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The effect of root and shoot pruning on early growth of hybrid poplars

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ABSTRACT

Planting stock type and quality can have an important impact on early growth rates of plantations. The goal of this study was to evaluate early growth and root/shoot development of different planting materials in typical heavy clay soils of northwestern Quebec. Using one-year-old bareroot hybrid poplar dormant stock, four planting materials were compared: (1) regular bareroot stock, (2) rootstock (stem pruned before planting), (3) whips (roots pruned before planting), and (4) cuttings (30 cm stem sections taken from the basal portion of bareroot trees, i.e. roots and shoot pruned). Rooted stock types (bareroot and rootstock) produced, on average, 1.2 times larger trees than unrooted stock types (cuttings and whips). However, shoot-pruned stock types (rootstocks and cuttings) reached similar heights and basal diameters as unpruned stock types (bareroots and whips), during the first growing season. Shoot pruning reduced leaf carbon isotopic ratios, suggesting that unpruned stock types were water-stressed during the first growing season. The stress was most likely caused by early leaf development while root growth occurred later in the summer. We conclude that shoot pruning bareroot stock is a useful management option to reduce planting stress without compromising early growth rates of hybrid poplars.

1. Introduction

Establishment of fast-growing plantations is considered one of the main tools to produce more wood on reduced land areas in order to, in part, preserve a larger proportion of native forests without affecting the forest industry (Anderson and Luckert, 2007). Rapid establishment and growth of trees are crucial in such plantations, especially where the growing season is short, such as in boreal regions of Canada. Planted trees that have rapid early growth can reduce rotation length and shade out weeds sooner, reducing maintenance costs. Planting stock type and quality can have an important impact on early growth rates and thus affect profitability of such plantations.

In Europe and United States, hybrid poplars (*Populus* spp.) are usually planted as unrooted cuttings or whips (Stanturf et al., 2001). In Quebec, Canada, planting stock provided by provincial nurseries to tree farmers is tall (approximately 1–2 m in height), one-year-old bareroot dormant stock; large bareroot stock was originally designed to avoid dear browsing problems and also to better compete with weedy vegetation (Dey and Parker, 1997). Practitioners have also moved away from planting unrooted dormant cuttings in the field because the use of herbicides to eliminate weedy vegetation in plantations is prohibited in Quebec. It is generally understood that bareroot stock is a superior competitor because of its large size (Mohammed et al., 2001; Mc Nabb and Vanderschaaf, 2005). Weeds, however, can significantly reduce growth of hybrid poplars, even if they are shorter than the planting stock, since the competition pressure comes from the soil (temperature, water and nutrients; Landhäusser and Lieffers, 1998; Coll et al., 2007). Hence, it is widely recognized that hybrid poplar plantations be kept weed-free at all times (Dickmann et al., 2001), making it unnecessary to use tall planting stock to outcompete weedy vegetation. Moreover, growth of these tall bareroot trees usually stagnates the year of planting, and the trees often show stem dieback damages (necrosis of the tree tip) during their first growing season in the field (Guillemette and DesRochers, 2008). This could be due to unbalanced root/shoot ratios (RS) of such large plants with few large woody roots, trimmed before storage and planting (Struve and Joly, 1992; South, 1996; DesRochers et al., 2004). Shoot growth stagnation and stem dieback often discourage woodlot owners to invest in the establishment of hybrid poplar plantations. Furthermore, even after the trees have established, there can be a carry-over effect from the planting stress when the transplants did not have well developed root systems (Grossnickle, 2005), reducing the productivity of the plantation over several years.

Growth stagnation, or planting stress, is often explained by a period of time needed by a tree to grow an adequate root system for the site where it is planted (Rietveld, 1989; Grossnickle, 2005). Tall poplar bareroot stock bears many leaf buds along the stem and usually develops many shoots after planting, although their root system has been trimmed to a manageable size (usually to a

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diameter of about 20 cm) after lifting in prevision for storage and planting the following spring. Such planting material is thus probably water-stressed after planting in the field (Grossnickle, 2005). Proper root-to-shoot balance is an important morphological attribute, because it determines the tree's water loss and water uptake capability at the time of planting (Grossnickle, 2000). Therefore, pruning a portion of the stem before planting might speed up the establishment phase and increase initial growth of planted trees, as seen for red maple (*Acer rubrum* L.; Rietveld, 1989) and pines (*Pinus* spp.; Lauderdale et al., 1995). Reducing the size of planting material is also interesting to practitioners to reduce lifting, packing, shipping and planting costs (South, 1996).

The main objective of this study was to evaluate early growth and root–shoot development of different planting materials in typical clay soils of northwestern Quebec. Using one-year-old bareroot hybrid poplar dormant stock, four planting materials were compared: (1) regular bareroot stock, (2) rootstock only (stem pruned before planting), (3) whips (roots pruned before planting), and (4) cuttings (30 cm stem sections taken from the basal portion of bareroot trees). We anticipated that shorter planting stock (rootstocks and cuttings) with less initial leaf biomass would produce more vigorous trees and outgrow taller planting material over a two-year period.

2. Methods

Four hybrid poplar clones recommended by the Quebec Ministry of Natural Resources and Wildlife for the region of northwestern Quebec were chosen based on their different parentage and availability: 915319 (*P. maximowiczii* × *balsamifera*), 915004 (*P. balsamifera* × *maximowiczii*), 747210 (*P. balsamifera* × *trichocarpa*) and 1079 (*P. deltoides* × *balsamifera*). The planting stock consisted of dormant, one-year-old bareroot trees ranging 1.3–1.6 m in height. Before planting, trees were prepared according to the four types of planting materials to be tested (Fig. 1): (1) regular bareroot stock, (2) rootstock (stem pruned), (3) whips (roots pruned before planting), and (4) cuttings (a 30 cm stem section taken from the basal portion of bareroot stock, i.e. roots and shoot pruned). The four types of planting materials were randomized and replicated four times as split-plots within each of the four clones. The experimental units consisted of 15 trees of each stock type and clone. The clones were also randomized and replicated into three blocks, on each of three planting sites ($n = 2160$): Despinassy (48°45′N and 77°28′W), St-Dominique (48°45′N and 78°04′W) and Lasarre (48°50′N and 79°15′W).

The three plantation sites are part of the western balsam fir-paper birch (*Abies balsamea* – *Betula papyrifera*) bioclimatic domain (Grondin, 1996), and located on the Quebec–Ontario clay belt resulting from deposits left by the proglacial Lakes Barlow and Ojibway (Vincent and Hardy, 1977). Soil texture was heavy clay Grey Luvisol (Canada Soil Survey Committee, 1987). Average annual precipitations were 900 mm for the last three decades (Environment Canada, 2004). Before plantation establishment, the Lasarre and St-Dominique sites were dominated by grasses and a few patches of alder (*Alnus incana* ssp. *rugosa*) and willow (*Salix* spp.), while there were only grasses at the Despinassy site since they had recently been mowed for hay.

In October 2005 shrubs were removed where present, and the sites ploughed to a depth of approximately 30 cm with a farm plough and tractor. This allowed to break-up the heavy texture of these soils during the winter. In spring of 2006, the sites were cross-cultivated with disks in order to level the soil and break-up remaining clumps of clay.

Trees were planted in May 2006 with planting shovels to a depth of approximately 30 cm, so that the cuttings and rootstock stock types were completely buried into the ground after planting. We found that burying the whole cutting or stem usually prevented more than one bud to develop and form multi-headed trees. Trees were planted at a spacing of 4 m × 2.5 m at St-Dominique and Despinassy, and 3.5 m × 3.5 m at Lasarre, to accommodate tractor width and land shape. Weeds were mechanically removed by disking or cultivating with a rototiller in between rows and trees, three times during the 2006 and 2007 growing seasons. All stock types were spot-fertilized at planting (van den Driessche, 1999) with 110 g of 18N–23P–18K commercial blend mineral fertilizer.

Height and basal diameter of trees were measured at planting and at the end of the 2006 and 2007 growing seasons in October. Root–shoot ratio development was monitored by destructively sampling two replicates of each combination stock type × clone during the first growing season, in July–September, at each of the three sites. Trees were delicately excavated by hand with brushes and shovels, and separated into leaves, stems and roots. Total leaf area was measured with a Li-Cor 6100 Leaf Area Meter (Li-Cor, Lincoln, NE), and all plant parts were oven-dried to constant mass at 75 °C and dry mass determined. Root–shoot ratio was calculated as roots dry mass divided by stem plus leaf dry mass. To have an

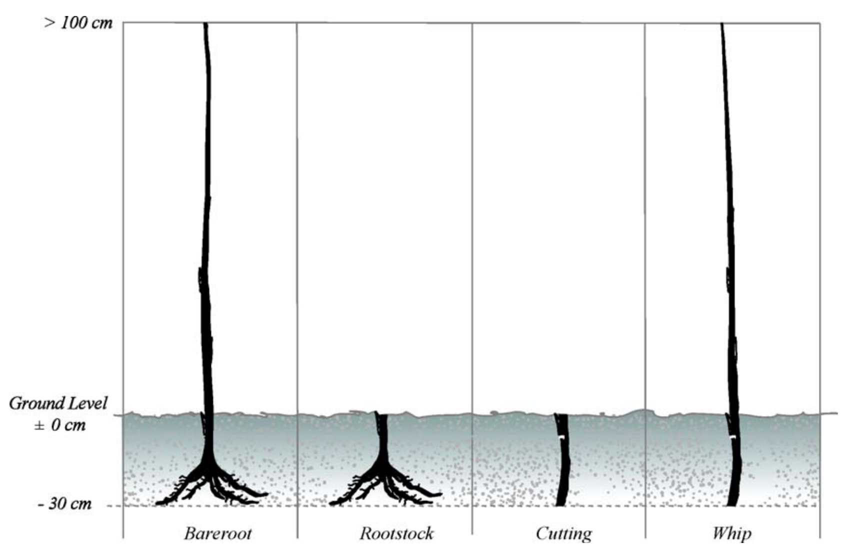

Fig. 1. Scheme of the different stock types.