Hybrid Poplar Plantation Establishment in Saskatchewan: First Year Results

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Abstract

The production of Short-Rotation Woody Crops (SRWC) has been growing steadily throughout North America. In Saskatchewan, interest is focused on developing hybrid poplar (var. 'Walker') plantations for an expanding fibre industry, and as a means to diversify farm income and possibly to increase sequestered carbon. Preliminary results from a small 6 year-old plantation suggest that there is good potential for operational-scale hybrid poplar production over a 15 to 20 year rotation period. Larger-scale field trials were established in the spring of 2002 on two sites in the Meadow Lake region, to assess and compare select silvicultural practices that are regarded to enhance the growth of hybrid poplars. After one growing season, both types of rooted stock (cuttings and plugs) showed superior survivability (~92 %) compared to non-rooted cuttings (~40 %), underscoring the reduced risk in planting rooted stock, especially during dry years. Measurements of tree growth (tree height, stem volume, total plant biomass and root production) all indicated a noticeable advantage of rooted versus non-rooted stock. Observational data pointed to the necessity of thorough site preparation, adherence to proper planting techniques, and mechanical or chemical weed control for successful plantation establishment.

Introduction

Cultivation of short-rotation woody crops (SRWC) has received increasing attention in the past 20 years as a means of marginal land utilization and an alternative to traditional crop production. Species of the genus *Populus* and their hybrids (also termed "poplars") have been utilized and grown for decades in North America, and knowledge of poplar husbandry has been well documented (Cram 1968; Dickman et al. 1996; Walker and Schroeder 2001). One type of SRWC management is the hybrid poplar plantation, which is an agroforestry system that exploits the rapid growth of poplar, their ease of management, and expanding market for a variety of services and end products.

Research conducted on two sites in northwest Saskatchewan, encompassing a total of 44 ha (~ 105 acres), is directed by a collaborative group representing the University of Saskatchewan (Saskatoon, SK), University of British Columbia (Vancouver, B.C.), Mistik Management (forest company, Meadow Lake, SK), AAFC-PFRA (Agriculture Canada, Indian Head, SK), PRT (tree seedling nursery, Prince Albert, SK) and the cooperating landowners (D. Cubbon and W. Culbert). The field trials are designed to assess and compare various silvicultural (tree management) practices that have generally been regarded to enhance the growth of hybrid poplars. These practices include: 1) the type of tree stock used in plantation establishment, 2) the application (both rate and frequency) of fertilizer, 3) pruning secondary trunks and lower branches from the trees, and 4) weed control. One of the primary research goals is to achieve maximal rates of plant production, in both the tree components above ground and their root systems below ground. Research activity also focuses on biophysical processes and interactions, such as nutrient uptake and recycling, root production and turnover, and competition between trees and weeds.

Materials and Methods

Two 8 ha plantations (Cubbon and Culbert) were established on agricultural land in the Meadow Lake region of western Saskatchewan, Canada (54^{o} 7' N 109^{o} 30' W). The Cubbon site is situated on predominantly sandy loam Orthic Gray Luvisolic soils developed from glacial till (Loon River association). The soils at the Culbert site are more heterogeneous, a mixture of sandy loam Brunisolic Gray Luvisols and Orthic Gray Luvisols, (Bittern Lake association), with significant inclusions of sandy Orthic Regosols (Pine association) (SCSR 1995). The landscape of both sites is very gently undulating, with slopes less than two percent. The Cubbon and Culbert sites were previously managed as an alfalfa field and a pasture, respectively. Site preparation included one application of glyphosate and a combination of deep tillage and light cultivation.

Three treatment types include stock type (non-rooted cuttings, rooted cuttings, and rooted plugs), fertilization (fertilized and non-fertilized), and pruning (pruned and unpruned). The treatments are set up in a 3 X 2 X 2 randomized complete block design and replicated three times, to account for differences in landscape position. Plots have a split design, thus allowing fertilizer to be applied in year 2 and year 4 to each half of the split plot. Granular ammonium nitrate fertilizer (34-0-0) will be surface broadcast at a rate of 100 kg ha^{-1} at each time of application.

Hybrid poplar seedlings (var. 'Walker') were mechanically planted in the spring of 2002. Treatment plots contain 176 trees, which are spaced 2.5 m apart within-row and 3.2 m between rows. Buffer strips (10 m width) were planted at the same tree density to minimize treatment border effects, using rooted 'Walker' cuttings. Weed control consisted of applied glyphosate in mid July (2.5 L ha^{-1}), applied linuron in late October (4 kg ha^{-1}), and mechanical tillage in August and September.

Tree growth was determined through measurements of tree dimensional growth (i.e. height, root-collar diameter), total plant biomass, and root production. Forty trees from each plot were selected and marked for annual end-of-season measurements for percent survival, height and root collar diameter. Accumulated plant biomass was measured by excavating three trees from each stock type at each site after which they were dried and weighed. Eighteen minirhizotron tubes

were installed at a 40^{o} angle underneath individual trees at each site, and camera-recorded images along the tube length were taken at monthly intervals to assess root production, mortality and longevity. Due to the preliminary nature of the collected data, statistical analyses have not been completed, however, compared data that demonstrate a difference of practical significance will be pointed out and further discussed.

Results

The Cubbon and Culbert plantations experienced difficult growing conditions during the summer of 2002, as precipitation was well below monthly mean values during June and July, and temperatures were above normal. Assessment of seedling survival (Table 1) of all measurement trees at each site (n=1440) indicated the severity of seedling mortality with respect to the cuttings stock type. At the Cubbon site, 52 % of cuttings (C) survived compared to 96 % and 97 % of rooted cuttings (RC) and rooted plugs (RP), respectively. Similarly, survival of C at the Culbert site was only 30 %, whereas the RC and RP had survival rates of 89 % and 86 %, respectively.

Table 1. Tree Seedling Survival for Stock Types at Cubbon and Culbert Sites After the 2002 (1st) Growing Season.

Stock Type	Cubbon	Culbert
	Survival (%)	
Cutting (C)	52	30
Rooted Cutting (RC)	96	89
Rooted Plug (RP)	97	86

Tree seedling growth in terms of height and stem volume (as calculated from height and root-collar diameter) indicated the superiority of rooted stock (RC, RP) compared to non-rooted stock (C) at both sites (Fig. 1). Mean height for RC and RP ranged from 52 cm to 61 cm compared to C, which ranged from 22 cm to 29 cm. Calculated stem volumes also show large differences between RC and RP versus C. This difference in dimensional tree growth is expected, however, as the rooted stock types were grown for one year before field-planting, whereas the cuttings had no existing stem nor root stock. It is anticipated that continued annual measurements would provide clarity as to the effect of stock type in establishing hybrid poplar plantations.

Rooted stock types were more proficient in plant biomass accumulation compared to non-rooted stock. Total accumulated plant biomass and its distribution among plant components (leaves, stem, new roots, existing roots) is shown in Figure 2. Biomass was highest for the RC and RP at Cubbon and the RC at Culbert, ranging from approximately 50 g to 85 g of total plant biomass, on a dry weight basis. The C at both sites and the RP at Culbert had the lowest biomass values, with less than 20 g of total plant biomass.

Root production was measured monthly from July through September and analyzed according to stock type and site, and depicted as cumulative root length observed from the ca. 50 images (each image displays an area of 1.89 cm^2) along the length of each tube (Fig. 3). Root production rates one month after plantation establishment (July) ranged from near 0 mm (CUB C, RC and CUL RC) to 97 mm (CUB RP). Greater differences occurred during August as RC

and RP ranged from 200 to 300 mm while C remained between 50 and 80 mm. Root production continued to increase in September for all stock types, and end-of-season cumulative values ranged from 380 to 490 mm for RC and RP and from 230 to 280 mm for C.

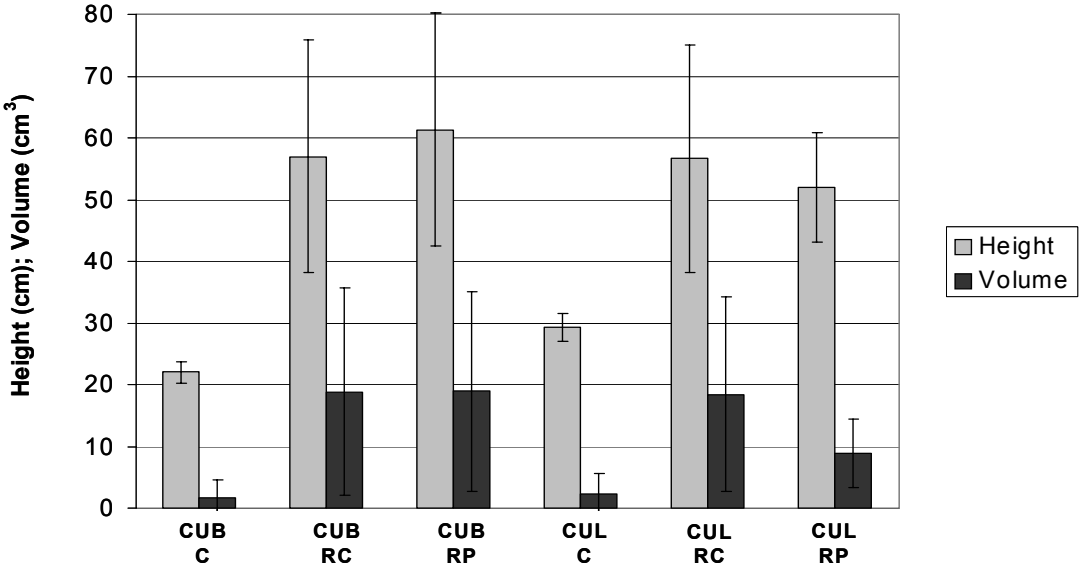

Figure 1. Tree height and calculated stem volume of cuttings (C), rooted cuttings (RC) and rooted plugs (RP) at Cubbon (CUB) and Culbert (CUL) sites after the first growing season (2002).

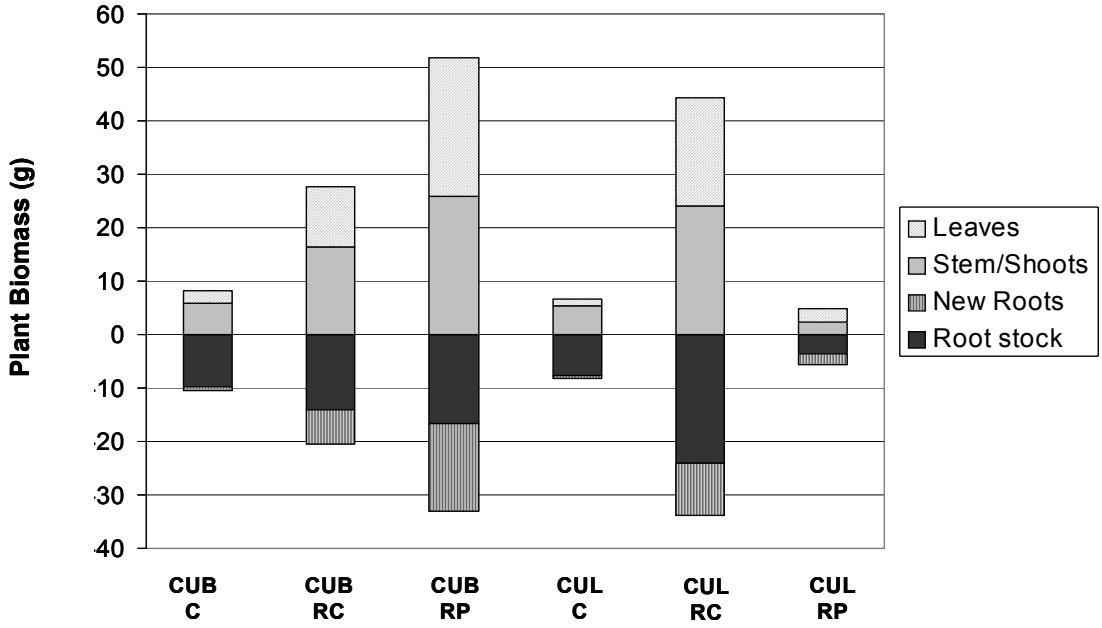

Figure 2. Total plant biomass (g) for hybrid poplar cuttings (C), rooted cuttings (RC) and rooted plugs (RP) at Cubbon (CUB) and Culbert (CUL) sites after the first growing season (2002).

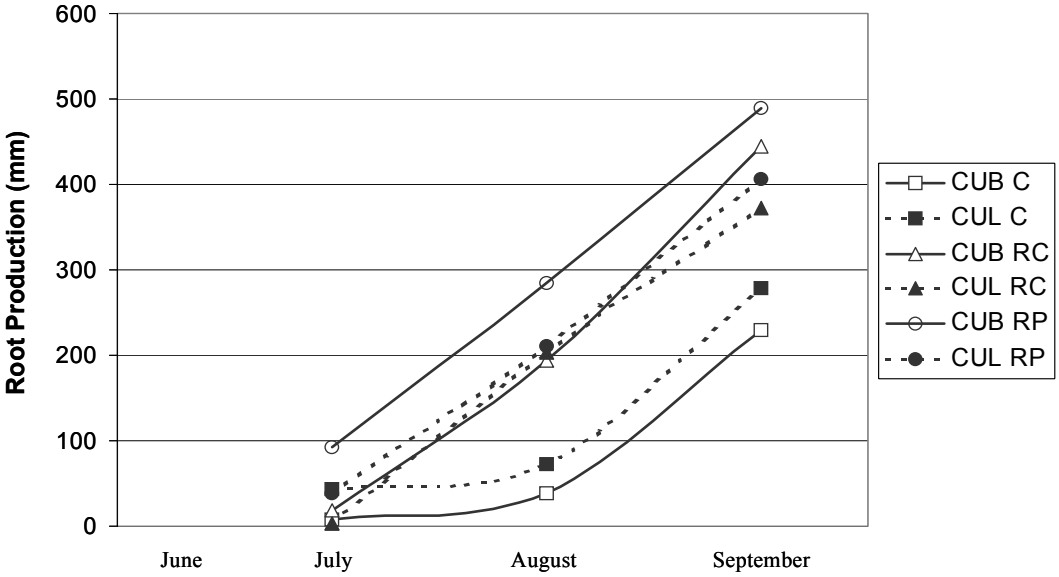

Figure 3. Cumulative root production (mm) for cuttings (C), rooted cuttings (RC) and rooted plugs (RP) at Cubbon (CUB) and Culbert (CUL) sites after the first growing season (2002).

Discussion and Summary

In light of the longevity of this study (5+ years), results after the first growing season cannot be deemed conclusive, however, our research and observations to date provide an indication of the challenges associated with plantation establishment in Saskatchewan under dryland conditions. Tree seedling stock type was the only comparable treatment, as fertilization and pruning are initiated in the second year. Results of tree seedling growth suggest an advantage to planting rooted stock (RC, RP) compared to non-rooted stock (C). Rooted stock demonstrated greater survival rates in dry conditions and higher rates of production in aboveground stems and belowground root systems. Considering the unpredictable nature of precipitation during the growing season in boreal transition regions of western Canada, hybrid poplar plantation establishment using rooted stock presents less risk of tree mortality, thereby reducing potential re-planting costs. A study by King et al. (1999), found that root systems of 2 to 3 year old hybrid poplar comprise a significant portion of the plant, up to 63 % of total plant biomass, alluding to the importance of developing vigorous root systems in the first few years of plantation establishment.

Agronomic practices such as thorough site preparation and weed control were observed to be beneficial in facilitating the growth of hybrid poplar. Although no formal study was conducted, it would seem reasonable that a lack of competition for moisture, nutrients and sunlight has greater potential to enhance tree growth. Research led by AAFC-PFRA at the Cubbon and Culbert plantations will investigate the effect of weed control on hybrid poplar growth over a 4-year period. It is anticipated that our collaborative work will yield positive results, providing research-based expertise in hybrid poplar production, and a means toward greater economic diversification.

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