injury depends upon the duration of exposure to stress, as well as the intensity of that stress. Injury is the result of whole or partial impairment of physiological processes such as photosynthesis or respiration. In other words, the stress is intense and long enough to affect the living cell. Concentration of toxic substances, biochemical lesions, protein hydrolysis and other abnormalities usually result. These lead to growth reduction or cessation, and in the worst case, death of parts of the plant or the whole plant.

In nature, the temperature of tree seedlings is very close to the ambient. In an unnatural situation, as when boxed seedlings are exposed to heat, excessive heating is possible. Since water replacement through the roots cannot take place in such a situation, rapid desiccation can also occur.

The symptoms of sub-lethal heat stress will only be noticeable after the stock has been planted either in pots or in the field for some weeks. Obviously, this is too late for the nursery manager, or the field forester, to make decisions about suspected improperly handled stock.

One major objective of this study was to determine to what extent heat stress applied to seedlings results in loss of growth and survival potential. A second major objective was to determine if certain tests which detect physiological changes could be used to detect heat stress in seedlings prior to planting. This memo reports on the first objective.

A white spruce (Picea glauca [Moench] Voss.) seedlot from Prophet River, Fort Nelson Forest District, was grown in styroblocks under operational conditions at Pelton Reforestation Ltd., Maple Ridge, in 1987. A random sample of 4800 seedlings was taken on November 25, 1987 when the whole crop was lifted. Bundles of 25 seedlings were wrapped in clear plastic and packed in waxed boxes lined with paper bags. Seedlings were transported to the B.C. F.S. Research Laboratory on Glynn Road in Saanich and stored at -2°C.

In spring, 1988, boxed seedlings were thawed for 8 days at 5°C prior to treatment. Heat treatments were applied to nursery standard boxed seedlings at test temperatures of 5, 10, 20, 30, and 40°C. Samples were removed after 12, 24, 48, 72, and 96h. Thawing and heating were conducted in growth chambers in which temperature was continuously monitored.

Growth and Survival

Two blocks of 25 heat-treated seedlings for each treatment combination (1750 seedlings in total) were planted in a completely randomized design on a farm field site at the Glynn Road Research Laboratory. No water or fertilizer were applied throughout the growing period.

Damage was scored as a percentage of the whole tree affected after 14, 28, and 63 days and at lifting time and...
averaged over each block. Final mortality for all treatments after one season in the field are shown in Table 1.

Needle damage to live seedlings was also assessed after planting (Figure 1). Over the growing season, seedlings treated to 96h at 5, 10, and 20°C, to 48h at 30°C, and to 12h at 40°C showed no significant damage. But after 63 days, 100% mortality was recorded in seedlings treated for 72h at 40°C (Figure 2). In addition, shoot extension, stem diameter (Figure 3), shoot dry weight, and root dry weight were significantly reduced after 72h at 30°C, and after 24h at 40°C. Terminal bud flushing was not significantly affected at 5, 10, or 20°C (Figure 4) for up to 96h but was severely affected by 30 and 40°C temperature treatments.

**TABLE 1.** Final mortality (%) of various heat treatments on white spruce seedlings after one season in the field

<table>
<thead>
<tr>
<th>Heat treatment (°C)</th>
<th>24</th>
<th>48</th>
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<th>96</th>
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<tr>
<td>40</td>
<td>&lt;10</td>
<td>&gt;50</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**FIGURE 2.** The mortality (%) of heat-treated white spruce seedlings at 14, 28 and 63 days after planting and at lifting time. n = 50 seedlings.

**FIGURE 1.** Average damage (%) to living heat-treated white spruce seedlings at 14, 28 and 63 days after planting and at lifting time. n = 50 seedlings.

**SUMMARY**

Growth and survival were affected by the intensity of temperature and the duration of heat treatment. Seeding damage and the reduced growth and survival at the higher temperatures in this study were considered to be the result of primary indirect heat injury. Seedlings showed considerable tolerance to heat stress above 10°C over short durations. However, as a precaution, exposure of seedlings to temperatures above 5°C after cold storage, but prior to planting, is not recommended.

Managers should monitor conditions when removing seedlings from cold storage, during transportation to the planting site, and at the field site prior to planting, to ensure that temperature and length of exposure do not exceed these limits. Physiological data recorded in the course of this study will be used to develop more sophisticated tests for predicting seedling survival and vigour.
FIGURE 3. Shoot extension (cm) and stem diameter (mm) of field planted seedlings exposed to various temperatures for up to 96h. Data were collected at the end of one season's growth. The 10°C temperature treatment was similar to the 5°C treatment and, therefore, is not shown. n = 50 seedlings.

REFERENCE


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