

## Changes in Root Growth and Photosynthesis in Stored White Spruce Seedlings

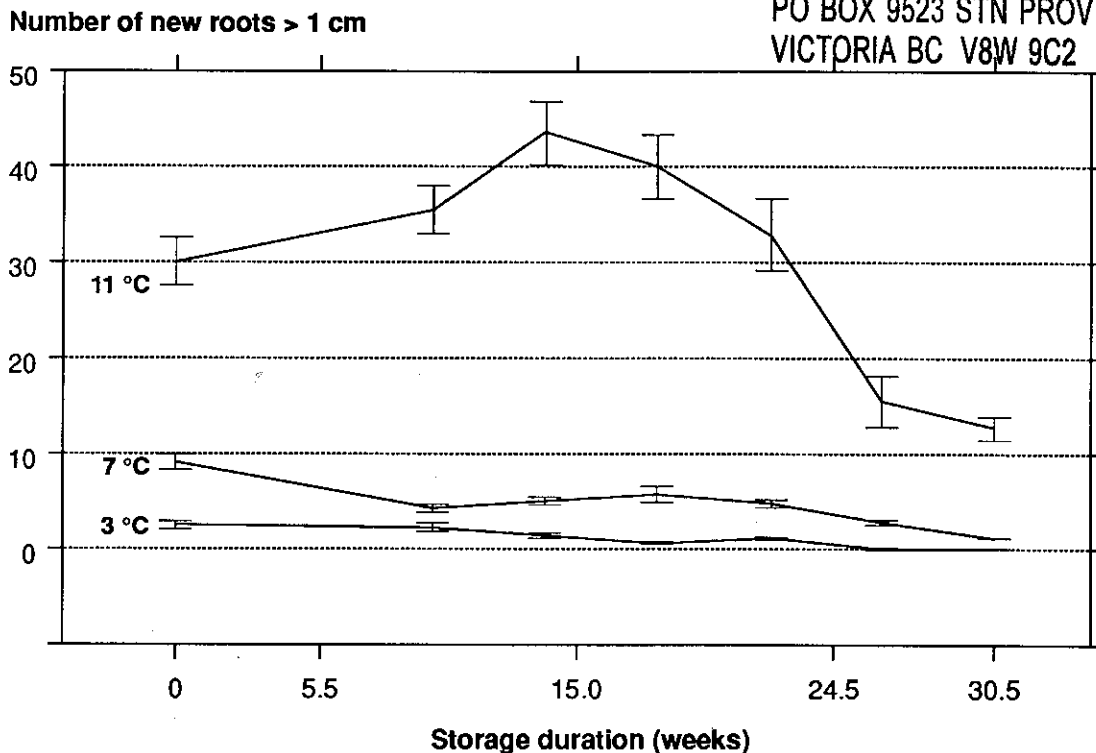
Every year a large portion of the planting stock in British Columbia is cold stored. The logistics of planting 200+ million seedlings demands some form of storage. Past research has shown a reduction in carbohydrate reserves and bud dormancy with increasing storage duration. Also evidence of photosynthetic decline has suggested long-term storage may disrupt CO<sub>2</sub> fixation, and possibly affect growth. In response to interest in extended cold storage as a possible factor in poor spruce plantation performance and also concern over poor root growth in cold soils, a research project funded by the B.C. Science Council was conducted at U.B.C. The project determined the effects of varying lengths of cold storage in conjunction with outplanting soil temperatures on seedling photosynthesis, stomatal conductance, and root growth. By monitoring these physiological variables and others (bud

break, height growth, etc.) a picture of seedling recovery from storage in cold soil conditions can be developed.

### DESIGN

White spruce seedlings (PSB 313, 1+0) from the Forest Service Surrey Nursery were lifted in December, 1988, culled according to Ministry specifications, boxed and stored at -5 °C (-2 °C seedling temperature). After storage periods of up to 30.5 weeks (7.5 months), seedlings were thawed, potted, and grown for 28 days in a growth chamber at 11 °C air temperature, and 3, 7 and 11 °C soil temperatures. Seedling physiological condition was monitored every three days. New root growth over 1 cm was measured after the month-long growth period.

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FIGURE 1. New root growth >1 cm after 28 days at various soil temperatures, after dark freezer storage of up to 30.5 weeks. Error bars are 1 Standard Error of the Mean (points are means based on 40 samples).

## RESULTS

1. **The number of roots produced after planting changed during storage, and the extent of the change depended on the temperature of the soil (Figure 1).** Unstored seedlings planted in 3 and 7 °C soil produced few roots longer than 1 cm in the first 28 days after planting, and this number declined significantly after 6 months in storage. Seedlings planted at 11 °C produced more roots than those at the lower temperatures. Root number in 11 °C soil increased somewhat after 14 weeks but declined rapidly after longer durations.
2. **Net photosynthesis (carbon fixation) declined with storage duration greater than 22 weeks (Figure 2).** Stomatal conductance did not appear to be limiting carbon fixation. In fact, stomatal conductance significantly increased with storage over 22 weeks. Fluorescence results suggest the decline in net photosynthesis may be due to degeneration of the photosynthetic system during storage leading to photoinhibition upon outplanting. This effect was soil temperature dependent, with maximum reduction noted at the 3 °C soil temperature.
3. **The number of days to terminal bud break steadily decreased with increasing length of storage from an average of 16.3 days at 9.4 weeks storage to 9.2 days at 30.5 weeks storage.** As a result, longer storage produced earlier bud flush, channelling photosynthate into shoot development possibly at the expense of new root growth. The reduction in root

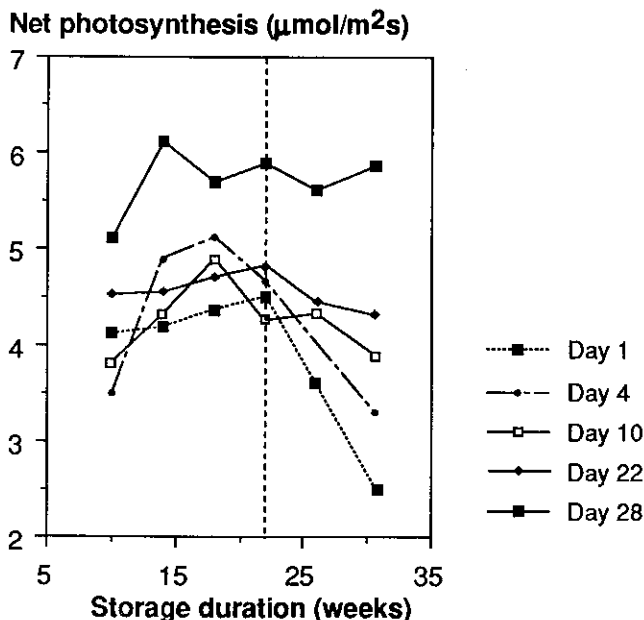


FIGURE 2. Net photosynthesis over 28 days growth after removal from dark freezer storage and outplanted at 3 °C soil temperature (points are means based on 40 samples, solid and dashed lines represent the level at various days after outplanting).

growth with increasing storage may be partially dependent on the length of time between outplanting and bud flush.

4. **At the soil and air temperatures used in this experiment, the stomates did not open fully for 7-10 days after outplanting.** This recovery period was seen after all storage durations. Fluorescence measurements made on longer-stored material indicate that the photosynthetic efficiency of the chloroplast membranes also takes 7-10 days to recover.

## MANAGEMENT IMPLICATIONS

1. **This study suggests that spruce seedlings stored for long periods may lose some ability to grow roots in cold soils, probably due to a combination of normal developmental changes and direct effects of storage.** Decreased photosynthetic ability and increased stomatal opening in the nursery foliage of long-stored seedlings demonstrate reduced vigor. Earlier bud break may appear to be an advantage for locations with short growing seasons, but poor seedling establishment may result because of insufficient root growth and poor overall vigor. It is important to mention that, in many cases, spruce seedlings stored for long durations have fared well, and that the effect on seedling condition of other variables (such as pre-storage, storage, and planting conditions) may alter the effect of long-term storage. In short, storage duration is yet another of the considerations involved in tailoring seedling growth potential to site conditions.
2. **Soil temperature is extremely important for new root development.** Site preparation to increase soil temperatures above at least 11 °C may greatly enhance root growth in white spruce. Planting in cold soils may severely reduce root growth resulting in poor seedling establishment. The results suggest root growth potential measurements made at relatively warm temperatures may not reflect the actual ability of seedlings to produce roots at lower temperatures resulting in an overestimation of performance expectations.

Further information on this project can be obtained from:

*Dr. Edith Camm or George Harper*  
(604) 228-5223 (604) 228-6021

*Faculty of Forestry*  
*University of British Columbia*  
*270 - 2357 Main Mall*  
*Vancouver, B.C. V6T 1W5*