Hardwood seedling production in Quebec

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Abstract

The production of hardwood seedlings is relatively new in Quebec. The high-value hardwood reforestation objective is 3 million seedlings a year. We have already acquired the necessary skills to mass-produce many hardwood species, but much work remains to be done to solve problems of seed supply, storage and dormancy control as well as to master container and even bareroot produbtion techniques for several hardwood species.

Résumé

La production de plants de feuillus est une activite encore nouvelle au Quebec. L'objectif annuel de reboisement avec des feuillus nobles est de 3 millions de plants. Nous avons acquis les connaissances necessaires pour produire plusieurs essences feuillues sur une grande echelle. Cependant, beaucoup reste a faire pour rdsoudre les problemes d'approvisionnement, de conservation et de maitrise de la dormance des semences. On dolt encore *ameliorer les techniques de production de plants en recipients et méme a racines nues pour plusieurs especes de feuillus.*

Introduction

High-value hardwoods have always played a minor role in the reforestation of Quebec's land. This is primarily due to the preponderance of the softwood forest in the province and to the establishment of large-scale regeneration programs for softwood forests in the late 1970s.

Prior to 1986, the *ministere de l'Energie et des Ressources (MER)* produced between 50 000 and 200 000 hardwood seedlings per year at the *Pepiniére de Berthier.* These hardwood seedlings were all bareroot grown and most of them were planted in the Montreal region.

In 1986, the MER decided to put greater emphasis on the reforestation of high-value hardwoods so as to increase long-term supplies of quality wood, which is used essentially for furniture-making. The medium-term goal was to plant three million seedlings per year. Hardwoods most demanded nowadays are Northern red oak, sugar maple, white ash, and yellow birch. They represent more than 80% of the total demand (Table 1).

Generally speaking, the implementation of a high-value hardwood reforestation program is more complex than that of a softwood program. Many botanical genera are involved in the production of hardwood seedlings compared to just a few in the cultivation of softwoods.

Table 1. Demand for high-value hardwood seedlings Québec 1990

Species	Number of seedlings	%
Main species		
Northern red oak	614 000	24.0%
Sugar maple	603 000	23.6%
White ash	521 000	20.4%
Yellow birch	345 000	13.5%
Other species		
Black cherry	108 000	4.2%
Black walnut	81 000	3.2%
American elm	75 000	2.9%
American basswood	74 000	2.9%
White oak	40 000	1.6%
Burr oak	31 000	1.2%
Butternut walnut	24 000	0.9%
Green ash	23 000	0.9%
Minor species	18 000	0.7%
		18.5%
Total	2 557 000	100%

Seed collecting and seed treatment

Seed collecting

At the *Pepinière de Berthier,* hardwood seedlings are produced only from seed, which is brought in mainly from the Outaouais, Estrie, Quebec, Montreal, Bas-Saint-Laurent and Trois-Rivieres regions. The *MER* manages the seed collection program in each region. Seeds are gathered from isolated trees or in logging areas. Seed trees are selected according to certain morphological characteristics. Most seeds are gathered in the fall, with the exception of white elm and silver maple seeds, which are collected in June (Table 2).

Meeting hardwood seedling production objectives depends first and foremost on the annual availability of sufficient stocks of quality seed. It also depends on the success of breaking dormancy required to obtain a good germination rate.

Several factors affect seed collection : the seed-production cycle, weather conditions before and during collection, the pillage of squirrels and birds, damage caused by insects and seed accessibility.

Assessing seed quality

The seeds are sent to the *Centre de semences forestieres de Berthier* as soon as possible after collection. Black walnut and black cherry seeds are

Table 2. Fructification characteristics of some hardwood species

Species	Minimum seed-bearing age (years)	Interval between large seed crops (years)	Time of seed maturity
Northern red oak	25	2 - 5	mid Sept. - mid Oct.
Sugar maple	4 - 40	3 - 7	end of Sept. - mid Oct.
white ash	20	3 - 5	end of Sept. - early Nov.
Yellow birch	40	2	end of Sept. - Oct.
Black cherry	5	1 - 5	end of Aug. - early Sept.
Black walnut	12 - 15	1 - 3	Sept. - Oct.
American elm	15	1	mid May - early June
American basswood	15	1 - 2	end of Aug. - early Sept.

Table 3. Specific conditions for safe storage of hardwood seeds

Species	Moisture content (% fresh weight)	Conservation method	Temperature (o C)	Possible storage period (years)
Orthodox				
Sugar maple	10-15%	dry, sealed	-10 to 3	2 +
Ashes	4-7%	dry, sealed	1 to 3	3 +
Birches	1-3%	dry, sealed	-25 to 3	10 +
Black cherry	8%	depulped, dry, sealed	1 to 3	3
American elm	2-3%	dry, sealed	-4 to 3	2
Recalcitrant				
Oaks	35-48%	moist and aerated	1 to 3	overwinter
Black walnut	husked	moist and aerated	1	1
Butternut walnut	unhusked	sealed	1	4
Silver maple	30-45%	sealed	1 to 3	a few weeks
Bitternut hickory	90% (RH)	sealed	1 to 3	2

Table 4. Stratification treatments to promote germination

Species	Type of dormancy	Stratification treatments	Stratification period (days)
Northern red oak	physical	humid, cold and aerated	70
Sugar maple	internal + physical	cold soaking + cold and humid in anaerobic condition	90
White ash	internal + physical	warm and humid + cold and humid	90
Yellow birch	internal + physical	cold	30
Black cherry	internal + physical	humid, warm alternating with cold	90
Walnuts and American basswood	internal + physical	cold and humid	90 - 120

depulped mechanically as soon at they are delivered at the Center. Laboratory personnel draw a representative sample of each seedlot and assess various parameters, including the number of seeds per liter, lot purity, moisture content of the seeds and embryo quality.

For the past few years, the Center has been using radiography to measure embryo development and detect the presence of insects or larvae. X-raying is impossible with walnuts. Hickory and American basswood X-rays are difficult to read. These seeds are thus cross-sectioned to assess the state of the embryo.

These various tests make it possible to determine the germination potential of the seed lots.

Seeds of American elm and silver maple, collected in spring, cannot become dormant. They have a germination potential which corresponds to their effective germination rate. The germination potential of other seeds corresponds to the maximum germination rate obtained if dormancy is broken.

Seed storage

Seed storage techniques have yet to be perfected for several hardwood species. As fructification is often irregular, the seeds collected during good seed years must be stored to ensure supply for the nursery. Since 1986, the *Centre de semences forestieres* has been researching the storage of hardwood seeds, in the hope of being able, eventually, to build up a seed reserve.

For storage purposes, hardwood seeds fall into two groups : orthodox and recalcitrant (Table 3). The first group comprises small seeds such as sugar maple, ashes, birch, black cherry and American elm. These seeds can be stored relatively well, over long periods, if the seed's moisture content is lower than 15 percent and where the temperature is less than 3°C.

Recalcitrant seeds include oaks, walnuts, silver maple and hickory. These seeds cannot be stored as easily. They do not tolerate even moderate dehydration or temperatures below 1°C. Because of their high moisture content, they germinate readily during storage. For instance, some lots of red oak seeds germinated after a few month's storage. The viability of silver maple seeds drops very rapidly.

Breaking seed dormancy

Different treatments are applied to break seed dormancy (Table 4). The dormancy of oaks and birch seeds is easy broken by a simple cold treatment.

Other seeds, such as sugar maple, ashes, walnuts, black cherry and American basswood have a more or less deep dormancy. The stratification treatment of the walnuts seeds in beds during winter is not sufficient to break adequately their dormancy resulting in an average germination.

Sugar maple seeds germinate at a satisfactory rate when subjected to cold, and humid conditions. When they are sown in beds, their germination depends directly on spring weather conditions.

Low germination, has been observed in white ash and black cherry seeds while poor germination has been obtained with American basswood.

Tests to break dormancy in an artificial environment were begun in 1986, at the Pepiniere de Berthier, to improve the low germination rate obtained with several species.

Obviously, much more research is required, particularly in the area of seed dormancy. It is extremely important to find a quick method to assess dormancy. It would then be possible to take appropriate actions so as to improve current germination rates. Dormancy could eventually be controlled and ready to germinate seed lots would always be available.

Seedling production

The current production objective for the *Pepiniere de Berthier* is 2 million bareroot seedlings and less than 1 million tunnel-grown container seedlings. Over 9 hardwood genera including 19 species are grown in the nursery (Table 5). Tree planters generally prefer container-grown seedlings as they are easier to plant.

Sugar maple, ashes, walnuts and hickory are bareroot grown exclusively, whereas birch and American elm perform when they are grown in containers. Either method can be used to grow Northern red oak and silver maple. Poor germination does not allow us to produce black cherry and American basswood in significant quantities. It should be pointed out that these data change constantly.

Table 5. Hardwood seedling production method
Pepinière de Berthier

Method	Species	Age class
Bareroot production	oaks	2-0
	sugar maple	2-0
	ashes	2-0
	walnuts	1-0
	silver maple	1-0
	bitternut hickory	2-0
Containerized production	Northern red oak	1-0
	yellow birch	1-0
	American elm	1-0
	silver maple	1-0

Table 6. Autumn sowing prescriptions for bareroot seedlings

Species	Sowing depth (cm)	Usual germination potential	Number of viable seeds/seedling	Germination period	Desired density (nr. of seedlings per linear meter of seedbed)
Northern red oak	4	85%	2	May	75
Sugar maple	2.5	2%	6	April-May	100
White ash	2.5	0-25%	6	April-May	80
Black walnut	6	90%	4	June	50

Bareroot production

The soil and climate of the *Pepiniere de Berthier* are well suited to growing hardwoods. Growing soil is mostly loam and sandy loam. At Berthier, the frost-free period lasts an average of 136 days. Precipitation from April to October generally total nearly 600 mm, and close to 3 000 degree-days are accumulated over a period of approximately 240 days.

First, the soil is plowed, and dolomitic lime is added to obtain a pH (CaCl2) level of between 5.5 and 6. It is incorporated into the soil using a disk harrow.

Before sowing, we use a spring-tooth harrow to make a good seeding bed. Phosphorus, potassium, and especially magnesium are added. Then, the seedbeds are moulded.

Seeds are hand-sown in five furrows using a modified transplanter. Sowing is usually done in the fall as soon as possible after the seedlots have been received and assessed. Sowing should be completed by the end of October (Table 6).

Only a very small portion of sowing is carried out in the spring. We then sow silver maple whose fructification occurs in June.

Oaks are the only species with which the desired density is obtained, in fall sowing. Oak seed dormancy is easily eliminated by cold stratification. For the other species, expectations are more hazardous; the real germination capacity cannot be determined until spring. Some of the seeds of white ash and black walnut may not germinate before the second year. Furthermore, if the furrows are too deep, germination will be delayed and sometimes reduced.

Chemical weed control consists in spraying a pre-emergence herbicide in spring and a grass-control herbicide in July. In certain cases, the seedbeds also have to be weeded manually or mechanically.

Particular attention is given over to keep the seedbeds moist while the seed is germinating. Afterwards, a tensiometer placed at root level inaicates the need for water.

Nitrogen fertilizers are applied several times during the growing season.

All hardwood seedling roots are pruned horizontally in mid-September of the first season. This stimulates the formation of secondary roots in all species and limits the length of oak, walnut and hickory taproots. Root pruning reduces growth during the second season.

To facilitate nursery and reforestation operations, it was agreed with our customer regions to produce seedlings between 30 and 60 cm in height. To do so, we must sometimes wrench the seedlings that reach the desired height in 2-0.

When seedlings growth is completed, roots are pruned vertically to facilitate extraction.

Container production

Among the numerous containers available on the market, we chose to use the *Styroblock* for its easy handling, durability, and size. *Styroblock #28* is used for Northern red oak production and *Styroblock #45* for species with a narrower crown, such as birch and American elm (Table 7).

Containers are filled mechanically with a mixture of sphagnum peat moss and vermiculite to which a wetting agent and a slow-release granular fertilizer are added. The mixture normally has a pH level of 4.

Birch seeds are sown in the fall using a drum seeder. Northern red oak acorns are pre-germinated in the spring and sown by hand. Immediately after sowing, the cavity is covered with a layer of calcite. The containers are then placed on trays in the tunnels.

Fertilization begins as soon as real leaves appear. Water-soluble fertilizers are injected into the irrigation system throughout the season. In July doses are reduced to limit the seedlings height growth.

Birch seedlings are thinned and transplanted in early June, approximately one week after fertilization begins. The humidity level of the plugs is carefully monitored during germination and transplanting, and the lateral openings of the tunnels are kept closed at all times.

It is neither easy nor advisable to transplant or thin Northern red oak seedlings, since only a single pre-germinated seed is planted in each cavity.

During active height growth, the plugs are kept moist but they can be allowed to dry slightly between waterings. The sides of the tunnels are kept open at all times.

In July, when the seedlings reach the desired height, the polyethylene are removed to limit height growth, since seedlings grown at a high density tend to be tall and spindly. Diameter growth continues until the end of the season, improving the seedling's height/diameter ratio.

Extraction, grading and packaging of bareroot and container-grown seedlings

In October, the seedlings are extracted, sorted and trimmed, if necessary. Fifteen to forty per cent of the seedlings are rejected, namely because they are too short or deformed.

Observation of recent productions, has led us to divide most of the trees into two height classes. A minimum diameter has been determined for the smaller specimens.

Table 7. Characteristics of containers

Type	Number of cavities	Cavity volume (cm^3)	Growing density (cavities/m^2)
Styroblock #28-328	28	328	130
Styroblock #28-500	28	500	130
Styroblock #45	45	328	210
MM 85 (France)	12	380	193
Plantek #25	25	380	156
Spencer-Lemaire Super 45	27	750	321
Ecopot Ps 8	45	489	250

After grading, bareroot seedlings are tied into bunches. The plugs of the container-grown seedlings are placed in a polyethylene bag in bunches of 4. Most of the seedlings are then packed. Small seedlings are placed in bags made of water-proofed Kraft paper, while tall seedlings are bundled with all top in one direction in waxed paper covered with a piece of jute.

The seedlings thus packed are placed in cold storage (-2°C) for the winter. The rest of the production are heeled outdoors to be packaged in the spring.

Reforestation follow-up

We control the quality of a large part of the stock we deliver by replanting a few samples in the nursery where they are followed for one or two years. The survival rate for all species is very high (almost 100%), but there are a few problems.

For instance the crown of tall sugar maple seedlings often dries out. New growth starts at the base of the stem, which implies a significant loss in growth. These seedlings were not root pruned in the nursery, which leads us to suspect a weak root system or an excessive height/diameter ratio to be the cause of the problem.

Close to half the crowns of bareroot grown oak seedlings dry out, regardless of their height. Since their root system was well developed, we find it difficult to explain this phenomenon, unless it is inherent to the species. Container-grown red oaks displayed much the same behaviour. New growth in the oaks begins high enough, resulting in a negligible delay in growth.

Reforestation follow-up enabled us to identify the species sensitive to frost, such as walnuts and hickory, as well as extremeley hardy species, such as ashes and birch.

Height growth of reforested trees is the same in absolute terms whatever their height class. In relative terms, it is inferior for seedlings over 40 to 50 cm. We thus believe that it is not advisable to grow excessively tall seedlings.

Conclusion

Hardwood seedling production is relatively new in Quebec. Much work remains to be done to solve problems of seed supply, storage and dormancy control and to master the techniques of container and even bareroot production for several hardwood species. Through active research and by working in conjunction with other researchers and procuders, we hope to find solutions to these problems. We have already acquired the necessary skills to mass-produce many hardwood species. Seedlings grown in the *Pepiniere de Berthier* showed high survival rates after planting. However, seedling production and plantation maintenance methods must be constantly reevaluated to ensure not only the survival, but also the rapid and harmonious development of the trees. Our industry already suffers from a lack of local quality wood, and hardwood reforestation is one of the ways we have to ensure its long term survival.