CANADIAN TREE IMPROVEMENT ASSOCIATION/
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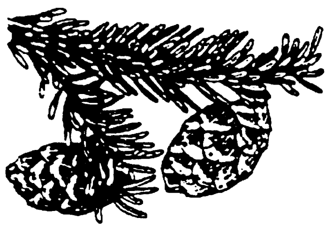

Tree Seed Working Group

NEWS BULLETIN

No. 39 June 2004

ENVIRONMENTAL IMPACTS ON SEED BIOLOGY

THIS ISSUE AT A GLANCE

CHAIR'S 'ARMCHAIR' REPORT

I hope everyone has been having a good summer. My present focus is on helping to organize the upcoming Canadian Tree Improvement Association (CTIA) meeting in Kelowna, BC. I look forward to seeing friends and colleagues involved in tree seed and tree improvement activities. The meeting will take place from July 26th to 29th. The theme is "**Climate Change and Forest Genetics**". Additional information can be found at our website: http://www.for.gov.bc.ca/hti/ctia/index.htm

The Tree Seed Working Group (TSWG) will have a workshop on July 26th covering the topic of "**Quality Assurance in the Seed Handling System**". Please see the next article for a full description of planned TSWG activities for that day. There will also be a Monday evening session discussing the results of a National Survey of Forest Genetic Resources Management Processes and Practices in Canada. This discussion is primarily directed at people involved with reforestation policy and landscape planning levels for reforestation, although all interested parties are welcome to attend. Additional information is available on the CTIA meeting website.

Prior to the CTIA meeting, a tour of the BC Ministry of Forests Tree Seed Centre will be conducted on July 23 (afternoon). If there is sufficient interest we can also provide a tour on Friday, July 30th (afternoon) after the CTIA meeting. Please contact me to indicate if you are interested in either of these tours.

Following the CTIA business meeting (Thursday afternoon, July 29th) the BC Tree Seed Dealers association (BCTSDA) will be hosting their annual meeting in a restaurant a few blocks from the CTIA meeting facilities. For additional information, please contact Patti Brown at

Patti.Brown@canfor.com.

Two new extension notes 'The Reproductive Biology of Western White Pine' and 'Environmental Effects of Yellow-cedar Pollen Quality' can be downloaded as a PDF file from the BC Forest Genetics Council website http://www.fgcouncil.bc.ca/framdocs.htm. An area occupying many peoples' time in BC is the construction of the Chief Foresters standards for Seed Use. An update of the status of this project can be found at: http://www.for.gov.bc.ca/hti/treeseed/chief-forester.htm

In addition to our biennial workshop, the main TSWG activity is the production of this News Bulletin twice a year. I strongly believe that it is an important and informative newsletter serving a vital need to those involved in reforestation. Obtaining content is challenging and I ask for your assistance in helping to keep the News Bulletin going. Contributions can be in a variety of formats including – technical or scientific articles, meeting announcements and reports, new equipment, or opinion. It allows for a wide-variety of input in a relatively free form format.

I often look back at why we exist and how we are contributing to improving 'tree seed science and technology'. The TSWG began in 1983 with four objectives on promoting tree seed science and technology through:

1) Seed research from bud initiation to seed utilization,
2) Identification of seed problems relating to tree improvement and forest management,
3) Exchange of information on seed related problems, and
4) Advising on implementation practices.

I bring up our objectives (again in the Armchair Report), as the focus of our next News Bulletin **(#40)** will be "**What are your biggest problems or information needs with respect to tree seed**". It is a topic that we can all write something about and one I urge you to contribute your opinions on. This year has been a CTIA-heavy year in helping to organize CTIA and I would really appreciate receiving volunteer contributions from our readers. Have a great summer and I look forward to seeing many of you in Kelowna this summer.

David Kolotelo
Chairperson

EDITOR'S NOTES

This issue contains several interesting contributions addressing the theme of 'environmental impacts on seed biology.' We are all aware of year to year variation in phenology and timing of seed collections. But could there be a trend that phenology is changing over time? The article "Plant Development" indicates this is indeed happening for trembling aspen in Edmonton, Alberta. Yet another example of climate change impact. Seed orchard management practices can also influence fitness and adaptation of seed. Climate can also impact fundamental processes such as dormancy and germination. These topics are covered in other articles in this issue.

Dave has been busy not only on the organization committee for the CTIA meeting but also planning a TSWG Workshop. The list of topics and speakers is presented in the next article. The Workshop should be informative and of interest to anyone involved in tree seed.

Dale Simpson
Editor

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

TREE SEED WORKING GROUP WORKSHOP

The Tree Seed Working Group will be holding a workshop on July 26th in conjunction with the CTIA meeting in Kelowna, BC. The theme of the workshop is '**Quality Assurance in the Seed Handling System**" and I am very grateful to the following speakers for agreeing to participate in this workshop. I will be encouraging dialogue and participation at this workshop – be prepared to share your experiences! Two additional speakers have also volunteered to present material on seed moisture content: George Edwards and Conor O'Reilly.

Time	Title	Speakers
8:30	Introduction	Dave Kolotelo
8:45	Crop Maintenance and Collection in Seed Orchards	Chris Walsh
9:00	Quality Assurance in Cone and Seed Processing	Al Foley
9:15	Quality Assurance in Seed Storage	Donna Palamarek
9:30	Quality Assurance in Seed Testing	Dale Simpson
9:50	**Coffee**	
10:15	Quality Assurance in Seed Preparation	Dave Kolotelo
10:40	Quality Assurance in the Nursery	Susan Thorpe Fernando Rey
11:00	Session Wrap-Up/ Discussion	
	Volunteer Papers	
11:10	Thermo-kinetics of Water Absorption, With Special Reference to Noble Fir Seeds	George Edwards
11:40	Effect of Moisture Content During Pre-treatment or Storage on the Germination Response of Alder, Birch, and Oak Seeds	Conor O'Reilly

There is no charge to attend CTIA workshops. I encourage you to register and attend the entire meeting, but if you are only attending the TSWG Workshop, please let me know so that we have adequate catering services available. I'm looking forward to the workshop, seeing familiar faces and meeting new faces interested in tree seed science. See you in Kelowna!!

Dave Kolotelo

SEED ORCHARD AFTER-EFFECTS. DO WE NEED TO WORRY?

Introduction

Most conifer seed orchard programs take advantage of warmer, drier southern climates to provide a natural inductive effect to promote flowering and substantially better seed production. This is the case in British Columbia as well. In particular for the Prince George Seed Production Unit, about 50 million seedlings are required annually. The bulk of this seed will be produced from seed orchards located in the warm, dry Okanagan (50ºN) for planting back in the Prince George area (53ºN). Seed production estimates will be met but are we jeopardizing genetic gain and/or plantation success when seedlings produced from northern/high elevation selections in southern/low elevation seed orchard sites are planted back to there northern environments? Do we need to worry?

Over the past 20 years, numerous studies have shown that progeny performance is affected by parental environment. This effect is long lasting and appears to be non-Mendelian (see reviews by Skrøppa and Johnsen 2000 and Saxe *et al.* 2001). Changes to adaptive traits, caused by contrasting environments, have been extensively reported for Norway spruce (Johnsen *et al.* 1996; Johnsen and Skrøppa 1996; Skrøppa and Johnsen 2000), and other species including Scots pine (Lindgren and Wei 1994), shortleaf pine (Schmidtling 2004), white spruce (Bigras and Beaulieu 1998, Stoehr *et al.* 1998) and larch (Greenwood and Hutchison 1996). In addition to delayed frost hardiness and bud flush, Stoehr *et al.* (1998) reported differences in germination traits, number of needle primordia, height growth, and frost hardiness in white/Engelmann spruce.

This phenomenon, first observed when northern parents were moved to a southern seed orchard location for enhanced seed production, is called seed orchard after-effects. Early evidence of after-effects (see further references in Johnsen 1989a, b and Johnsen *et al.* 1989) came from experiments with Norway spruce where progeny from seed collected from northern (63–66º N) selections was compared with controlled crosses from similar genotypes raised in grafted seed orchards at 53º N latitude. Under nursery conditions, seed orchard progeny suffered more damage in controlled freezing experiments (Johnsen 1989a) and consistently flushed and set buds later, had higher frequencies of lammas growth, delayed stem lignification, and were 15% taller than northern progeny after seven years (Johnsen 1989b). Johnsen *et al.* (1989) further showed that these changes in growth and frost sensitivity remained the year after transplanting into the field.

Since these studies were confounded by comparing wind pollination (in the natural environment) with control pollination (using seed orchard pollen only), Skrøppa *et al.* (1994) confirmed the earlier results with control pollinations of identical crosses done under contrasting environments. Furthermore, Johnsen *et al.* (1995) compared progeny created from like genotypes under the warmer conditions of a glasshouse to those from a nearby seed orchard. Again, progeny created under the warmer conditions of the southern seed orchard or glasshouse showed delayed development of fall frost hardiness.

The Mechanism

We do not know the mode of action resulting in these after-effects or their mode of inheritance. However, Skrøppa *et al.* (1994) and Johnsen *et al.* (1995) suggested that temperature and photoperiod, acting on reproductive development, may be the important triggers. Johnsen *et al.* (1996) provided evidence that the effect is not acting through male development (meiosis, pollen maturation) but rather through maternal development, the exact stage of which is still to be determined.

To test this hypothesis, we (Webber *et al.* 2004) subjected like genotypes of white/Engelmann spruce to two temperature regimes under the same photoperiod during: maternal development starting at the end of female receptivity (post pollination) and ending at early embryo development and paternal development starting at pollen bud swell (pre-meiosis) and ending at pollen shed.

Two populations of progeny were created from the two heat treatments experiments. In the first experiment, mother trees were exposed to cool (14°/8°C) and warm (22°/8°C) day/night treatments in walk-in growth chambers for a 12/12h day/night period. Treatments began at the end of seed cone receptivity (after meiosis) and ended with the onset of embryo development. In the second experiment, pollen development was also exposed to two different temperatures (10°/8°C and 20°/8°C day/night temperatures) beginning at pollen cone swelling (on-set of meiosis) and ending at pollen shed. Pollen from the two heat treatments was then applied to non-treated seed cone mothers. Seed from these two experiments were grown under nursery and field conditions and height and frost hardiness (spring and fall) were measured over a four year period.

Growth was unaffected by heat treatments applied during either maternal or paternal development. However, both spring and fall frost hardiness was significantly reduced by heat treatments applied to maternal development but not paternal development. The most consistent effect was on fall frost.

These results agree with the conclusions of Johnsen *et al.* (1996) that altered frost hardiness did not occur from environmental (temperature) affects acting on male development but they did occur when acting on female reproductive development. Furthermore, our results suggest that it is temperature and not photoperiod that induces the observed changes in frost hardiness.

Skrøppa and Johnsen (2000) offered two possible hypotheses to explain the results: gamteophytic selection and gene regulation. We can eliminate gametophytic selection during male meiosis/development but it is a possible mechanism acting through maternal development (Schmidtling 2004). Skroppa and Johnsen (2000) argued against such a mechanism suggesting that only 3–7 pollen grains per micropyle or 2–4 embryos per ovule are too few to select from. However, in our (Webber *et al.* 2004) experiment, an average of six to eight cones were treated each with a potential of 90 ovuliferous scales or 180 ovules per cone and a further potential of 2 archegonia per ovule. The selection pressure for this particular treatment could then range from 3,200 to 10,000 pollen grains which were available to fertilize 2,100 to 2,800 ovules. With this kind of intensity it seems reasonable to suggest that gametophytic selection (either male or female) could occur.

Skrøppa and Johnsen (2000) also suggested that gene regulation with long lasting effects could explain the results. Genomic imprinting (whether a gene is expressed or not) has been proposed to explain changes in other plant systems but it certainly has not been demonstrated in conifers.

Conclusion

Seed orchard after-effects appear to be a real phenomenon, at least in the species studied. Temperature during seed cone development can affect frost hardiness. Photoperiod has also been implicated but it was not a factor in our experiment. However, we must not dismiss the possibility that both temperature and photoperiod interact. Regardless of the mechanism, temperatures applied during sexual reproduction in spruce had a significant effect on fall frost and to a lesser extent on spring frost hardiness.

The observed environmental effects on progeny performance have important biological implications but they are not likely to change current breeding or seed production strategies. The extent of altered adaptive performance seldom exceeded 10–15%. However, if significant changes occur to our climate, then the effect of temperature on progeny performance could have an important effect on deployment strategies for seed orchard stock.

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ENVIRONMENTAL IMPACTS ON DORMANCY AND GERMINATION

Introduction

My purpose is to review observations on genetic, maternal-environmental, and environmental effects on dormancy and germination speed. These observations grew out of a number of genetic studies at our location on adaptive variation in widespread conifer species. This is not a general review of environmental impacts but some information from the literature has also been included. We worked primarily with four coniferous species (Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), lodgepole pine (*P. contorta*), and western hemlock (*Tsuga heterophylla*)) whose dormancy requirements were satisfied by a period of moist chilling and temperatures conducive to embryo development. Other conifer species mentioned are, to the best of my knowledge, species whose seed dormancy is primarily satisfied by moist chilling.

Germination timing will be referred to in either of two ways. Germination speed will refer to the time (T) between entering conditions favorable for embryo development and emergence of the radicle from the seed coat. Germination rate will refer to embryo development per unit time (1/T) between entering favorable conditions and radicle emergence. The two terms have different statistical properties when applied to a population of seeds. If dormancy requirements are satisfied, germination frequencies of seeds within the population are normally distributed on the rate scale (i.e., the 1/T scale), whereas germination speeds are highly skewed on the time (or T) scale (Campbell and Sorensen 1979).

Two other relations, first between germination temperature and length of chilling and, second between germination rate and length of chilling should be mentioned. In the first case, the range of temperatures at which an embryo will develop is directly related to the length of chilling; the longer the period of moist chilling, the broader the range of temperatures at which embryos will develop (Vegis 1963). In the second case, embryo development rate is directly related to the chilling period on a log-log scale (Sorensen 1980, 1983). In other words, if increasing the chilling period from 1X to 2X days increases the embryo developmental rate by 20%, then to increase the developmental rate by another 20%, the chilling period must go from 2X to 4X days.

Genetic Effects

The interest here is in environmental effects, but it might be well to have an impression of genetic variation before evaluating the environment. Germination speed in conifers is highly heritable and is controlled in particular by the maternal diploid genotype (Stone 1957, McLemore and Barnett 1966, Bramlett *et al.* 1983, Hoff 1987, Downie and Bewley 1996). In a test with ponderosa pine, 296 families from 225 locations in central Oregon were given two chilling period-germination temperature treatments (30 days chilling/16°C germination, called warm) and (60/11.3°C, called cold) (Weber and Sorensen 1992). Variation among families in germination speed (days to 50% germination) was very large ranging from 2.3 to 20.0 days (mean 4.3) in the warm test and from 2.6 to 30.9 days (mean 6.8) in the cold test. Variation among locations was highly significant statistically, but in spite of the large number of locations tested, families within locations accounted for about 60% of the total family variance. Campbell and Ritland (1982) found similar variation among 12 locations (family-within-location effects were not reported) of western hemlock. Much of the variation among locations could be related to latitude, elevation and distance from the ocean, but the relation was complex.

The main point here is that there is much genetic variation in germination behavior. If environmental effects are to be evaluated, genetic variation needs to be controlled. The following list of environmental influences, as far as I can tell, comes from studies in which genetic and environmental effects were not confounded.

Environmental Effects

Seed Maturity

In Douglas-fir, unstratified immature seeds germinate more quickly (have lower dormancy) than unstratified mature seeds from the same trees. However, embryo development rate of mature seeds has a greater response to stratification, such that after long stratification all seeds germinate at the same rate (Sorensen 1980).

Post-harvest Handling of Cones

Samples from a common lot of Douglas-fir cones were sent to four locations for cone drying. Cones were then returned to a common location for seed extraction. Seed germination variables were recorded under a combination of three stratification periods and two incubation temperatures. Germination percentage, mean rate of germination, and uniformity of rate all differed significantly among cone-drying treatments (Sorensen 1991). Allen (1958) also observed that cone drying treatment influenced rate of germination.

Storage of Cones

Germination rate of Douglas-fir seed was reported to be increased with length of cone storage (Bloomberg 1969). Both germination rate and total germination were sensitive to cone storage conditions in southern pines; rate being more sensitive than total germination (Bonner 1987).

Dry Storage of Seed

Dry storage of seeds can potentially reduce dormancy and increase germination rate through after-ripening, or decrease germination rate through induction of secondary dormancy. Because one of our tests indicated that seed storage might have affected time to emergence, we tested the effect of dry storage on the seed of 12 Douglas-fir families at storage temperatures of -12°C and +3°C for short periods up to 32 weeks and longer periods up to two years. The effect of both short- and long-term storage on germination rate was significant, but unimportant in practical terms (Sorensen 1999). Other tests have given different results. Stone (1957) found that the first 12 months of Jeffrey pine (*P. jeffreyi*) seed storage changed germination behavior considerably. Vanesse (1974) reported a significant increase in dormancy of Douglas-fir seed after several years of storage. Older ponderosa pine seed also has deeper dormancy than fresh seed (Woods and Blake 1981). Moisture content of the seed in storage influences dormancy (McLemore and Barnett 1968), which partially may account for the inconsistent results among the cited tests.

Year of Collection

Cones were collected from the same two blocks of an Oregon Douglas-fir orchard in two different years and, as much as possible, uniformly handled and processed. Seed germination was compared under a combination of two stratification periods and two incubation temperatures. All three germination variables (percent, rate and uniformity) differed significantly between years of collection (Sorensen 1991).

Maternal Environment

Pre-germination treatments and germination test conditions are standardized for Douglas-fir (Schopmeyer 1974: 678–679). These tests included a maximum chilling duration of 3 weeks and were reasonably satisfactory for wild stand collections. However, when seed lots from Willamette Valley, Oregon orchards were tested under the same conditions, apparently good seed lots germinated slowly and incompletely. When the orchard seed was stratified for 12 weeks, germination was rapid, uniform and complete, even at an incubation temperature of 15°C (Sorensen 1991). The environment in which the cones developed, maturity of the seed when cones were collected, and the different handling and processing of seed orchard versus wild stand cones all could have contributed. In the southern pines, seed orchard culture has increased seed size and decreased dormancy compared to seed collected in the wild (Barnett 1995). In *Picea abies*, seed from orchard ramets germinated more slowly than seed from ortets in natural stands (Bjørnstad 1981).

Conclusion

Genetics, maternal-environment, and environment can influence dormancy and embryo development rate of conifer seeds whose dormancy requirements are met by moist chilling. There appears to be much interaction among environmental effects themselves, and possibly between environmental effect and species. In all cases that we have studied, increasing the duration of moist chilling of healthy seed reduced the magnitude of genetic and environmental effects. This was particularly true if germination was at cool temperatures.

There is one interesting side issue to the maternal effects. Dormancy appears to be under strong maternal control (citations given above). If the covering structures regulate dormancy and the covering structures are of maternal origin, one would expect seeds within a family to germinate at the same rate. But this is not the case, there is much variation in germination rate among seeds from a single tree (Sorensen and others, unpublished). Possibly the embryonic genotype is important, but considering the many environmental effects noted above, it also may be worth considering how much within-family variation might be due to variation in environmental conditions within the crown (Huber 1926), or even within the cone (Munns 1921)?

Finally, although not including much on conifers, a good review of parent-environment effects can be found in Fenner (1991).

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PLANT DEVELOPMENT

Major stages in the development of plants, such as budding, leafing, and flowering are triggered by seasonal changes in temperature, moisture, and the amount of light. In southern Canada, plants begin to develop rapidly when average daily temperatures reach and stay above certain critical levels.

As a result, the timing of plant development varies from year to year with changes in weather conditions. The early arrival of warm weather results in plants developing sooner, while their development is slower if warm weather is delayed. Over the longer term, these changes in the timing of plant development make a good indicator of changes in climate. Farmers, ranchers, and gardeners are especially interested in these changes because of their effects on the way crops, livestock, and garden plants have to be managed.

As our climate has changed, spring across much of the country has been getting warmer earlier. This should give most plants a head start on their development and result in the earlier arrival of noticeable events like budding and flowering.

At various intervals over the past 100 years, observers in the Edmonton, Alberta area have recorded the flowering date for a common North American tree, the trembling aspen (*Populus tremuloides*). Researchers from the University of Alberta put four sets of observations together to see if there has been any noticeable change in the flowering dates during the twentieth century. They found that between 1901 and 1997 the average date of flowering has advanced by about 26 days – from early May at the beginning of the century to early April at the end (Fig. 1).

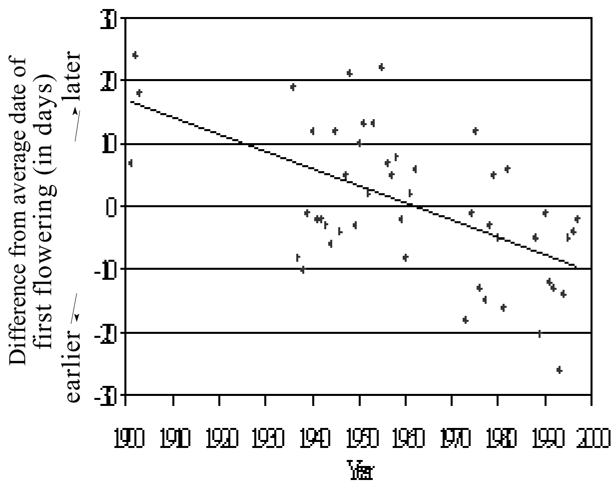

Figure 1. Date of first bloom for trembling aspen at Edmonton, Alberta.

The trend towards earlier flowering coincides with warmer springs on the Prairies. During the twentieth century, daily high temperatures in spring increased, on average, by more than 2°C, and overnight lows increased even more. The city of Edmonton has warmed more than nearby rural areas, mainly because it has less green space and more asphalt and buildings. This "urban effect" may have also influenced the earlier flowering of the trembling aspen in the area.

Most studies of plant development in Canada cover periods of about 20 years or less. Nevertheless, these and the few long-term studies that are available agree with what was seen in Edmonton – most plants are reaching major stages in their development earlier in the spring. Since 1937, for instance, the average date of full bloom for McIntosh apple trees in Summerland B.C. has advanced by about 5 days. Similarly, the average date when lilacs come into leaf in the United States and southern Canada advanced by 5–6 days between 1959 and 1933. In Europe, where more data covering longer periods are available, the trends are even stronger. Satellite observations also show an earlier greening of the Northern Hemisphere. Northern forests are now coming into leaf earlier and losing their leaves several days later than they did in the early 1980s.

These changes could have important consequences for ecosystems, agriculture, and human health. Earlier development means a longer growing season, which creates opportunities for growing new crops and improving farm yields. However, disease-carrying and crop-eating insects could become more of a problem since their breeding and growth are also affected by temperature. Hay fever sufferers could find their miseries starting earlier too. In addition, complex ecological relationships could be upset if interacting species, like plants and the insects that pollinate them or birds and the insects they eat, respond at different rates to climate change.

EDITOR'S NOTE: This article was reproduced with permission from the Canadian Council of Ministers of the Environment publication "Climate, Nature, People: Indicators of Canada's Changing Climate", November 2003.

EFFECTS OF CHILLING DURATION AND GERMINATION TEMPERATURE ON GERMINATION OF EASTERN HEMLOCK SEED

Eastern hemlock (*Tsuga canadensis*) seed from the Maritimes may exhibit a higher degree of dormancy than in other parts of it's range. The germination testing prescription for eastern hemlock is 28 days pre-chill at 3–5°C followed by 28 days in a germination cabinet at constant 15°C (AOSA 2002, ISTA 2003). Eastern hemlock seed tested using this recommendation has resulted in extremely poor germination. The Atlantic Tree Seed Centre in Kingsclear, N.B., chills eastern hemlock seed for 6 months and germinates it at 20°/30°C. This prescription was being used at the National Tree Seed Centre and had yielded very good results.

Methods

A germination experiment was set up to test chilling and germination requirements. Four single tree seed lots from each of two New Brunswick provenances were selected. Four replicates of 50 seed each were placed on moist Kimpak in Petawawa germination boxes. The seed in the boxes were chilled for 0, 4, 8, 12, 16, 20, and 24 weeks at 3°C before being placed in germination cabinets set at 15°C, 10°/15°C, and 15°/25°C with 8 hours light/16 hours dark and a constant RH of 85%.

Germination assessments were carried out at days 7, 14, 21, and 28. Germinants were categorized into three classes: radicle greater than 1X length of seed; radicle greater than 4X length of seed; and fully germinated having a well developed radicle and hypocotyl and with the seed coat starting to separate from the cotyledons. Results presented here are for fully germinated seed.

Results and Discussion

Germination temperature had a dramatic impact on the ability of the seed to fully germinate. Seed germination was highest at 15°/25°C for all but one of the chilling times (16 weeks) (Table 1). Germination was consistently lower at 10°/15°C. Seed germination at 15°C was less than at 15°/25°C until after 16 or more weeks of chilling when it was about the same. The poor germination at 10°/15°C clearly shows that this is not an appropriate temperature regime for germination of eastern hemlock seed.

The steady increase in germination with increasing chilling time indicates that dormancy was steadily being alleviated. The warmer germination temperatures of 15°/25°C promoted higher germination for seed chilled 12 weeks and less as a result of higher germination speed. After 16 weeks of chilling dormancy was sufficiently alleviated that the two warmer germination temperatures had little impact on total germination.

Average germination of the fresh seed, before storage, which had been chilled for 24 weeks and germinated at 20°/30°C was 91.5% which is similar to the results obtained in this experiment for seed chilled for 20 weeks and germinated at 15°C (87.7%) and 15°/25°C (90.0%). One seed lot consistently had poor germination. When this seed lot was excluded, the fresh seed chilled for 24 weeks and germinated at 20°/30°C germinated at 92.2% compared to 92.8% and 94.4% for the seed chilled for 20 weeks and germinated at 15°C and 15°/25°C, respectively.

The chilling requirement of 4 weeks recommended by ISTA and AOSA is clearly insufficient for breaking dormancy in eastern hemlock seed from New Brunswick and possibly also for other sources in the northern extent of the species range. Moist chilling of the seed for 16 weeks is more appropriate, however, the Seed Centre will adopt 20 weeks to account for variation in chilling requirements within and among seed lots. The recommended germination temperature of 15°C works well although germination at higher temperatures (15°/25°C and 20°/30°C) also yielded good results. It appears that once dormancy is overcome, seed will germinate under a wide range of temperatures. However, germinating the seeds under cooler conditions such as a 10°/15°C regime is clearly inferior for eastern hemlock.

Table 1. Germination (%) of eastern hemlock seed chilled for 0, 4, 8, 12, 16, 20, and 24 weeks and germinated at 10°/15°C, 15°C, and 15°/25°C

Germination temperature	Chilling time (weeks)						
	0	4	8	12	16	20	24
10°/15°C	0	0	0	0	33.1	50.2	55.3
15°C	0	13.1	58.5	74.6	88.1	89.3	88.7
15°/25°C	0	65.3	77.1	82.3	87.5	91.8	90.0

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NEW ISTA WEBSITE

The International Seed Testing Association recently launched its new website. The menu bar covers six categories including: About ISTA, Member Services, Technical Committees, Accreditation, Publications, and Seed Testing Links. A drop-down menu will appear when you place the cursor over any category allowing you to quickly access additional relevant information. Publications can be ordered online. You can visit ISTA at their same address: www.seedtest.org .

UPCOMING MEETINGS

Canadian Tree Improvement Association
plus Tree Seed Working Group Workshop
July 26-29, 2004 Kelowna, BC
Contact: Dave Kolotelo Dave.Kolotelo@gems7.gov.bc.
or http://www.for.gov.bc.ca/hti/ctia/index.htm

Forest Nursery Association of BC
24th Annual Meeting
Do's, Don'ts, and Diligence
September 27-29, 2004 Surrey, BC
Contact: Dave Trotter dtrotter@gems2.gov.bc.ca
or John Kitchen john.kitchen@prtgroup.com

IUFRO Seed Physiology & Technology Research Group
Tree Seed Symposium
September 20-22, 2004 Nanjing, China
Contact: Fangyuan Yu fyyu@njfu.edu.cn or http://www.njfu.edu.cn/seed2/index.htm

8th International Workshop on Seeds
"Germinating New Ideas"
May 8-13, 2005 Brisbane, Australia
Contact: info@seedbio2005.asn.au

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With a topic as broad as "Environmental Impacts on Seed Biology" a bibliography would cover several hundred pages. I have selected several topic areas (I'm sure I've missed some) and selected references in my files that are either considered 'classics' or may be somewhat obscure and unknown to most readers. Many are from outside the narrow scope of tree seed and I hope they are informative and thought-provoking. Enjoy! **Dave Kolotelo**

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