Recent Research Results in Tree Reproduction in Québec

Research Note
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Recent Research Results in Tree Reproduction in Québec

by

Fabienne Colas[1], Denise Tousignant[2] and Stéphan Mercier[3]

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Ministère des Ressources naturelles, de la Faune et des Parcs du Québec (MRNFP)
Direction de la recherche forestière (Forest Research Branch)
2700, rue Einstein
Sainte-Foy (Québec) G1P 3W8
CANADA

Telephone: (418) 643-7994
Fax: (418) 643-2165

fabienne.colas@mrnfp.gouv.qc.ca
denise.tousignant@mrnfp.gouv.qc.ca
stephan.mercier@mrnfp.gouv.qc.ca

www.forestrycongress.gouv.qc.ca
www.mrnfp.gouv.qc.ca

[1] Biologist, D.E.S.S.
[2] Biologist, M.Sc.
[3] Forest Engineer, M.Sc.

Abstract

This brief presents the most recent results of research carried out on tree reproduction at the Forest Research Directorate of the *ministère des Ressources naturelles, de la Faune et des Parcs du Québec* (Canada). The research approach relies on the simplicity of the methods so they will be easily applicable in a number of forestry contexts. Important breakthroughs were made in the management of conventional and interior container seed orchards, mass-pollination techniques to increase seed yield, pollen collection and storage techniques, technical conditions needed for nursery seed germination and development of large-scale cutting propagation systems. The close collaboration among researchers and practitioners in Québec had significant spill-over effects in nurseries and seed orchards. Several unique prototypes were developed and are now in general use.

Keywords: conifer, reproduction, pollen, pollination, seed orchard, seed, germination, vegetative multiplication, rooted cuttings, Québec

Introduction

Québec's forests cover more than 75 million hectares. They represent 20% of Canada's forested area and 2% of the world's forests (MRN[4] 2002a). The forestry sector is of major economic importance in Québec. In fact, the sector employs more than 80,000 persons, or nearly 16% of jobs in the manufacturing sector (MRN 2002b).

The *Stratégie de protection des forêts du Québec* (MRN 2002a) (Québec Forest Protection Strategy) favours natural regeneration in harvested areas. Nevertheless, 15 to 20% of the areas have to be reforested in order to ensure sufficient, good-quality regeneration. The *ministère des Ressources naturelles, de la Faune et des Parcs du Québec* (MRNFP) produces seeds and plants used for reforestation (MRN 2002a). The plants are produced by six public and 20 private nurseries. Approximately 150 million plants are established each year. Most are produced from seed, but a small proportion (about 3%) are from rooted cuttings.

Currently, plantations cover only 5% of the globe's area. However, they supply 35% of the harvested timber (FAO 2001). Reforestation significantly increases forest productivity. The mean annual yield of Québec's natural forests is generally less than 2 m^3/ha/year, but yields can attain 4 to 8 m^3/ha/year from plantations on good quality sites. Besides, the awareness that forests are carbon sinks puts the forestry sector in a key position to reduce greenhouse gasses, as required by the Kyoto Protocol. The new Canadian *Forest 2020* initiative, launched by the Canadian Council of Forest Ministers, places plantations, and particularly those using fast-growing species, among the scenarios to attenuate global warming (Canadian Forest Service 2001). Furthermore, in its biodiversity conservation strategy, Québec plans to subtract 8% of its forests from harvesting in 2005 (MENV 2002). Reforestation using high-performance trees could limit the effect of this reduction while maintaining forest productivity.

The success of sustainable reforestation requires a continuous supply of high-quality seeds for plant production (Haavisto and Skeates 1995). To achieve this, Québec established a network of improved sources with the aim of increasing plantation yields and tree quality, but also to regulate seed supply (MRN 2002a). Québec now has 94 first-generation seed orchards, with an expected genetic gain of 3% to 10% (Masse 1999). Thanks to new genetic selections, anticipated gains for second-generation orchards are even higher. These orchards are now being established using the principal reforestation species used in Québec: black spruce (*Picea mariana*), white spruce (*Picea glauca*) and jack pine (*Pinus banksiana*). The use of plants from rooted cuttings is another preferred tool in establishing high-quality forests. By 2012, 97% of trees planted in Québec should be of superior genetic quality.

Tree reproduction research plays a leading role in achieving the MRNFP's reforestation objectives using improved genetic material. Thus, large-scale reproduction techniques, using sexual or asexual propagation, help to put the results of genetic selection in

[4] On April 29, 2003, the *ministère des Ressources naturelles du Québec* (MRN) became the *Ministère des Ressources naturelles, de la Faune et des Parcs du Québec* (MRNFP).

concrete form by making the material available for the production of nursery plants. Also, the use of simple methods facilitates their application in several other forestry contexts. This brief summarizes the most recent results of work carried out by the Forest Research Directorate in the area of tree reproduction. They were achieved through close collaboration with the operations sector of the MRNFP.

Results and discussion

Seed orchard management

Two types are being studied, the conventional field orchard with special management (soil type, planting spacing, use of windbreaks, mass pollination), and the interior container seed orchard (Mercier and Périnet 1998).

- *Conventional seed orchards*

First-generation orchards have been established in natural forests throughout the province to support the reforestation needs for all of Québec's ecological regions. By contrast, second-generation orchards are being established at public nurseries for ease of operations. The anticipated genetic gains for the second generation are such that they justify using several methods to ensure the best possible seed yields.

In order to guarantee the genetic quality of orchard-produced seeds, contamination from exterior pollen sources must be minimized. To do this, we are experimenting with the establishment of orchards between windbreaks. These create microclimates and accelerate flower development by several days (Guyot 1983). Our initial results confirm that the windbreaks reduce wind speed and provide a slight increase in temperature between the hedges at the crown level (unpublished data). We are continuing studies on flowering phenology to see if the increase in temperature effectively translates into earlier development of male and female flowers, compared to trees located in the area surrounding the orchard.

- *Interior container orchards*

This type of orchard was chosen for the larches (*Larix* sp.), because the particular characteristics of their development and flowering are much easier to manage when the trees are grown in a shelter. We adapted standard tunnels to increase their height (**Figure 1**). To increase and stabilize seed supply, we are studying the growth regime, tree form, pollen harvesting and pollination methods, and operational extraction and germination of seeds.

Figure 1. Shelter adapted to grow containerized larch grafts. Following pollination, tunnel covers are removed to provide optimal light conditions. (Photo: F. Colas, MRNFP)

To produce hybrid larch seeds, the use of stored pollen allows us to get around the phenological mismatch between the parent species. By growing trees under shelters, pollination work is not affected by weather conditions because the risk of frost is almost nil. Moreover, pruning controls tree height.

Mass pollination

Mass pollination is used to increase the genetic gain in seed orchards, because it increases seed production while limiting pollen contamination (Bramlett 1997). After having tested many pollination methods (Mercier and Parent 2003), we opted for electrostatic pollination using a portable and self-contained pistol (**Figure 2**), which can be attached to a simple carriage or a trailer. The trailer is pulled by an all-terrain vehicle and is easily moved throughout the orchard. We adapted the model developed for larch orchards in France (Philippe and Baldet 1997). The electrostatic force puts a negative charge on the pollen, which increases the amount of pollen deposited per bract, compared to natural pollination.

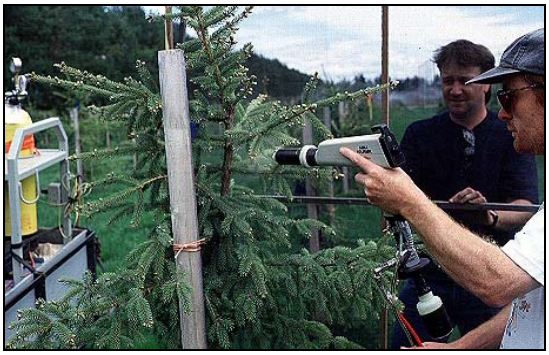

Figure 2. Mass pollination in a seed orchard using an electrostatic pistol. (Photo: S. Mercier, MRNFP)

Mechanized pollen collection

Pollen is either used fresh or taken from the Ministry's pollen bank (Colas and Mercier 2001). Using an electrostatic pistol on a large scale increases pollen requirements. In order to collect the required quantities at low cost, we developed a mechanized technique using a modified, portable vacuum apparatus (**Figure 3**; Colas 2001).

Figure 3. Vacuum apparatus used to collect pollen. Pollen is collected the same day it is disseminated, thus ensuring its quality. (Photo: S. Mercier, MRNFP)

Improving seed germination

In Québec, the MRNFP collects and supplies seeds at no charge to produce seedlings for reforestation. Our research is undertaken in collaboration with the development team at the Berthier[5] Seed Centre, which processes and ships all the seeds to the province's forest nurseries. Our objective is to perfect techniques that are easily converted to a large scale, and which increase germination rates in the nursery to get the most possible from seeds collected from orchards.

Our work led to implementing operational stratification of white spruce and white pine (*Pinus strobus*) before delivering them to nurseries. However, their high moisture level (25 to 35%) requires very rapid seeding to ensure that the seeds retain the beneficial effects of stratification. For non-stratified seeds, containers are filled and seeded in advance, and placed in the growing areas when conditions are favourable. We are verifying that the stratified seeds with high moisture content can also support these variations in climatic conditions between the time of seeding and the start of germination. Also, we are testing whether drying the stratified seeds has an effect on

[5] Complete information in French on the Berthier Seed Centre is at the following link: http://www.mrnfp.gouv.qc.ca/forets/entreprises/entreprises-semences-berthier.jsp

their subsequent germination. If it were possible to dry the seeds without losing the benefits of stratification, nurseries would benefit from greater flexibility in deciding when to seed.

Another facet of our work consists in improving conditions of germination tests conducted at the Seed Centre, to guarantee reliable and reproducible results, which ensures the delivery of seeds in sufficient quantities for seedling production. Optimizing germination test conditions in the laboratory will help provide reliable germination data to nurseries, leading to better crop management.

Plants produced by cuttings

Québec has a unique expertise in the field of propagating forest tree cuttings. Currently, three million conifer plants are produced annually from cuttings at the Saint-Modeste[6] Nursery. The rooting installations, designed and developed by researchers and practitioners at the MRNFP, are unique in the world. Since the 1980s, our research has continued to optimize the cultivation of stockplants and the rooting of cuttings for the species being used. This work led to original solutions that are applicable at a large scale and are quickly transferred from testing to practice.

Plants propagated by cuttings come from the best controlled crosses recommended by geneticists. High genetic gains justify the slightly higher production costs of rooted cuttings, compared to seedlings (1.5 to 1.7 times). From now to 2005, the MRNFP expects to triple its annual production of conifer cuttings to over 10 million plants. This target illustrates the efforts that the MRNFP is using to increase the productivity of Québec's forests.

- *Bouturathèque system*

The *Bouturathèque* system (from the French *bouture*, for cutting) allows rooting of semi-lignified cuttings in environmentally-controlled compartments (Vallée and Noreau 1990). This system is particularly appropriate for propagating black spruce, which presently accounts for 75% of cutting production (Tousignant et al. 1996). Each shelving rack consists in four superimposed, airtight compartments that are individually lit by fluorescent tubes (**Figure 4**). Their main advantage, other than the space saving, is to allow for year-round production, since rooting takes place in climate-controlled rooms, independent of outside weather. This approach involves the forced growing of stockplants in the greenhouse to provide four to five harvests of cuttings per year.

[6] Complete information in French on the Saint-Modeste Rooted Cuttings Centre is at the following link: http://www.mrnfp.gouv.qc.ca/forets/entreprises/entreprises-semences-modeste.jsp

Figure 4. One of the six *Bouturathèque* shelving racks at the Saint-Modeste Nursery. (Photo: MRNFP)

- *Double exterior enclosure*

White spruce and Norway spruce (*Picea abies*) stockplants respond less well to forcing than does black spruce. Hybrid larch, on its part, requires a lot of rooting space to accommodate its long needles. For these three species, a summer cutting technique has been developed since 1998. Cuttings root in enclosures contained within standard tunnels (Tousignant and Rioux 2002). These light infrastructures are economical and multi-purpose, and their use is growing rapidly.

Each rooting enclosure can contain between 150,000 and 230,000 cuttings. Inside an unheated tunnel, metal hoops support a clear plastic film, forming a completely airtight compartment (**Figure 5**). An irrigator robot is controlled by a “Mist-a-Matic”® system, as well as programmable temperature and air humidity sensors. Thus misting takes into account the time of day, air humidity and temperature conditions.

Figure 5. Interior view of a rooting enclosure within a standard tunnel. (Photo: P. Lemay, MRNFP)

The white spruce and Norway spruce stockplants are grown outside, while the larch

stockplants are forced for a short period at the end of winter. After three annual cutting harvests, the stockplants are retrieved and used for reforestation.

- *Cultivation of rooted cuttings*

In order to attain the desired dimensions, the rooted cuttings are transplanted and grown for two years as bareroot stock or in containers larger than 200 cm^3. Transplanting is a crucial event in their cultivation. Research was undertaken recently to identify the cultural treatments needed to ensure better survival of the cuttings after transplanting, adequate filling of the container plug and achieving better bareroot seedling root quality. We are trying to reduce production costs while increasing the available quantities of deliverable rooted plants.

Conclusion

Research on the sexual or asexual reproduction of trees has the special feature of being quickly transferable to an operational scale. It therefore has direct effects on Québec's reforestation program. Whether for pollen collection, mass pollination or propagation of rooted cuttings in the *Bouturathèques* or in exterior enclosures, our research has resulted in the creation of prototypes that have been widely adopted by the operations sector of the MRNFP. The forests are enriched, because the quantity of seeds and quality plants coming out of our province's genetic improvement programs continue to increase and diversify.

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