Height growth of black spruce and jack pine seedlings in flooded flats

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Abstract

Black spruce (*Picea mariana* [Mill.] B.S.P.) and jack pine (*Pinus banksiana* Lamb.) seedlings were grown in a greenhouse on peat-filled flats flooded with nutrient solution or distilled water. None was aerated. However, an O_2 concentration gradient existed across the flats, 3.0 – 3.7 ppm along the edges, and 1.4 – 1.9 ppm in the centers. After 4½ months seedlings of both species grew taller with nutrient solution than with distilled water. In flats supplied with nutrient solution, seedlings of both species grew taller along the edges than in the centers, whereas in flats supplied with distilled water height differential did not develop. Jack pine grew taller than black spruce under similar conditions.

Introduction

Tree growth on peatlands is generally slow because of anaerobic conditions associated with poor drainage, lack of nutrients, or adverse climatic conditions (Heikurainen 1964, and others).

To date, no comparative autecological studies have been made of black spruce (*Picea mariana* [Mill.] B.S.P.) and jack pine (*Pinus banksiana* Lamb.) growing on peat. The greenhouse experiment described below was carried out to explore tentatively the influence of nutrient supply and oxygen content on seedling growth of jack pine and black spruce, under simulated peatland conditions.

Methods

Six 31 x 28 x 15 cm plastic flats, filled with a 3:1 mixture of sterilized peat and vermiculite, were each suspended in a basin with a constant liquid level control, three filled with Ingestad's (1967) nutrient solution, and three with distilled water. Nine 2.5 cm inflow holes in the sides of each flat maintained the solution/water levels to within 1.5 cm of the substrate surface. No aeration of the solution/water was induced; however, the free liquid-air interface in the basins permitted significant amounts of oxygen to dissolve. Measurements of O_2 concentration indicated a gradient across the flats with concentrations approximately 1.7 ppm higher near the edges than in the centers. Each flat was divided into quadrants. In each quadrant 25 viable seeds were evenly distributed. Two quadrants contained black spruce and two contained jack pine. In each quadrant a location along the edge of the flat (O_2 concentration 3.0 – 3.7 ppm) and a location in the flat center (O_2 concentration 1.4 – 1.9 ppm) were considered separately. Conductivity was measured on a Beckman conductivity bridge RC 16B2, O_2

Résumé

L'auteur fit pousser des semis d'Épinette noire (*Picea mariana* [Mill.] B.S.P.) et de Pin gris (*Pinus banksiana* Lamb.) en serre dans des contenants inondés d'une solution nutritive ou d'eau distillée qui ne furent pas aérées. Cependant un gradient de concentration d' O_2 existait dans les contenants, 3.0 – 3.7 ppm le long des bords et 1.4 – 1.9 ppm au centre. Après 4½ mois, les semis des deux espèces poussèrent mieux dans la solution nutritive. Dans celle-ci, les semis poussèrent mieux le long des bords des contenants qu'au centre, tandis que dans l'eau distillée, il n'y avait pas de différences de hauteur dans chaque contenant. Sous des conditions semblables, le Pin gris poussait mieux que l'Épinette noire.

concentration on a YSI model 51, and pH on a Beckman Zeromatic II. Readings were taken in each zone 12 times over a period of 4½ months. Buried plastic screen cylinders, 3.5 cm in diameter, closed with rubber stoppers permitted direct measurements in the soil solution without repeated disturbance of the substrate. The heights of the seedlings after 4½ months of growth were used for evaluation. The experiment, a randomized block design, was analyzed by the variance method. There were two treatments (nutrient solution and distilled water), two locations (edge and center), two species (black spruce and jack pine), and six replications (two locations of nine seedlings of each species in each of three flats).

Results

The average values of conductivity, pH, O_2 and mean heights of black spruce and jack pine after 4½ months of growth are shown in Table 1.

Seedlings of both species grew significantly taller ($p = 0.01$) in substrate flooded with nutrient solution than in substrate flooded with distilled water.

Dishing was a significant development in the experiment. In substrate flooded with nutrient solution, seedlings of both species were significantly taller ($p = 0.01$) along the edges of the flats than in the centers (Fig. 1).

In substrate flooded with distilled water there was no significant difference in height growth between seedlings of the same species growing along the edges and those growing in the centers of the flats (Fig. 2).

Jack pine seedlings were significantly taller ($p = 0.01$) than those of black spruce in substrates flooded with either nutrient solution or distilled water. The higher pH along the edges appeared related to the higher O_2 concentrations.

Discussion

It is well known that an adequate supply of nutrients is essential to the growth of trees. This experiment has shown that seedlings grew taller in peat substrate flooded with nutrient solution than in one flooded with distilled water. The role of oxygen, however, was also significant, although it

has been generally regarded as a secondary factor (Huikari 1954; Orlov 1958). In substrate flooded with nutrient solution, seedlings grew taller at the higher O₂ concentration of 3.7 ppm than at 1.9 ppm. Zinkan et al. (1974) found that in nutrient solution at an O₂ concentration of 3.3 ppm shoot lengths of black spruce and jack pine were similar to those at still higher O₂ concentrations, whereas at O₂ concentrations of 2.0 ppm the poorest growth occurred.

The better growth of seedlings along the edges appeared to result from two factors, viz., nutrient supply, expressed as the conductivity, and O₂ content, both of which were higher along the edges than in the centers.

In distilled water the higher oxygen levels along the edges appeared to have little effect on the height of seedlings. It seems that nutrient supply was the limiting factor. These results appear to parallel situations in nature, and could be applied in practical forestry. Seepage sites, minerotrophic peatlands, and often fringes of bogs are affected by telluric or mineralized waters. They frequently support tree growth which is limited by factors other than nutrient supply. Drainage would improve aeration and, subsequently, tree growth.

Ombrotrophic peatlands such as raised bogs are generally waterlogged and deficient in several nutrients. They support stunted or very slowly growing trees, or are treeless. Drainage and additions of the deficient nutrients would be required to make conditions suitable for the growth of merchantable trees. The results of this study and the author's observations of individual jack pine growing with black spruce on waterlogged bogs and on humic podzols in Ontario and Quebec indicate that jack pine can grow on black spruce sites and may even grow better on such sites. However, further autecological studies are required to determine if this holds true beyond the early stages of seedling survival and tree growth.

References

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FIG. 1. Flat irrigated with nutrient solution. Jack pine is taller than black spruce.

FIG. 2. Flat irrigated with distilled water. Jack pine is taller than black spruce.

Table 1. Mean heights of black spruce and jack pine seedlings after 4½ months' growth on peat substrate irrigated with nutrient solution or distilled water.

Treatment	Position in flat	pH of substrate	Properties of soil solution		Mean heights of seedlings	
			Conductivity (µmho)	O ₂ Content (ppm)	Black spruce (cm)	Jack pine (cm)
Irrigated with nutrient solution	center	4.0 (.09) ^a	342 (.30)	1.9 (.47)	3.9 (.59)	12.2 (.40)
	edge	4.7 (.21)	355 (.25)	3.7 (.42)	6.4 (.52)	14.6 (.33)
Irrigated with distilled water	center	3.9 (.06)	35 (.35)	1.4 (.23)	2.1 (.23) ^b	4.8 (.23) ^b
	edge	4.4 (.08)	45 (.76)	3.0 (.41)	2.3 (.28) ^b	4.6 (.24) ^b

^aBracketed figures are coefficients of variation.

^bnonsignificant differences within species.