DROUGHT TOLERANCE AND PHYSIOLOGICAL MECHANISMS OF DROUGHT RESISTANCE IN THREE NORTHERN CONIFERS

G.F. Buxton,[1] D.R. Cyr,[1] E.B. Dumbroff[1]

In order to maintain a sustained yield of commercially valuable wood from its forest lands, the province of Ontario supports an active program of production and outplanting of forest tree seedlings. Significant numbers of these seedlings are lost each year from various causes including insects, disease, fire, animal damage and drought. Moisture stress (i.e., any intensity of drought) may account for greater losses in growth and survival than all other factors combined. Although cultural prescriptions necessary to reduce these losses are urgently needed, their development has been delayed by a lack of basic information concerning the morphological and, particularly, the physiological characteristics that convey drought tolerance to newly outplanted seedlings. The present investigations have been designed to define, evaluate and compare the physiological mechanisms by which seedlings of black spruce *(Picea mariana [Mill.]* B.S.P.), white spruce *(Picea glauca* [Moench] Voss) and jack pine *(Pinus banksiana* Lamb.) respond to various intensities of moisture stress. Data derived from this work should provide the kind of information necessary to develop practical hardening procedures that will induce the physiological states most conducive to seedling survival following outplanting.

Seedlings are grown in liquid culture and moisture stress is routinely imposed by adjusting the osmotic potential of the nutrient solutions to specific values by additions of various quantities of polyethylene glycol 6000 (PEG 6000) (Michel and Kaufmann 1973). Future tests will compare the PEG method with the use of balanced, high-salt solutions in liquid culture (Cooper and Dumbroff 1973) and exposure of seedlings to alternate cycles of wetting and drying in sand cultures.

Although analyses of samples from our first formal study are still in progress, many preliminary results have been obtained. Shoot growth of the three species was reduced by approximately 70% of that of the controls when root systems were exposed to an osmotic stress of -400 kPa, and growth all but ceased during exposure to osmotic potentials of -1200 kPa. In contrast, root growth was stimulated under conditions of mild stress (-200 to -400 kPa) and this suggests the presence of drought avoidance mechanisms in all three conifers.

Water potentials and osmotic potentials decreased with stress, but pressure potentials (measured with a pressure bomb) showed little change from their initial values by the end of the 7-day stress period.

Transpiration rates in black spruce and white spruce fell during osmotic stress at -400 kPa but recovered quickly following stress relief. A similar response in jack pine did not occur until the seedlings were exposed to osmotic potentials of -800 kPa or less. Transpiration rates failed to recover in any of the species during the 72 hr of stress relief that followed exposure to -1200 kPa of osmotic stress.

Biochemical analyses include measurement of chlorophyll, chlorophyll stability, starch, soluble carbohydrate, total nitrogen, protein, total free amino acids and proline. Although most of this work remains to be done, there are strong indications that starch and proline levels increase in the spruces during stress and that total free amino nitrogen increases in jack pine. Little change was noted in the levels of soluble carbohydrate in any of the species.

Cooper, A.W. and Dumbroff, E.B.
1973. Plant adjustment to osmotic stress in balanced mineral-nutrient media. Can. J. Bot. 51:763-773.

Michel, B.E., and M.R. Kaufmann.
1973. The osmotic potential of polyethylene glycol 6000. Plant Physiol. 51:914-916.

[1]Department of Biology, University of Waterloo, Waterloo, Ontario.