CANADIAN TREE IMPROVEMENT ASSOCIATION/
ASSOCIATION CANADIENNE POUR L'AMÉLIORATION DES ARBRES

Tree Seed Working Group

NEWS BULLETIN

No. 37 June 2003

THIS ISSUE AT A GLANCE

CHAIR'S 'ARMCHAIR' REPORT

Welcome back. I hope you enjoy our new electronic format and that it reached you painlessly. This News Bulletin will focus on hardwood seed and I'd like to thank everyone who contributed. Our next News Bulletin will focus on "Seed Orchard Practices" and we are looking forward to contributions from researchers and operational facilities on the practices they employ for effectively and efficiently producing seed from selected parents.

Hardwoods are a minor, but important part of Canadian forestry. Hardwood seed is not as well studied partly because most aggressive programs use vegetatively propagated materials. Most hardwood species also have a more complicated seed biology system than conifers. A better appreciation of the positive attributes of conifer seed is often the result of starting to work with hardwoods. They present much greater variability between genera and it is not uncommon that species within a genus have very different seed biology "strategies". An exciting area of investigation for some and a frustration for those needing to operationally germinate hardwood species for which very little information is available.

In hardwood species, seed immaturity can be a more significant issue with some species shedding seeds with immature embryos. Many hardwoods can also be considered recalcitrant (see News Bulletin #33 for a review) or cannot be dried and stored at low moisture contents, therefore quickly losing their viability. This complicates any reforestation system that is dependent on this seed. Hardwoods also commonly have complex dormancy mechanisms that may require much more than the commonly used 'month' of moist chilling to overcome dormancy and initiate germination. Some species require very long stratification periods (one year or more), chemical treatments, moisture content control, scarification, and a host of other specialized treatments. Hardwood species are generally more difficult to process and I suspect that a large amount of the variability we see between seed lots is due to quality of seed processing and collection timing. These have improved greatly with our conifers over the past few decades, but we have a long way to go with our hardwoods. There is still a great deal of work to do in this area – Good Luck.

Planning is currently underway for the 29th Canadian Tree Improvement Association meeting in Kelowna, BC from July 26 – 29, 2004. The theme of the meeting is “Climate Change and Forest Genetics”. A Tree Seed Working Group workshop will be held on Monday, July 26 and I welcome all suggestions on potential topics. My initial thoughts have focused on two possibilities: a) Quality Assurance monitoring and b) Crown architecture and its control. Feedback on these or other topics is greatly encouraged. For those of you travelling through Vancouver I am also going to arrange a pre- or post-conference tour of our BCMOF Tree Seed Centre for those interested. Please indicate if you are interested.

There are a variety of seed-related meetings occurring this summer and fall (check Upcoming Meetings section). I encourage everyone with the time and funds to try and attend at least one of these meetings. We would also greatly appreciate brief reports or opinions of meetings that members attend. Have a great summer!

Dave Kolotelo
TSWG Chairperson

EDITOR’S NOTES

Hello again Folks and welcome to the first electronic version of the News Bulletin! I hope you were able to read and/or print it with no problems.

You will find several articles dealing with hardwood seed which I hope you will find interesting. The “Selected References” section is a good place to start if anyone is looking fro some information about a particular species. And, of course, there is the USDA Woody Plant Seed Manual web site http://wpsm.net .

More good news!! The TREESEED Discussion Group is online again. This forum has the potential to be a very useful means for communication among subscribers. If anyone has any questions, comments, announcements, etc. dealing with tree and shrub seed, then the Discussion Group is an excellent means of obtaining and/or disseminating information. If you are unsure whether or not you subscribed in the past, please subscribe again. That way the membership list will contain your current, active e-mail address.

To subscribe - Send e-mail to: listproc@nrcan.gc.ca with the message consisting of the following single line SUBSCRIBE TREESEED firstname lastname . A message confirming that your name has been added to the list will be sent to you.

To send a message to the list - Send an e-mail to: treeseed@nrn1.nrcan.gc.ca .

I look forward to some good discussions.

Dale Simpson
Editor

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Comments, suggestions, and contributions for the News Bulletin are welcomed by the Chairperson or Editor.

EFFECTS OF PHOTOPERIOD AND MOIST CHILLING ON GERMINATION OF WHITE AND YELLOW BIRCH SEEDS

This trial was one of the tasks taken on by the Tree and Shrub Seed Sub-committee of the Association of Official Seed Analysts (AOSA) to reconcile some of the differences in germination testing rules for some tree and shrub seeds between the International Seed Testing Association (ISTA) and AOSA. This trial was carried out in 1983. The over-all results had been reported to the Sub-committee at the AOSA annual meeting in 1983. I thought that the trial results for white birch (*Betula papyrifera* Marsh.) and yellow birch (*B. alleghaniensis* Britt.) may be of interest to seed users.

Methods and Materials

The seed lots used for this trial were taken from the Seed Bank of the National Tree Seed Centre at the former Petawawa National Forestry Institute, Chalk River, Ontario. Four seed lots from different crop years, locations, and seed quality were selected from each species for this purpose. The trial was designed to examine how pre-treatment (no chilling and 21-day moist chilling) and photoperiod (0, 8, and 16 hours) affect seed germination of the two birch species. Birch seed lots, especially white birch, have a high percentage of empty seeds due to the difficulty in removing empty seeds. To evaluate the real treatment effect, all seeds were x-rayed with a Hewlett Packard Faxitron x-ray unit on Kodak M® film at 15 kvp, 3ma using 60 and 80 second exposure times for white and yellow birch seeds, respectively. X-radiography was used to identify and quantity empty seeds and to adjust the germination percentages based on filled seeds.

Germination was carried out on moist blotter paper with a layer of Kimpak® underneath in the Petawawa germination box (Wang and Ackerman 1983) in a Conviron G30 germinator (Controlled Environments, Winnipeg) at diurnal temperatures of 30°C with an 8 or 16 hour photoperiod and of 20°C for 16 or 8 hours darkness. For each treatment, random samples of four replications of 100 seeds each were used. Moist chilling was done by placing the dry seeds on top of the moist blotter paper germination medium and storing them in a cold room at 2–4°C. Both the control and treated seeds were scheduled to germinate at the same time. Germination was monitored weekly and the criterion for evaluation was based on filled seeds and vigor classes 1–4 (Wang 1973).

Statistical analysis was conducted to evaluate the effects of moist chilling and photoperiod on the germination data using the GLM procedure of SAS® (SAS 2001).

Results and Discussion

Seed Quality

Seed quality, in terms of percentage of filled seeds, varied with seed crop years and seed sources (Table 1). The percentage of empty seeds ranged from 4–55% for yellow birch and from 16–89% for white birch seed lots. The high percentage of empty seeds (16–89%) in the white birch seed lots is higher than the 14–47% empty seeds in a white birch seed crop reported by Safford *et al*. (1990). Such variation in the percentage of filled seeds among seed lots seems to reflect the importance of collecting seed in better seed years when the percentage of empty and discolored seeds is lowest (Safford *et al*. 1990). This could also be simply due to different processing efficiencies. The high percentages of empty seeds in white birch can be reduced by only collecting seed in good seed years which occur every other year. Because of the general problem in seed processing and purity analysis of birch seeds, ISTA (2003) prescribes germination testing by weight replicates (four replications of a specified weight of seeds; for the two European birches, *Betula pendula* and *Betula pubescens*, the replicate weight is 0.1g). However, the prescription for germination testing of white birch seeds remains the same as other conifers in the ISTA rules. To obtain uniform results in laboratory testing and nursery sowing, birch seeds should be further processed by liquid flotation methods which can effectively remove empty, insect damaged, and defective birch seeds (Bjorkroth 1973).

Table 1. Percentage of filled seeds based on x-radiographic images by species and seed lots

Species	Seed lot[1]	Provenance	Filled seeds (%) Rep. range	Filled seeds (%) Average	Empty seeds (%)
Yellow birch	672044	Harrington, Qc	31–56	45	55
	673053	Alginquin Park, ON	62–82	76	24
	703092	Chalk River, ON	92–99	96	4
	743493	Algonquin Park, ON	76–94	86	14
White birch	752041	Verendrye Park, Qc	23–31	27	73
	754032	Agassiz Forest, MB	23–31	27	73
	773200	Ramsey Lake, ON	76–90	84	16
	777193	Hope, BC	7–20	11	89

[1] the first two numbers represent the collection year

Seed Dormancy

Yellow birch seeds have a water-soluble inhibitor in the seedcoats that can be alleviated by light or moist chilling (Erdmann 1990). The degree of seed dormancy, in terms of increased germination by 21-day moist chilling under 8-hour photoperiod, varied between seed lots ranging from 4–23% in yellow birch (Figure 1 and Table 2). Although white birch seeds are not considered dormant, some seed lots seemed to respond positively to both extended photoperiod and moist chilling (Table 2). According to Bevington and Hoyle (1981), white birch is induced to germinate by moist chilling at 3°C or by red light which is mediated by phytochrome.

Table 2. Effects of moist chilling and photoperiod on germination of yellow and white birch seed from four provenances

		Percent germination by chilling and photoperiod					
		Non-chilled			21-day chilled		
		Photoperiod			Photoperiod		
Species	Seed lot	0	8 hrs	16 hrs	0	8 hrs	16 hrs
Yellow birch	6630530	6	73	79	53	81	84
Yellow birch	6720440	27	74	78	59	78	76
Yellow birch	7030920	5	57	73	36	80	73
Yellow birch	7434930	30	76	73	70	80	77
Average		**17**	**70**	**76**	**54**	**80**	**78**
White birch	7520410	40	80	81	72	67	88
White birch	7540320	25	62	68	53	72	79
White birch	7732000	77	87	96	93	98	95
White birch	7771930	31	76	67	61	41	64
Average		**43**	**75**	**78**	**70**	**70**	**82**

Effect of Photoperiod

The presence of light significantly improved germination of yellow birch seeds (Table 3). Germination of non-chilled seeds increased an average of 53% at the 8-hour and 59% at the 16-hour photoperiod compared to those germinated in the dark. For chilled seeds, germination increased 26% at the 8-hour and 24% at the 16-hour photoperiod compared to the dark (Table 2). Although the extended photoperiod did not significantly improve germination over that of 8 hours, it improved germination of three of the non-chilled seed lots (4–16%) but only one chilled seed lot (3%) (Table2). According to Erdmann (1990), germination tests are conducted at alternating day and night temperatures of 30°C and 20°C with at least 8 hours of light for non-chilled seeds.

Table 3. Effect of photoperiod and moist chilling on mean germination of yellow and white birch seed

	Photoperiod			Chilling	
Species	0 hrs	8 hrs	16 hrs	non-chilled	chilled
Yellow birch	36	75	77	54	71
White birch	57	73	80	66	74

Although analysis of variance showed no significant effect of photoperiod on germination of white birch seed, germination did increase with increasing photoperiod (Table 3). In general, white birch seeds seemed to be able to germinate better in darkness than yellow birch, although light was essential for maximum germination. While 8 hours of light improved germination of non-chilled seeds by 10–45%, the extended 16-hour photoperiod further improved the germination by 1–9% for three out of the four lots tested (Table 2). Germination of chilled seed was variable within seed lots between the three photoperiods (Table 2). Apparently, the response of non-chilled seeds to light treatment and germination temperature varies with seed source of white birch (Bevington and Hoyle 1981).

Effect of Moist Chilling

Standard laboratory germination tests for yellow birch seeds prescribed by AOSA (2002) require paired tests (i.e., with and without 21-day moist chilling). Moist chilling improved germination 17% (Table 3). These results are quite different from Eardmann (1990) who reported that germination test results of yellow birch are always higher for non-chilled than chilled seeds. When yellow birch seeds were moist chilled, extended photoperiod had a small positive effect on the total germination of one seed lot (Table 2). Moist chilling also improved seed germination in darkness, however, the differences in germination between chilled and non-chilled sed decreased as photoperiod increased (Figure 1). The 21-day period of moist chilling proved to be adequate for complete germination of yellow birch seeds due to a smaller percentage being classified as low vigor.

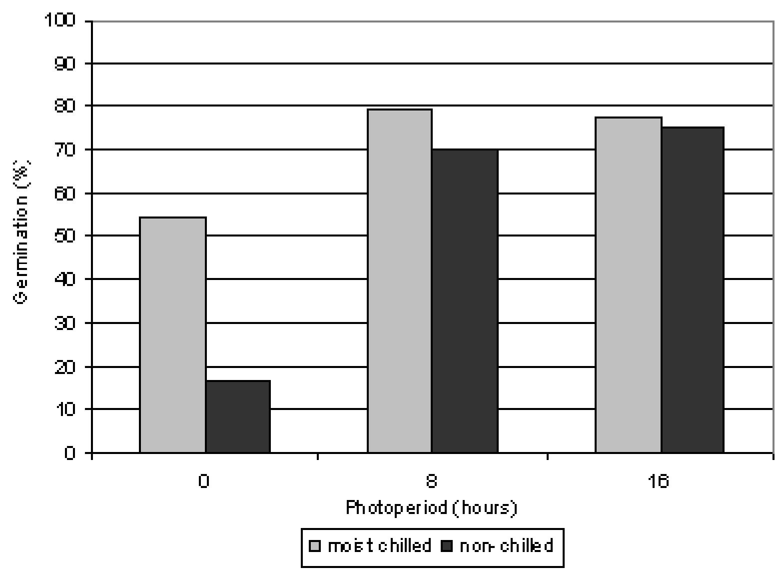

Figure 1. Effects of moist chilling and photoperiod on the germination of four yellow birch seed lots (each bar represents the mean of 16 replicates of 100 seeds each).

Although white birch seeds were not considered dormant, moist chilling was found to be beneficial to the germination of two lots (10–11% increase), but detrimental to two others for the 8-hour photoperiod (Table 2). Seed that was moist chilled had higher germination in the dark than non-chilled seed (Figure 2). Past experience has indicated that moist chilling does not have a detrimental effect on germination of non-dormant seeds unless the seeds were damaged in processing or the treatment is improperly applied. However, it is interesting to note that some white birch seed lots from New Hampshire, Alaska, and Ontario showed a loss of moist chilling stimulus following various periods of moist chilling when germinated at a lower temperature of 18°C (Bevington and Hoyle 1981). This is quite unusual because coniferous seeds become less sensitive to germination temperature following moist chilling (Wang, 1987). Moist chilling was especially effective by increasing the germination of white birch seed in the dark (Figure 2) (Bevington and Hoyle 1981).

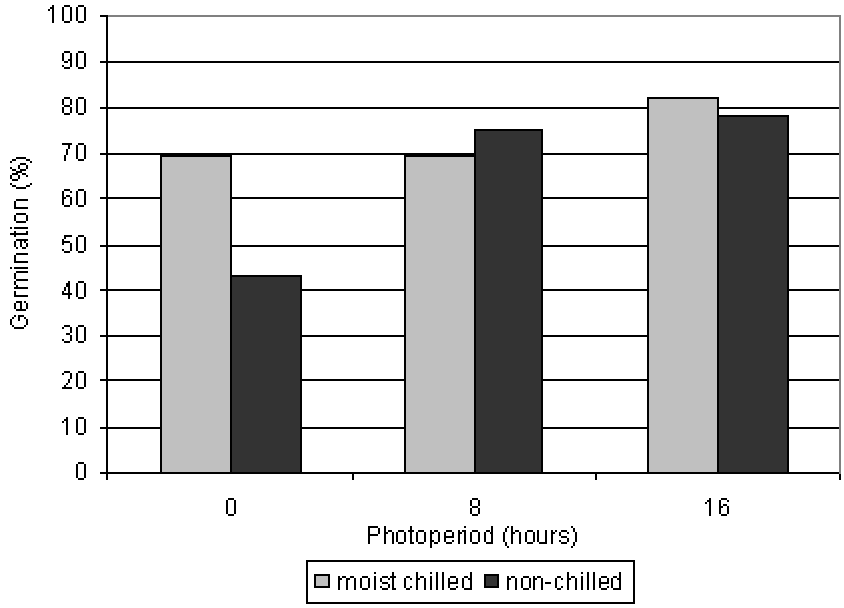

Figure 2. Effects of moist chilling and photoperiod on the germination of four white birch seed lots (each bar represents the mean of 16 replicates of 100 seeds each).

The following conclusions can be deduced from the above results:

1. In view of the variability in seed quality, in terms of filled seeds and previous research findings, birch seed collections should be made in the best seed crop years. To improve seeding efficiency of birch seeds, seed lots with low percentages of filled seeds should be upgraded by liquid flotation techniques to remove empty and insect damaged seeds. This is especially critical for container seedling production.

2. Yellow birch seeds are dormant and require 21-day moist chilling for maximum and uniform germination. This confirms the current AOSA prescription for this species (AOSA, 2002). Since moist chilled seeds can not only germinate better and faster but can also germinate at lower temperatures and low light intensity, it would be technically and economically advantageous to incorporate the upgrading and moist chilling pre-treatment into container seedling production.

3. For white birch seeds, 8 hours of light are essential for maximum seed germination although extended photoperiod and moist chilling treatment could further enhance germination. The prescriptions for laboratory germination testing of white birch seeds between AOSA and ISTA are the same except the recommendation for using a 16-hour photoperiod by AOSA (2002).

Acknowledgements

I would like to thank Steve D'Eon and Dave Kolotelo for reviewing the manuscript, Margaret Penner and Craig Robinson for assistance in statistical analysis, and Gordon Brand and Blair Kelley for making graphs and tables.

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MAXIMIZING QUALITY OF *Betula papyrifera* SEED

White birch (*Betula papyrifera* Marsh.) seed is very light and is winged making it impossible to remove most dead and empty seed using air aspiration. As well, the presence of the wings greatly adds to the volume resulting in large containers being required to store large volumes of seed. If testing showed the germination of a seed lot was poor (< 30%) then there was a tendency to discard the seed. This can be frustrating when effort and financial resources have been expended to collect and process the seed particularly if the collection was made from phenotypically superior trees. National Tree Seed Centre staff noted the variation in germination between seed lots collected over a number of years. It was not until a number of seed samples received from a cooperator were processed and found to have higher than average 1000-seed weights and high germination that a serious attempt was made to investigate a means of improving the quality of seed lots. It was also noted that most of the wings were missing from these samples.

The first attempt at removing empty seed involved de-winging by gently hand rubbing in a light cotton bag and aspirating the rubbed sample. This worked to a certain extent but it was difficult to control the air flow enough to prevent lighter filled seed from being removed and not removing heavier empty or partially filled seed. The Seed Centre routinely uses floatation in absolute ethanol to separate filled from empty seed in *Larix, Picea*, *Pinus*, *Tsuga*, and, more recently, *Alnus*. This technique was tried on the de-winged birch seed following aspiration. Several seed lots were evaluated and paired testing (winged and de-winged + alcohol separation) conducted. A dramatic improvement in germination was observed for seed that had been de-winged and alcohol separated. After consulting the literature, it was found that this technique was not new for birch (Björkroth 1973).

An alcohol separation apparatus can be easily constructed. For small seed lots, a ring stand, ring support, glass or clear plastic funnel, clear tubing, clamp, strainer, and two 1000 ml beakers are needed (Figure 1). Insert the end of a 20 cm long piece of tubing onto the funnel. Place the funnel into the ring support and attach to the ring stand. Adjust the height so the bottom of the tubing is just above the strainer which sits on top of the beaker placed on the base of the ring stand. Place the clamp near the bottom of the tubing. It pinches the tubing to not allow the alcohol to flow through until the seed have sunk. About 300 ml of alcohol are poured into the funnel, the seed added, and stirred to allow heavy seed to sink. When the tubing is full and seed may have also accumulated on the bottom of the funnel the clamp is released causing the seed and alcohol to flow into the strainer which collects the seed with the alcohol flowing through into the beaker. The clamp must be quickly replaced to prevent any of the floating seed being washed down with the sinkers. The seed in the strainer are then immediately rinsed in cold (cool) running tap water for about 30 seconds then placed on paper toweling or fine mesh screen for air drying. The empty strainer is placed back on top of the beaker and the clamp removed to allow the seed that floated and alcohol to wash through. The beaker containing the alcohol is switched for the empty beaker and the strainer containing the seed is placed on the empty beaker. The alcohol is then poured through the funnel to remove all remaining seed and collect them in the strainer after which they are disposed of. For larger seed lots, a much larger version of this apparatus can be constructed with the tubing becoming a larger diameter column of clear PVC plastic or equivalent.

Figure 1. Alcohol separation apparatus.

Effect of Immersion in Alcohol on Seed Germination

One obvious concern about using alcohol separation was the potential impact of alcohol on the health and long-term survival of the seed. Normally, seed is immersed in alcohol for up to 15 seconds before being thoroughly rinsed in running water. A trial was set up using one seed lot. Seed was immersed in absolute ethanol for periods of 15, 30, 45, 60, 120, 180, 240, and 300 seconds. Following immersion the seed was rinsed in running water for 15 seconds and spread on paper towel to dry. After 24 hours, 4 replicates of 50 seed each were placed on moistened Kimpak in Petawawa germination boxes and placed in a germination cabinet for 21 days. Germination conditions were diurnal cycles of 20°C and darkness for 16 hours followed by 30°C and light for 8 hours. Humidity was maintained at 85%. Although, at day 21, overall total high vigor germination was not affected by duration of immersion in alcohol, there was a noticeable impact at days 14 and 18 (Figure 2). At 14 days, there was a substantial decrease in germination for samples that had been in alcohol 60 seconds and longer. This same trend was obvious at day 18 but had disappeared by day 21. In practice the seed are only exposed to alcohol for 10-15 seconds before being thoroughly rinsed. Therefore it is unlikely the alcohol affects the health of the seed.

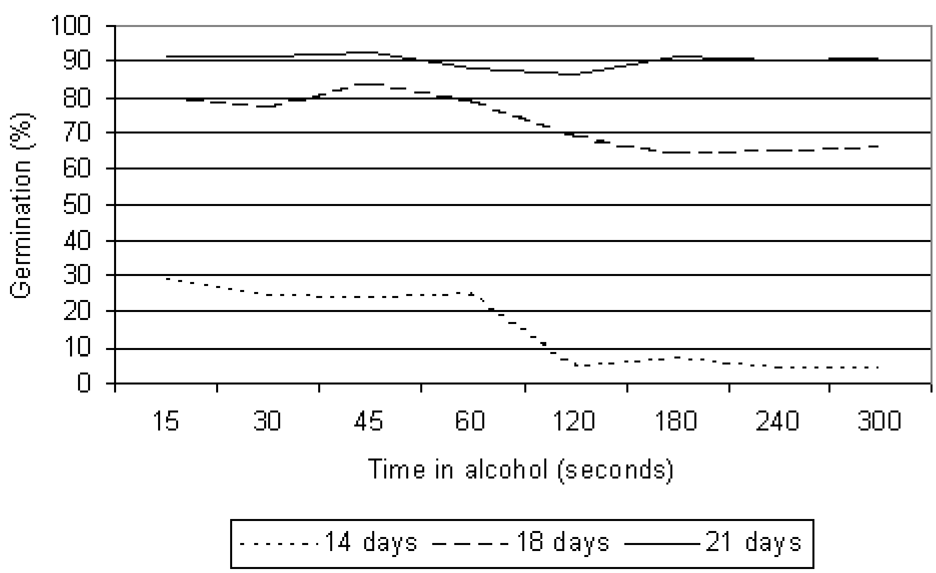

Figure 2. Effect of duration in alcohol on germination of white birch seed after 14,18, and 21 days (from Daigle and Simpson 2002).

Germination of Winged vs. De-winged + Alcohol Separated Seed

To further evaluate the improvement in germination due to alcohol separation, an experiment was set-up in 2002. Catkins were collected from 3 or 5 trees from 5 populations. Following two months of air drying indoors, the catkins were gently rubbed to break them apart and placed in an aspirator to separate the seed from the bracts, catkin axes, and other debris. A sample of seed was removed for germination testing. The remaining seed was placed in a cotton bag and gently rubbed to break off the wings. The contents were then dumped onto a fine sieve to separate the crushed wing debris from the seed. Following this phase, the seed was immersed in absolute ethanol and stirred to ensure any heavy seed had an opportunity to sink. When most of the seed had completed sinking in the column (15 seconds) the “sinkers” were collected in a strainer and rinsed under running tap water for 30 seconds. The wet seed was spread on fine mesh screen trays and allowed to dry for several days at room temperature. Germination tests were set up following the same manner as described above.

Germination was assessed at 7, 14, and 21 days. Germinants, classified as high vigor (cotyledons green and separated with a well developed radicle and upright hypocotyl), were removed at each assessment time. At day 21 a count was made of any low vigor germinants. Germination of winged seed from individual trees ranged from 0 to 73% while de-winged + alcohol separated seed ranged from 41 to 97%. There was clearly a substantial improvement in germination due to the de-winging + alcohol separation. There were large increases in germination among individual trees as well as at the population level. Initial seed quality varied considerably among populations with the proportion of improvement in germination dependent upon initial seed quality (Figure 3). For example, winged seed from Clair and Coy Bk. populations had the lowest initial germination but the largest increase in germination after treatment. Another advantage of this treatment was the virtual elimination of low-vigor seed. Seed that floated in the alcohol was not germination tested. Previous experience showed that the germination of this seed was low and any seed that did germinate exhibited low vigor.

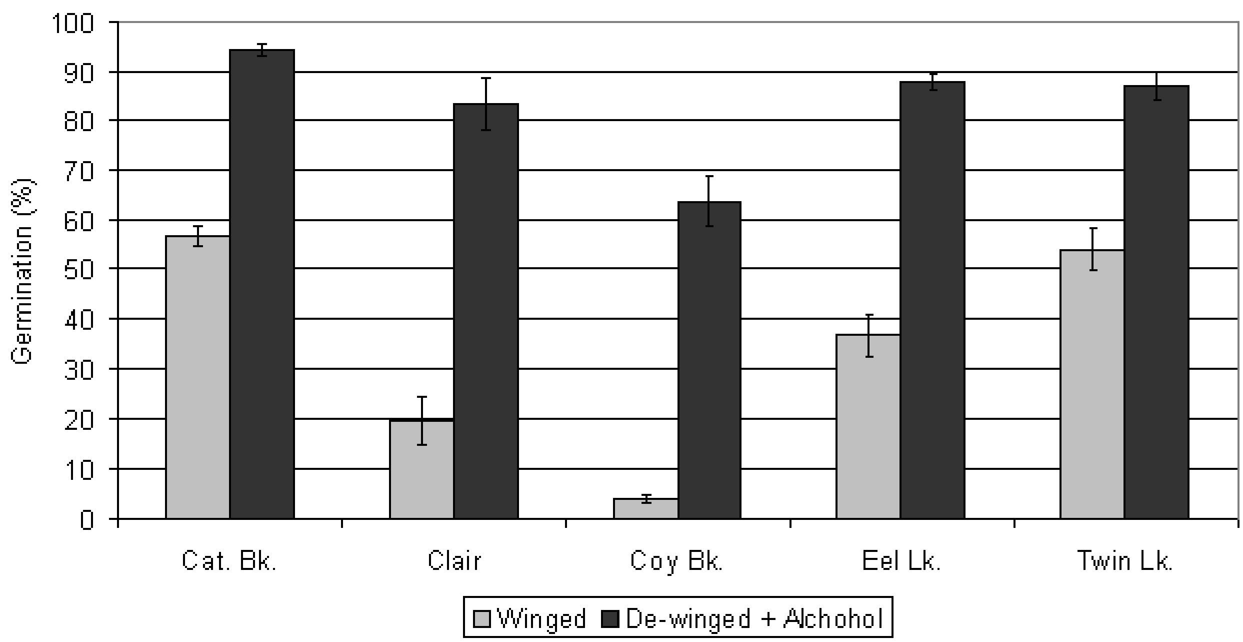

Figure 3. Germination of white birch winged and de-winged + alcohol separated seed collected from individual trees in five populations.

Conclusions

Germination of white birch seed can be substantially improved by removing the wings and floating the seed in absolute ethanol to separate the empty and light filled seed from the heavier filled seed. The process not only improves germination but also greatly reduces the volume of seed to be stored. A trial showed there to be no decline in total germination at 21 days for the length of time the seed is immersed during a typical separation of up to 15 seconds.

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BOOK REVIEW

Vozzo, J.A. (Ed.) 2002. Tropical Tree Seed Manual. USDA, For. Serv., Agric. Hndbk. 721, 899 p.

Following is the Abstract from the manual. "The 'Tropical Tree Seed Manual' is a one-volume reference manual for students, technicians, and scientists that provides comprehensive, internationally compiled data about tropical trees. The emphasis is on species of the Americas; however, a number of tropical tree species from other countries are also included. The manual is divided into two parts. The first part consists of nine chapters written by authorities on each area. The second part presents descriptions of 197 botanically and economically important tropical tree species. The manual is published in English and Spanish. It contributes to the academic and scientific communities by collating and organizing a wealth of internationally significant research and practical data into one publication. It should be used with similar references on seed technology and handling to give students, technicians, and scientists a thorough understanding of tropical tree seeds."

Part 1 consists of 236 pages and the following chapters: Tropical Tree Seed Biology, Collection, Storage, Orthodox and Recalcitrant Seeds, Dormancy and Germination, Pathology, Ecology, Ethnobotany, and Notes on Tropical Dendrology. The Seed Biology chapter is liberally illustrated using color diagrams and photographs. Although the focus is intended toward tropical tree species there is much that has been gleaned from the literature on temperate species. There is an impressive list of references with about 2 400 citations. This in itself is a valuable resource as most chapter authors have reviewed the literature quite extensively. I highly recommend this book (manual) as a valuable addition to your bookshelf. The best means of enquiring about obtaining a copy is to e-mail the editor at: JVozzo@CFR.MsState.edu

Dale Simpson

HARDWOOD SEED TREATMENTS IN QUÉBEC

Each year in Québec, an average of one million hardwood seedlings of 15 different species are reforested. To produce this million seedlings, an average of 245 hl of seeds are harvested each year. This corresponds to about 80 seed lots of the 15 species. Most of the hardwood seeds are harvested in southern Québec, in natural stands. The harvesting season depends on when the fruit reaches maturity. For example, silver maple (*Acer saccharinum*), red maple (*A. rubrum*), and white elm (*Ulmus americana*) seeds are harvested in the spring while those of other species in the fall. All the seeds are sent to the Centre de semences forestières de Berthier (75 km east of Montreal) where they undergo processing and germination testing.

Regardless of their final destination, all the seedlings are produced at the Berthier nursery. Seedlings are grown in containers or as bareroot. The major species are yellow birch (*Betula alleghaniensis)*, red oak (*Quercus rubra*), sugar maple (*Acer saccharum*) and white ash (*Fraxinus americana*).

Seed Stratification Requirements by Hardwood Species

Some hardwood seeds are dormant and fail to germinate after processing when placed under conditions considered adequate for germination. Depending on the species, dormancy is physiological and / or physical. The degree of dormancy can vary according to the collection site.

Seed of each hardwood species requires a specific stratification method to overcome the dormancy. Furthermore, within the same species, seed lots can require different stratification periods to overcome dormancy. **As the stratification periods differ for each seed lot, we have to undergo preliminary tests to determine the proper duration for further operational stratification**.

The stratification methods have been adapted from the few references on this subject or developed in

Québec. The methods used in Québec for the dormant hardwood seeds grown in containers are described in Table 1. For seedlings cultivated bareroot, stratification conditions can differ. Some species are sown non- stratified and the stratification occurs naturally in the seedbed. Others are stratified using a method that can differ from the one used for container production. The stratification methods used for hardwood seeds grown for bareroot production are described in Table 2.

Table 1. Stratification methods for hardwood seeds grown in containers

Common name *Latin name*	Type of dormancy	Stratification method
Sugar maple *Acer saccharum*	Physiological and physical	Soak seeds in water for 14 days at 3°C, Drain excess water, Stratify in cold (3°C), humid, anaerobic conditions without medium for 3 to 5 weeks, depending on germination test results, until radicle emergence.
Red maple *Acer rubrum*	Physiological and physical	Soak seeds in water for 2 days at 20°C, Drain excess water.
Silver maple *Acer saccharinum*	None	Not required
Yellow birch *Betula alleghaniensis*	Light	Put seeds in a net between 2 layers of humid peat moss at 3°C for 21 days.
White birch *Betula papyrifera*	None	Not required
White ash *Fraxinus americana*	Deep physiological and physical	Soak seeds in water for 2 days at 20°C, Drain excess water, Put seeds in a mix of humid peat and sand in a bag (25 l), Warm stratify (20°C) for 4 weeks, Cold stratify (3°C) for 18 to 22 weeks, depending on germination test results.
Green ash *Fraxinus pennsylvanica*	Physiological and physical	Soak seeds in water for 2 days at 20°C, Drain excess water, Put seeds in a mix of humid peat and sand in a bag (25 l), Cold stratify (3°C) for 19 to 22 weeks, depending on germination test results.
Black cherry *Prunus serotina*	Physiological and physical	Soak seeds in water for 2 days at 20°C, Mix seed with moist peat moss and sand and stratify in polyethylene bags for 17 to 19 weeks, Alternate cold and warm stratification: 2 weeks at 20°C, 6 weeks at 3°C, 1 week at 20°C, 8 to 10 weeks at 3°C depending on germination test results.
Red oak *Quercus rubra*	Light	Store seeds in polyethylene bags (4 mil; 25 l) at 3°C without medium, 4 weeks before sowing time, soak seeds in water for 2 days at 20°C, Drain excess water, Put seeds into a polyethylene bag (4 mil) at 3°C until radicle emergence.
American basswood *Tilia americana*	Very deep physiological and physical	Soak seeds in water for 2 days, Drain excess water, Put seeds in a mix of humid peat and sand in a bag at 3°C for 26 to 30 weeks (poor germination).
White elm *Ulmus americana*	None	Not required

Table 2. Stratification methods for hardwood seeds grown for bareroot production

Common name *Latin name*	Type of Dormancy	Stratification method
Sugar maple *Acer saccharum*	Physiological and physical	Soak seeds in water for 14 days at 3°C, Drain excess water, Stratify in cold (3 °C) and humid condition without medium and in anaerobic conditions for 2 to 4 weeks before radicle emergence.
Bitternut hickory *Carya cordiformis*	Physiological and physical	Sow in seedbed in fall.
White ash *Fraxinus americana*	Deep physiological and physical	Same as container production.
Black walnut *Juglans nigra*	Physiological and physical	Put de-husked seeds into a polyethylene bag (4 mil; 25 l) at 3°C without medium during winter.
Black cherry *Prunus serotina*	Physiological and physical	Same as container production.
White oak *Quercus alba*	None	Sow in seedbed in fall.
Red oak *Quercus rubra*	Light physiological and physical	Sow in seedbed in fall.

Conclusion

The production of hardwood seedlings is very demanding:

1 Each species requires a specific stratification method and the duration of it must be evaluated after the collection of each seed lot before beginning operational stratification.

2 Cultivation and cultural requirements of the seedlings are specific and different for each species.

3 Hardwoods have such a great value (aesthetic and economic) that the investment in testing and cultivating is justified. It is essential to maintain a certain degree of biodiversity of the south-western forest of Québec.

For more information, visit the ministry web site: http://www.mrn.gouv.qc.ca/english/forest/quebec/quebec-system-management-plants.jsp (in English)
http://www.mrn.gouv.qc.ca/forets/entreprises/entreprises-semences.jsp (in French, more detail)

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HARDWOOD SEED STORABILITY REVISITED

In News Bulletin #28 I presented data on hardwood seed storability[1]. This information has been updated and it seems timely to report the results in keeping with the theme of this News Bulletin. Data are available on a total of 61 hardwood seed lots of the following species: green alder (*Alnus crispa*), red alder (*Alnus rubra*), white *birch (Betula papyrifera*), and trembling aspen (*Populus tremuloides*) (Table 1). Deterioration rates were estimated for each seed lot by quantifying the change in germination during storage:

Deterioration Rate = (Current GC – Initial GC) / (time between GC tests)

Table 1. Deterioration rates of hardwood species in storage at the BCMoF Tree Seed Centre

Species	# Seed lots	Deterioration rate △GC/year	Maximum age (years)	Initial GC range (%)
Green Alder	10	+0.33	7.3	24 – 86
Red Alder	18	+0.83	8.5	20 – 90
White Birch	24	+0.39	21.0	3 – 92
Trembling Aspen	9	-3.63	6	41 – 96

It is interesting to note that very little has changed in the relative deterioration rates of these hardwood species. Trembling aspen is still the fastest deteriorating species, although the current estimate of -3.63%/year is much less than the -8.6% estimated in 1998. The current rate is based on a larger dataset and longer storage durations providing more confidence in the estimate. The rate is still only based on nine seed lots and these varied tremendously in deterioration rates from 0.0 to -18.0%/year. It is interesting to note that although there exists a large range in initial germination, trembling aspen actually has the smallest range of the four hardwood species.

The remaining species had relatively similar deterioration rates and, as was the case in 1998, the species tended to increase in GC slightly during storage. This is unexpected and it is uncertain whether it is: 1) just an artifact of the data, 2) an indication of dormancy release during long-term storage (heresy some would cry!) as all species are tested dry, or 3) other factors not accounted for as being important (i.e. light). It is unlikely that I am going to resolve this question, but it is comforting that there is very little change in germination over time for these three species.

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[1] Note that in 1998 a decreased GC was indicated by a positive deterioration rate, but current methodology has the sign of the deterioration rate indicating the direction of △GC. This method of presentation appears to be more logical.

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SEED TESTING MANUALS

Both the Association of Seed Analysts (AOSA) and International Seed Testing Association (ISTA) have published new and updated seed testing manuals.

The AOSA "Rules for Testing Seeds" manual is in 3-ring binder format making it easy to add and remove pages and insert any additional information. The manual costs $55 US plus shipping and handling. You can contact Janice Osburn at aosaoffice@earthlink.net for additional information.

In the past, ISTA has published a complete manual "International Rules for Seed Testing" every three years following their Congress during which changes to the Rules were presented, voted on, and approved. The 'new' complete set of the International Rules for Seed Testing includes the following two separate publications: International Rules for Seed Testing, Edition 2003 and Annexe to Chapter 7, Seed Health Testing Methods. The Edition 2003 is in a binder format. Each year, updates, including additions or replacements of existing pages, will be published and can be separately inserted into the binder. The complete set costs ~ $215 US. You can contact Agnes Hegedüs at agnes.hegedus@ista.ch for further information.

Dale Simpson

UPCOMING MEETINGS

B.C. Seed Orchard Association Annual Meeting
June 17-18, 2003 Vernon, BC
Contact: George Nicholson (250) 546-2293
GWNicholson@Riverside.bc.ca

Western Forest Genetics Association Annual Meeting Genetics, Genomics and Adaptation
July 28-31, 2003 Whistler, BC
www.genetics.forestry.ubc.ca/wfga2003 for more information

IUFRO Seed Physiology & Technology Research Group Tree Seed Symposium
August 10-14, 2003 Athens, Georgia USA
Contact: Gary Johnson
wjohnson03@fs.fed.us or
www.ntsl.fs.fed.us for more information

XII World Forestry Congress
Forests , Source of Life
September 21-28, 2003 Quebec City
www.wfc2003.org for more information

Forest Nursery Association of BC
23rd Annual Meeting
S.O.S. (Seedlings/Objectives/Service)
September 22-25, 2003 Courtenay, BC
Contact: Siriol Paquet (250) 337-8487
svn@telus.net

ISTA Forest Tree and Shrub Seed Committee Workshop
October 20-25, 2003 Prague, Czech Republic
Contact: Zdenka Prochazkova
prochazkova@vulhmuh.cz

Seed Ecology 2004
Tentatively April 29-May 4, 2004 Rhodes Island, Greece
Contact: Costas Thanos
cthanos@biol.uoa.gr

ISTA Seed Symposium 2004 27th Congress
"Towards the Future in Seed Production, Evaluation and Improvement"
May 13-24, 2004 Budapest, Hungary
www.seedtest.org for more information

Molecular Aspects of Germination and Dormancy
May 24-25, 2004 Wageningen, The Netherlands

and

Third International Symposium on Plant Dormancy
May 25-28, 2004 Wageningen, The Netherlands
www.css.cornell.edu/ISSS/isss.htm for more information

If you know of a meeting that would interest the readership, please forward the information to the Chairperson or Editor.

SELECTED REFERENCES – HARDWOOD SEED

More papers from Dave's files. Mostly specific studies and not many reviews. Does anyone have some good reviews of hardwood seed biology? in their library that they would like to share with our readers? (EDITORS NOTE: see Flores 2002)

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EDITOR'S NOTE: Sincere appreciation is extended to Ben Wang for providing additional references to this list.

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