CONGRATULATIONS TO THE TREE SEED WORKING GROUP

Happy 25th anniversary to the Tree Seed Working Group and its continuous publication and expanded distribution of the News Bulletin (48 issues). The Working Group was formed based on my frequent discussions with Doug Skeates of the Ontario Ministry of Natural Resources Research Group in Maple, Ontario. Originally, we considered forming an independent group of some kind of association, but we felt it would be too small a group for tree seed workers and users. Eventually, we decided to form the group under the umbrella of the Canadian Tree Improvement Association (CTIA). At the 1983 CTIA meeting in Toronto, we proposed forming the Tree Seed Working Group and received the approval of the membership of the Association. I was honoured to be elected as the first chair and Dr. George Edwards of the Pacific Forestry Centre was the Editor of the proposed News Bulletin. We have been growing and thriving for 25 years! We owe our success and accomplishments to the sponsorship and encouragement of the Canadian Forest Service; leadership of the successive chairs and editors; CTIA for allowing our group to hold workshops in conjunction with its biennial meetings; and strong interest, enthusiasm, and support of the Working Group members.

Despite the decrease in funding for tree seed research and development in Canada over the years, keen interest in readership of our group’s News Bulletin remains high. I sincerely hope that our Working Group will continue to serve the forestry community as there are more tree seed problems to be resolved and more research is required. As a seed researcher for all my life, I would like to offer a word of caution to future tree seed research. It is important to include various seed lots from different provenances of different crop years in the experimental designs. My experience suggests that some of the published information with a single seed lot from one area of one seed crop year often could not be reproduced.

SEEDLING PRODUCTION IN QUEBEC: A SUCCESSFUL INTEGRATION OF THE MULTIDISCIPLINARY RESEARCH APPROACH!

For 40 years, the Research Division (Direction de la recherche forestière - DRF) of the Quebec Ministry of Natural Resources and Wildlife (ministère des Ressources naturelles et de la Faune - MRNF) has managed an avant-garde research and development program in the fields of genetic tree improvement for commercial species and the production of forest seedlings and seeds, while integrating new in vitro techniques for the multiplication of coniferous species. To fully profit from the genetic gains arising from these studies, each of the steps in the seedling production chain, from seed harvest through planting, had to be optimised in harmony with the others. Diversified, complementary, and highly skilled expertise constitutes the strength of our multidisciplinary group of researchers. Our work focuses on improving the morpho-physiological and genetic quality of seedlings destined for reforestation, while respecting the environment and genetic diversity.

DRF researchers in the fields of genetic improvement and seed and seedling production work in close collaboration with several universities and the Direction générale des pépinières et des stations piscicoles (DGPSP, MRNF), as well as the six provincial government forest nurseries. In addition to the work being done at the tree seed centre and at the DGPSP’s mass cutting propagation and somatic embryogenesis centres, research is also being conducted in some of the 18 private forest nurseries that make up l’Office des producteurs de plants forestiers du Québec (OPPFQ). This unique multidisciplinary integration of several projects constitutes the powerful force necessary to respond to the current preoccupations in Quebec forestry. This collaboration also facilitates the
rapid diffusion of scientific advances and new technologies flowing from the research projects, as well as their integration into daily operations under forest nursery conditions. This technology transfer extends from seed production, through seedlot management at the provincial tree seed centre in Berthierville, to the production of seedlings by conventional techniques, mass cutting propagation, or somatic embryogenesis.

This report presents a brief overview of the principal recent advances that have been integrated into the seedling production chain in Quebec in recent years.

**Genetics and Tree Breeding**

The work undertaken in the field of tree improvement in Quebec over the past 40 years has principally concentrated on commercial coniferous species, notably white spruce (*Picea glauca*), black spruce (*P. mariana*), Norway spruce (*P. abies*), jack pine (*Pinus banksiana*), tamarack (*Larix laricina*), and certain exotic larches (*L. decidua, L. kaempferi, L. x marschilinsi*). Of the broadleaved species, certain varieties of hybrid poplar (*Populus* spp.) have been selected for reforestation purposes; the list of recommended clones is revised periodically. More recently, studies have been conducted on red oak (*Quercus rubra*) and white ash (*Fraxinus americana*). The principal objective of the different improvement programs is to increase plantation yield (Rainville et al. 2003). As a result of this work, Quebec now has a sizable network of first- and second-generation seed orchards as well as four propagation centres for the vegetative multiplication of varieties obtained from controlled crossings. Overall, the 141 seed sources that are in place provide more than 85% of the demand for seedling production (Savary et al. 2008). The knowledge gained in the 40 years of tree improvement research has permitted us to define transfer rules for the various seed sources, obtain significant gains in terms of growth and quality of the reforestation stock, develop models to predict the effects of climate change on plantation yield (Andalo et al. 2005, Beaulieu and Rainville 2005), and acquire knowledge on wood quality of plantation-grown trees (Beaulieu et al. 2006, Daoust and Mottet 2006, Mottet et al. 2006). The MRNF has invested in clonal forestry of white spruce by emphasizing the installation of clonal tests. A large number of clones, produced by somatic embryogenesis, are planted each year for evaluation. In the future, tree breeders will also benefit from new genetic tools presently being developed within the framework of Arborea (2008), a tree genomics research consortium. These resources will be beneficial for selecting breeding stock as well as assuring better management of genetic resources.

**Seed and Pollen**

Research and development, principally being done with coniferous species, has permitted the creation of a pollen bank, now managed operationally using the methods we developed to evaluate pollen quality and conservation (Mercier 1995, Colas and Mercier 2000). To increase seed orchard yield for the different commercial species, a system of mass pollination with an electrostatic pistol (Mercier and Périnet 1998) was adapted from the model developed by Philippe and Baldet (1997). In response to the increasing demand for hybrid larch seedlings, we developed a concept of sheltered seed orchards enabling hybrid larch seeds to be successfully produced despite harsh northern climatic conditions and unsynchronised flowering of different larch species (Colas et al. 2006, 2008a). The progressive use of water activity measurements in collaboration with Cemagref (2008), a French research centre (Baldet et al. 2007, 2008; Colas et al. 2008b), will facilitate quality control of the seed and pollen used in reforestation programs. In the near future, we would like to integrate water activity measurements in the ISTA (International Seed Testing Association) rules. Finally, we plan on incorporating somatic embryogenesis (SE) into seed orchard management (refer to SE section).

**Mass Cutting Propagation**

Vegetative multiplication by mass cutting propagation permits controlled crosses exhibiting superior productivity to be reproduced, without the use of genetic modification. For cuttings of white, black, and Norway spruce, the stock plants are produced from controlled crosses, while hybrid larch stock plants are grown from seeds produced by mass pollination in sheltered seed orchards.

In Quebec, the MRNF began producing seedlings by mass cutting propagation at an operational scale in the early 1990’s, with the development of the *Bouturathèque* system for rooting black spruce cuttings (Vallée and Noreau 1990, Tousignant et al. 1996). In 1998, a complementary second system (double-walled rooting enclosures) was developed to facilitate the propagation of hybrid larch. With time, this system was refined and has now replaced the *Bouturathèques* for the rooting of all coniferous species in the program (Tousignant and Rioux 2002, Rioux et al. 2008). The rooting percentage reaches 75 to 90% in 12 weeks, depending on the species. In 2008, the total production of coniferous species via mass cutting propagation in the four provincial nurseries (DGPSP, MRNF) surpassed four million seedlings (Tousignant et al. 2008a).
Rooted cuttings are transplanted, either to bareroot beds or into larger containers, to complete their growth in the nursery. After two more growing seasons, they are delivered to reforestation sites as large-size seedlings. Seedlings originating from cuttings must meet 25 rigorous quality standards established for seedlings by the MRNF (Direction générale des pépinières et des stations piscicoles 2008), including those for root system architecture and foliar nitrogen concentration.

In response to the large family and clonal variability observed in white spruce (Lamhamedi et al. 2000), we significantly modified the cultural techniques specific to the production of stock plants of this species. The use of a mix of seeds from many controlled crosses for stock plant production has given rise to important differences in germination, growth, shoot architecture, as well as the number of cuttings (yield) that can be harvested from the stock plants. To achieve the mass cutting propagation objectives, each cross is now subjected to morpho-physiological evaluations at different points of the production chain: seed size and quality, stock plant growth and cutting yield, rooting ability, tissue nutrient status, etc. (Lamhamedi et al. 2005a, 2005b, 2007a; Tousignant et al. 2008b).

In an effort to optimise the rooting of cuttings taken from 75 half-sib white spruce families, a recent study found that the average family heritability for root length and root mass was 0.64 and 0.63, respectively, at the end of the rooting phase (Grenier et al. 2008). The average family heritability for root mass at the end of the first growing season was 0.74. This clearly shows that we can improve rooting capacity of cuttings by selecting the best families, while still preserving genetic diversity.

To reduce production costs and increase the multiplication rate from improved seeds, we are progressively integrating the use of hardwood (dormant) cuttings into our cultural scenarios. Other efforts are being invested in the integration of somatic embryogenesis into seedling production (Tremblay et al. 2007), as a complement to mass cutting propagation, using somatic seedlings as stock plants (Lamhamedi and Tousignant 2008). The use of this combination of vegetative propagation techniques paves the way for clonal forestry and genetic gains that are superior to those that have been achieved to date.

Somatic Embryogenesis

The DGSPSP has chosen to integrate somatic embryogenesis (SE) into the seedling production chain. The early studies, beginning in 1990, permitted the optimisation of different steps in the SE process and established the framework of clonal tests for black spruce, white spruce, and hybrid larches (Tremblay and Lamhamedi 2006). In 2001, SE was implemented at an operational scale at the Saint-Modeste forest nursery (MRNF) as a pilot project. White spruce was the first species considered for SE because its genetic improvement program was the most advanced. The development and adaptation of a unique acclimatization technique (without misting) (Lamhamedi et al. 2003), guarantees survival rates of over 98% for commercial species under forest nursery conditions. Since 2004, the SE program has used controlled crosses recommended by forest geneticists. Between 2004 and 2007, 1154 clones from 41 unrelated families have been conserved by cryopreservation (Tremblay et al. 2008). The identification of the best selected clones through clonal testing and their subsequent multiplication by SE will maximize genetic gains while maintaining genetic diversity. The scaling-up of SE techniques to an operational level is presently underway. These studies focus on the development of bioreactors and techniques for *ex vitro* sowing of somatic embryos.

During the same period, the MRNF initiated an original study to utilize the full potential of SE in the forest seedling production chain. Morpho-physiological characterization, specific to each clone produced for the clonal tests, was conducted under nursery conditions (Lamhamedi et al. 2000). This was followed by a systematic characterization of the clones at each stage of the SE process under laboratory conditions. Laboratory results will be correlated to those obtained in the nursery to determine early selection criteria for desired characteristics, in order to identify the best-performing clones before establishing clonal tests. The rooting ability of the clones was also evaluated. This will permit the MRNF to integrate the somatic stock plants in the cutting propagation program and reproduce the best-performing clones at minimal cost.

Quebec has the oldest clonal tests in Canada. Since 2001, production of seed and pollen cones by somatic black spruce clones has been observed as early as four years after planting. Our early results showed that somatic black spruce clones produced normal seed and pollen flowers. At maturity, the seed cones contain high quality seed, capable of germinating and producing seedlings with good morpho-physiological characteristics (Colas and Lamhamedi 2006). The seeds and seedlings produced by somatic clones are similar in quality to those produced by grafting or by standard seedling production techniques. Our objective is to integrate the best somatic clones in controlled crossings, as well as using them as seed trees in future seed orchards. We have conducted the same studies with white spruce somatic clones,
in order to accelerate the genetic improvement of both species and significantly increase the genetic gain of their seed orchards (Colas and Lamhamedi 2006).

Seedling Production

Although seedlings planted on reforestation sites in Quebec are of the highest quality, the production scenarios associated with new seedling stock sizes are very complex. Seedling producers must comply with strict environmental norms and adapt to the recurrence of extreme climatic conditions, especially in winter, in response to climate change. This calls for the continuous adjustment of cultural techniques and a judicious choice of genetic resources, which also must be adapted to climate change. Recent studies have permitted us to refine the computerized management of cultural practices in forest nurseries, including defining irrigation and fertilization regimes which optimize the morpho-physiology of white and black spruce seedlings, while at the same time, reducing the leaching of mineral nutrients (Langlois and Gagnon 1993; Gagnon and Camiré 1996, 2001; Gagnon and Girard 2001; Girard et al. 2001; Larocque et al. 2002; Lamhamedi et al. 2002, 2006; Carles et al. 2008). Other innovative research with nursery-grown hybrid poplar clones has been concerned with cultural techniques and the early selection of clones for desired characteristics such as growth, stem form, carbon sequestration, frost tolerance, and drought resistance (Lamhamedi et al. 2007b). Research conducted by the DRF, showed that under forest nursery conditions, the application of short-day treatments resulted in a significant increase of 20% in the percentage of tunnel grown (1+0) black spruce seedlings conforming to the established norms for sufficient rooting, thus reducing the number of seedlings rejected at delivery (Lamhamedi et al. 2007c). This simple approach will make a tangible contribution to improving the profitability of forest nurseries. Other work, conducted in close collaboration with Université Laval, has clarified the effect of genetics and cultural regime on root growth of white spruce seedlings (Carles et al. 2007).

Conclusion

In summary, the 40 years of research and development invested by the DRF in genetic improvement and the production of seeds and seedlings has been, and will continue to be, fruitful. The integration of all the steps in the seedling production chain, from seed to plantation, is unique to Quebec and allows for efficient technology transfer. The numerous innovations resulting from this research have translated into substantial benefits. Quebec is among the leaders in seed and forest seedling production. Quality seedlings significantly contribute to increasing the productivity and yield our forest plantations.

These benefits will become increasingly important with the reform of Quebec’s forest policy, in which the provincial government will be investing in an intensive silviculture strategy. Reforestation with both traditional and fast growing species will be prioritized to increase forest productivity, allowing the expansion of the land area dedicated to conservation, without affecting the overall productivity of Quebec’s forest land base.

References


Leptoglossus occidentalis seed bugs have long been the bane of conifer seed orchard production in British Columbia. Not only are they difficult to control, it has proven nearly impossible to monitor seed bug population levels effectively and just about as difficult to accurately estimate the extent of seed damage they cause. The Insect Communication Ecology lab at Simon Fraser University (SFU) shares with the BC Ministry of Forests and Range a long history of collaborative research aimed at increasing our understanding of seed bug biology and developing innovative, effective ways to manage populations in conifer seed orchards. Over the years, we have learned much about L. occidentalis but, until recently, have made little progress in improving our abilities to manage them.

Recent new research by the SFU group has provided not only a significant breakthrough for management of L. occidentalis but also a dramatic new development in our understanding of the way some plant-feeding insects perceive the world around them. As CBC Radio’s Bob MacDonald suggested during an interview aired on “Quirks and Quarks”, seed bugs effectively have developed their own version of night-vision goggles with which they hunt down seed cones.

Between 2006 and 2007, experiments developed by technician Steve Takács, director Gerhard Gries, and others at the SFU lab demonstrated that conifer seed cones emit infrared (IR) light wavelengths and that seed bugs perceive this light from a considerable distance and use it to home in on cones for feeding. First, using a combination of temperature recording thermocouples, IR imaging techniques, and cone-bearing trees at Canadian Forest Products’ Sechelt (BC) Seed Orchard site, Takács et al. demonstrated that seed cones are consistently warmer than needles or...
Happy Silver anniversary to the Tree Seed Working Group News Bulletin. It was 25 years ago today, Ben Wang and others taught the seedy guys and gals to play, it’s been going in and out of style, but guaranteed to raise an eye….

The first News Bulletin was published in December 1983 establishing the broad objective of “promoting tree seed science and technology” for the working group and we are still on that same long and winding road. The News Bulletin has provided a forum for the timely exchange of information on tree seeds at both the operational level, high tech research level, and everything in between. It is truly amazing that a volunteer Newsletter could survive for this long and it is a testament to all of those involved. The editors deserve much of the credit and we have had some dedicated Editors over our 25-year history (edition numbers in brackets) – George Edwards (1 to 3), Hugh Schooley (4 to 23), Ron Smith (24 to 35), and our current scribe Dale Simpson (36 to 48 and counting) – Thank you all. Every edition of the News Bulletin is available as a pdf document at the following webpage http://www.for.gov.bc.ca/hti/treeseedcentre/tsc/tswg.htm. Enjoy!

We had a successful workshop in Quebec City – thank you to Fabienne Colas and her team for putting it together. For those who haven’t heard, we are now a working group of the Canadian Forest Genetics Association (CFGA) due to the Canadian Tree Improvement Association changing its name. The workshop covered a variety of topics from strategic seed orchard planning, reviews of seed production systems, genetic conservation, water activity, and work on improving clonal production systems through rooted cuttings and somatic embryogenesis. In BC, we are looking forward to participating in future work on ‘water activity’ as a method of