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

Tree Seed Working Group

NEWS BULLETIN

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THIS ISSUE AT A GLANCE

CHAIR'S 'ARMCHAIR' REPORT

First, I'd like to wish everyone a Happy Holiday season. Hopefully you'll have time to leave all the mounting pressures of the world behind for a while. For many of us these times involve a close scrutiny of our 'seed programs' for budgetary, bureaucratic and political reasons. This is occurring across Canada and I urge all to become familiar with the situation in your province. This not only involves the lack of funding for tree seed research programs, as we've discussed in the past few years (i.e. Newsbulletin #29), but extends to questioning the level of responsibility for managing our genetic resources.

Thank you to all the authors who contributed to this Newsbulletin. The theme for the next Newsbulletin (June 2002) is a review of seed 'users' in Canada and their respective **legislation**, **policies** and **procedures** concerning tree seed and its use. I encourage all governmental and private institutions to make contributions and share your unique picture with others. If we are going to address issues regarding support for tree seed on a National level we need a good understanding of what is happening in each province. I will be contacting many of you in 2002 with more details about this topic. Although we do have a Newsbulletin theme, this does not exclude contributions on other topics. The subject of the Newsbulletin being available over the internet in the future vs. direct mailing has recently come up. Your opinions on this are requested.

The CTIA will be having its meeting this summer and we are planning on organizing a tree seed workshop. Please read the enclosed article and provide comments to Ron or myself concerning topics of interest and whether you are interested in presenting material. Our business meeting, at the CTIA, will also allow interested parties to discuss the landscape of legislation, policies and procedures currently present in Canada and how the TSWG can be a more active voice in issues regarding tree seed.

I would like to draw attention to the recent publication "Native Woody Plant Seed Collection Guide for British Columbia" by Mishtu Banerjee, Kim Creasey and Diane Gertzen. Although geared to BC, the text covers many nation-wide species in a well organized and illustrative manner. I'm also very pleased to announce the publication of the "Seed Handling Guidebook" through the BC Ministry of Forests and to thank the other authors who provided input into the publication: Eric Van Steenis, Michael Peterson, Robb Bennett, Dave Trotter, and John Dennis. For information on how to obtain the Seed Handling Guidebook, please contact me directly.

What I really want to talk about are the topics of "shooting eagles" and "toy research" that I promised to expand upon in this armchair report. These controversial topics are actually based on two papers with similar messages that I encountered during my forestry undergraduate degree. These articles, from quite different disciplines, provide two different visions or ways to 'characterize' research. They tie together ideas related to scientific vs 'corporate' impact; types of problems addressed and research performed; and a framework that questions what is currently happening. These issues are relevant to the current TSWG mandate and become more so if we are interested in lobbying for the increased support of tree seed research in Canada. (Continued page 2)

I'd like to first discuss a paper that characterizes the type of research and type of problem into two classes: real and toy (Sprague & Sprague 1976). This results in four possible combinations of problems and research with the objective being Real Research on Real Problems (Figure 1).

		Type of Research	
		Toy	**Real**
Type of Problem	**Toy**		
	Real		Objective

Figure 1. A view of the four combinations of type of research and type of problem. (From Sprague and Sprague, 1976).

The terminology may be insulting to some, but the authors contend that most research is of the Toy Research/Real Problem or Real Research/Toy Problem variety. They define a Toy Problem as: 1) a real problem that has been simplified to the point that results cannot be integrated with other results; or 2) where advancement of a 'technique' (i.e. form of analysis) takes precedence over the actual problem. The classic toy problem is the teaching example used to clearly illustrate theory using a simplistic model of reality.

Real problems are more complicated and involve the introduction of practicalities such as cost effectiveness, legal requirements, biological processes and their variability and the political flavour of the day. A balance must be made between modelling reality to allow research to proceed and ensuring the model is practical, applicable and clearly understood. The authors also make the point that these types of problems (toy and real) represent the extremes and a spectrum of problem types exist.

They define Real Research as that which confirms, denies, or leads to the development of theory. Under this definition falls the classic experimental research, but also the grossly underrated experiential research (i.e. quality assurance monitoring) that helps quantify problems or their signs in their 'natural' setting. The problem with peoples experiences is that they are often not quantified (or have no consistent procedures for quantification) or not compared with a control. Toy research is simply those studies that do not meet the definition of Real Research. While this paper stems from a totally different discipline and some of the messages are not relevant the image in Figure 1 illustrates the type of interactions possible and the goal of performing Real Research on Real Problems. I believe that thinking about what type of research is needed and questioning the research currently occurring is important to ensure our efforts are relevant and have practical application.

The second paper is easier to comprehend and closer to home, but is similar in that it presents four possible types of research projects based on corporate impact and scientific impact (Wolff 1986). In this classification research can be divide into four groups: dogs, cows, sheep and eagles (Figure 2).

		Scientific Impact	
		Low	**High**
Corporate Impact	**Low**	Cows	Eagles
	High	Dogs	Sheep

Figure 2. A view of four possible types of research projects based on scientific and corporate impact. (From Wolff, 1986).

The imagery is clearer here and one can see that the purpose is to motivate researchers to "shoot for the eagles" and have a high impact on both the scientific discipline and the corporation or business area. While the dogs are projects to be avoided the sheep and cows both have roles to play. The Cows can be thought of as the fire-fighting department that responds to immediate problems and has high corporate visibility and benefit. The sheep are those projects in which the application of research may not

have any immediate corporate application, but can have large long-term benefits.

The bulk of the paper focuses on how to manage for eagles and I'll discuss a few of these. The first is to work with people who make things happen and encourage the movers and shakers within any organization. Secondly, encourage problem-driven research which relates back to Toy Research as many young researchers may be more methods-orientated rather than problem-driven. For example, the young researcher may fall back on their expertiose with certain analytical tools and look for problems that can be solved rather than finding problems and then identifying the analytical tools to address the problem. A key element of the eagles is the ability to be a champion of their program and sell their results. Look at the researchers you most respect and you will probably find these traits clearly evident.

Sitting back in my armchair how does all of this come together? I believe that eagles are a rare breed and most of the research falls into the sheep and cow classes. The problem with this is that the people working on sheep and cow projects often do not speak the same language (i.e. have different priorities , values, and reward systems). In my opinion this is very much the case with tree seed research in Canada: it is hidden in some ivory tower or in some corporate filing cabinet – if it exists at all. There is a lack of a consolidated effort to address common seed problems and the sharing of information does not readily occur. A communication gap exists.

How can we 1)) motivate research scientists to reach for the eagles? and 2) encourage research on tree seed. The first requires that we breakdown the communication gap between basic and operational researchers. This is not easy, but if we don't accept it as a problem it will never be solved. The second requires a basic appreciation of the value of our genetic resources and a general increase in the level of funding for forestry research. This has been a large problem as BC, for example invests 0.26% of its gross forest product sales into forestry research. This is too low compared to the 1.2% for the United States and 1.75% for Sweden (Binkley 1990). Our genetic resources are too important and we know too little about their stability into the future to not fund the required research. I believe the Tree Seed Working Group is the forum to rally for funding of seed research that is relevant to Canada. This may be a pipe-dream, but who else is going to ensure that due diligence is provided and that our seeds are of high quality, used efficiently and adapted for today without compromising their ability to do so tomorrow.

References

Binkley, C.S. 1990. Creating a knowledge-based forest sector in British Columbia. Keynote address at the Forest Sector Conference. Vancouver, BC. Sept. 20 1990. 8 pp.

Sprague, L.G. and C.R. Sprague. 1976. Management science? Interfaces 7(1):57-62.

Wolff, M.F. 1986. Motivating research scientists to reach for the eagles. Research Management 29(5): 8-10.

Dave Kolotelo, Chairperson

EDITORS NOTES

My notes will once again be very brief. I am preparing to leave for China as I compile this Issue. My choice of wording is deliberate when I say 'compile'. Dave Kolotelo has once again done most of the work in recruiting articles for this issue. I promised Dave to do my best to publish a November Issue provided sufficient material arrived here by the middle of the month. Well, the fact that you are reading this more than adequately explains what happened. Once again, we should all thank Dave as well as those members willing to take the time out of their busy schedules to prepare 'stuff' for us to read an enjoy!!!

Please note the attached erratum page - Once again my apologies for the proper credits for an article having been omitted last issue. PLEASE REPLACE PAGES 17-18 FROM THE May 2001 Issue with the once enclosed with this issue. Once again, my apologies to Fabienne Colas.

The NewBulletin soon to be on the web!!!

In an effort to reduce printing and mailing costs we will looking to start publishing the Tree Seed NewsBulletin on the web in PDF format. In 2002, we will be sending out a short information sheet with BOTH the May and November NewsBulletins on which individual subscribers will be asked if they wish to continue to receive the paper copy. **ONLY THOSE SPECIFICALLY REQUESTING A PAPER COPY WILL CONTINUE TO RECEIVE IT IN THIS FORMAT.**

PLEASE BE ON THE LOOK OUT FOR THIS CHANGE!!!!!

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Comments, suggestions and contributions for the Newsletter are welcomed by the Chairman or Editor.

SEED ENHANCEMENT / UPGRADING TECHNIQUES - "READ THE SEED"

K.R. Creasey
Nature's Common Elements

[The following article was edited and has been reproduced with permission from a paper presented at the Western Forest And Conservation Nursery Association Meeting Kailua-Kona, Hawaii - 00/08/21-25]

To the Nursery Industry in Canada, seed enhancing and upgrading techniques have ever increasingly become and are now an integral part of their operations prior to greenhouse sowing. The terms 'enhancing' and 'upgrading' can be used interchangeably, but essentially mean the same thing. It's the idea of improving initial processed seed quality, which can be accomplished in many ways. Our upgrading work encompasses a number of coniferous species, such as White, Red, Jack, Lodgepole Pine, White, Black, Engelmann & Blue Spruce.

Credit for the initial "operational IDS" beginnings in Canada over and above the documented research goes to the former company of Western Tree Seeds of Blind Bay,B.C. - Frank Barnard and Tom Hilman. These two gents began with an idea and made it reality. Others have also had significant input, resulting in proving this technology as a benefit for the nursery industry.

Water separation techniques applied to cleaned seed, removing physically damaged seed, heavy debris, light debris and dead/empty/partially filled seed are making notable improvements to seedlot vigour and germination capacity. Seeding efficiency and conservative utilization of the seed are the most important and beneficial factors. When using water separation techniques seed is more responsive when compared to air separation equipment. The upgrading techniques for this presentation center themselves by utilizing the combination effects of (1) PREVAC (pressure vacuum) and (2) I.D.S. (Incubation, Drying, Separation). Important scientific principles and attention to detail for each of these is integral, the cornerstone to achieving successful results. Tracking moisture content initially and throughout the processes is essential and very interesting to follow. A picture is provided by this information as to what moisture levels are in various stages of treatment.

It is very important to have a pre-set worksheet to record initial seedlot details as well as all pertinent and necessary information collected through all processing stages. Once treatment is completed, a wonderful snapshot is created giving an excellent reference of the seedlot dynamics and how the results were derived. Similar situations with other seedlots can be determined by comparison whether the results are favourable or not or even as an antidote to describe something unique.

Prevac: The principle for PREVAC is that when vacuum is created within a pressure vessel containing the appropriate amount of seed and water, 'air and airspace is replaced by water'. Damaged seed (whether cracked, abraded or chipped) and heavy debris therefore become heavier than the water and sink. Species tolerance to vacuum pressures and time needed must first be established before the proper protocol can be set for operational routines. With some species, ie. Black Spruce, modified solutions, Glycerin based ($C_3H_3O_2$), need to be used sometimes to achieve a proper sink/float pattern. Seed density can improperly represent damaged seed and cause sound healthy seed to end up as part of the sunken fraction.

A transparent "Cone" constructed from acrylic and lexan material with a bottom valve is the unit used for separating the good and damaged portion of the seedlot after the pressure treatment has been applied.. Remember - the floating seed in this stage is the good fraction, the sunken is the removed or discarded fraction. In order to achieve the best separation the floating seed will need careful/frequent stirring/poking with a small dowel stir stick while in

the "Cone" to allow the damaged seed and debris to move through the seed mass and settle to the bottom.

To collect the damaged seed fraction, a mesh nylon bag is placed over the valve outlet and opened. The water is drained until the good seed fraction just reaches the valve inlet and then the valve is closed quickly. Water is refilled and the process repeated, a couple of times may be necessary in order to gain the desired result. Initially the water may be very murky due to resin dust being removed off the seed, so a close eye must be kept as to where the base of the good fraction is and that no funneling is occurring within the cone as water is being drained. Once finished, the good fraction is also collected into a mesh nylon bag. Catching the seed in separate mesh bags then allows the water to be spun from the seed using a "Spin Dryer" unit. "Tip" - To know that the process is done well, the good seed will have a "nice rustling" sound to it as the seed is moved within the bag. Some floating debris may still be remaining but this is something that represents little concern as it will come off with the floating fraction through the IDS treatment, but watch that it does not become a pathogenic source through the next stage. Spin seed until water draining out slows to just a slight drip. To prevent equipment damage or premature wear, ensure centrifuge is balanced while spinning.

Collecting a sample for moisture testing is very necessary after this separation is completed for both the good and removed fractions for two reasons, 1) to draw a comparison of the actual percentage of seed/debris removed from the seedlot through the dry weight calculation 2) calculating the dry weight of the good fraction is the basis for determining moisture content right up to the point of separation and a very important primary function. It is always interesting to note the difference in moisture content between the two fractions. The good fraction will range in moisture content in an area of 12% to 15%, while the removed fraction will range broadly from a low of 16% to a high of about 30%. Species types and certainly individual seedlots have interesting resultant moisture contents.

Prevac Equipment; Build Your Own!!

Equipment Supplier: VWR Canlab
www.vwrcanlab.com or 1-800-932-5000
Equipment Details:
Gast Pressure/Vacuum Pump - Model #523-V4F-G582DX Cat. # 54908-005 now N/A
@$690.03 CDN plus taxes and freight, Alternately - Model #0323V4AG582DX
Cat. #54907-057 @ $748.28 CDN
Vacuum Chambers, Nalgene
- 8 3/4" o.d. X 10" h, Cat. No. 54929-62 @ $233.72 CDN
- 12" o.d. X 12" h, Cat. No. 54929-084 @ $435.11 CDN

290 PUR Tubing, Ether-Grade, Nalgene - 1/4" i.d. X 3/8" o.d.; 1/16" wall thickness
Cat. No. 63014-228 @ $78.95 CDN per 50' coil

Separation Cone and stand are items that are custom built and is something that could be constructed very simply if you are handy with design and fabrication work.

Protocols By Species

Black Spruce

Prevac:

- Prevac, letting vacuum pump reach a maximum vacuum pressure of 25 inches of hg. The approximate run up time is about 10 sec.
- Remove seed from vacuum chamber, by pouring seed into "Cone", partially filled with water, stir, drain and collect the seed fractions into a mesh bag. - Remove excess surface water using the "Spin Dryer".

OR

- Prevac as above, remove seed from vacuum chamber, by pouring seed into "Cone", partially filled with just water and collect the sunken portion into a separate mesh bag from that of the floating fraction. - - Remove excess surface water using the "Spin Dryer". Modified solution separation will only be used on the sunken fraction to recover lost seed and can be simply done by adding glycerin to the water until the desired seed float is "observed". Experience can be the best teacher.

Separation:

- Mix up a glycerin ($C_3H_8O_3$) solution with a specific gravity of 1.060, check first to ensure this is the correct specific gravity required by first treating a couple of 100 seed reps. The test separation is evaluated by germination test information received.
- This specific gravity is generally acceptable for Sb seed @ 14 to 15% moisture, but expect seedlot variations.
- Pour seed into the mixed solution contained in separation cone.

- Stir to mix in well and allow to settle over the next few minutes. Resins, stones, other heavy debris and cracked and damaged seeds will sink to the bottom.
- Remove as debris, seed and particulate material collected in the bottom of the cone and those seed suspended below the main floating fraction.
- Use a catchment container for glycerin liquid as solution can be stored and reused.
- Rinse both fractions well in cold running water and again remove excess surface water in spin dryer. Floating seed fraction can now be combined with initial floating fraction.
- Separation is complete, next stages of upgrading treatments can now proceed.

Solution variations due to Moisture Content:

1.033	7 to 8 %
1.060	14 to 15%
1.100	26.1% - large size fraction
1.115	25.9% - small size fraction

Other Species

Jack Pine - Prevac: Prevac, letting vacuum pump reach a maximum vacuum pressure of 27 inches of hg. for 1 min., inclusive of run-up to pressure.

Lodgepole Pine - Prevac: Prevac, letting vacuum pump reach a maximum vacuum pressure of 15 inches of hg. for 30 seconds to 1 min., inclusive of run-up to pressure.

White Pine - Prevac: Prevac, letting vacuum pump reach a maximum vacuum pressure of 27 inches of hg for 30 seconds, inclusive of run-up to pressure.

Red Pine, White Spruce - (Engelmann Spruce, Sx Spruce, Sitka Spruce, Blue Spruce) - Prevac: Prevac, letting vacuum pump reach a maximum vacuum pressure of 20 inches of hg. The approximate run up time is about 8 seconds, inclusive of run-up pressure.

IDS: The principle for I.D.S. is that 'only living tissue can retain moisture; dead and dying tissue is exactly that .....dead and dying seeds will float by creating the precise density differential through dryback. Initially metabolic activity within the seed first needs to be mobilized before the sequence proceeds to its' end.

"I" - thus represents a Modified Stratification and requires that seed be at a high mc, 28%-35% to begin the process in alleviating seed dormancy. The seedlot is first afforded a 24 hour aerated cold water soak, spun dry removing surface moisture only, followed by three weeks in a customized "Refrigerated Misting Cabinet" with temperatures, 2° to 5°C and 100% humidity level. Seed is contained in a 6" by 28" acrylic tube fitted with a combination of nylon screening and gortex end covers held in place with friction rings constructed from nylon tubing that is fitted to the inside of the tube. The gortex end covering allows seeds'free air exchange and moisture uptake. The nylon screening provides a separation between the inner chamber and gortex, thus preventing the seed mass from blocking the air exchange across the membrane (Downie 1999). At this stage it is essential to allow seeds' additional water and proper air exchange to ensure that initial metabolic activity is not impeded and the seeds' do not suffer anoxia. Rolling the tubes daily repositions the seed mass and ensures a close inspection of the seed. The optimum volume per tube is 3.500 kg. but if necessary the maximum volume per tube could be as much as 5.600 kg. Required humidification within the cabinet is provided using a "Slat/Fin Electric Warm Mist Germ Free Humidifier".

"D"- represents "Dryback" which is the procedure to effectively create a density differential and establish a sink/float ratio that matches the dead seed component from the most current germination test results. Marked sampling assessment over the drying period is used to establish when the separation point is attained. Prior to beginning the full drying phase, and this is the essential key to getting an optimum dryback period, the seeds' are removed from their tube, placed into a mesh nylon bag, spray rinsed for part of its time while in the spin dryer and then put into the right side of our refrigeration unit at 2°C. to 5°C. where No Humidity is added. We call this process AWS -Alternate Water Stablization. The seed is uniformly spread within the bag on a the screen shelf and left for a period of approximately 16 hrs. This is a secret so don't tell anybody!!! Seedlots will lose some of their water over this time in varying degrees, from as little as .2% to almost 3%(2.73%) which is rather significant. When the seedlot exhibits a substantial moisture reduction it can indicate that dead/dying seeds' are going to be removed from the seedlot quickly and that you just might expect an excellent germination increase. The example of 2.73% was from a Black Spruce seedlot that ended up with a germination capacity of 100%.

After completing the AWS step the seeds' are weighed to determine their moisture content from the dry weight calculation obtained after the prevac treatment or from initial moisture content information. The seedlot is now ready for the full

drying phase. Depending how you feel about the drying times, intervals are very flexible, as little as 5 minutes to as much as 25 minutes, using a temperature range of 25° to 28° C. The dryer used for our work is my own design and operates as a fluidized bed dryer giving the seed the latitude to move within the tray. The dryer can deliver a maximum air volume of 1100cfm. A four speed fan gives effective control of air volume. Seldom has anything but the first selector position been used. An overhead hood and filtering mechanism provide dust removal over the drying phase. Seed drying can present a problem in this stage and rather than increase temperature it is much safer to increase the air volume.

At the finish of each drying interval, two 100 seed samples are collected to assess what the sink/float ratio is, "very important". What you are trying to represent in this ratio, is the dead fraction of the seedlot. ie. If initially 91% was the germination, nine seeds average would be what was required as the floating fraction. To get to this average, successive drying intervals may be required and varying time durations, less time the closer you get to the marker point. As well as collecting the seedlot moisture content at each of these intervals, each 100 seed sample is weighed, to again note what has occurred and provide a tracking sequence.

Earlier the "Separation Flume" had been filled with the appropriate water volume. To conduct the sink/float procedure, water is used from the flume only. This represents the exact water characteristics when the seed is ready for its separation stage. This is very important in order to ensure consistency between assessment and separation.

The individual samples are dropped into separate transparent containers of water, stirred and waited on to see what the outcome is. Floaters are viewed by cut testing to look at anatomical structures present, ie. empty seed, dead filled, damaged tissues, absent or immature embryos.

As a general rule of thumb if the average floating seed number represents the dead fraction of the seedlot plus or minus 1 or 2 seeds, then it is ready for the separation stage.

When prevac has been used in the treatment of Jack Pine (always) or Lodgepole Pine, new germination tests are setup using a 2 week stratification period not a 3 week as in the "I" stage. This allows the upgraded Prevac germination results to be used in place of the initial germination information, establishing a float average using the most accurate germination value.

"S"- represents Separation, dead and dying seed float while good seed sink into sedimentation compartments along the bottom of the separation unit known as a "Separation Flume". This particular flume has six bottom compartments in which the seed can settle into.

Bottom Fractions termed as "Sinkers" - identified as "B". These fractions sink and settle across the bottom of the Separation flume and are grouped as follows;

B1 & B2 - highest and best fraction of living viable seed and best germination/vigour, appropriate for single seeding. Kept separate after separation.
B3 to B6 - lower germination/vigour than found in the B1& B2 fractions, more appropriate for double seeding. Grouped as one after separation.

Top Fraction termed as "Floaters". This fraction floats and is regarded to be debris and contains the following; Weak, dead filled and empty seed comprise this fraction. There will be some germinates within this fraction but germination capacity and vigour is low and a large number of abnormal germinates could be expected.

The seed, now ready for separation is poured into a mesh nylon bag and from the bag is introduced into the feed hopper of the flume. The seed moves along a vibratory channel at a slow even feed rate into a water bath. By pre-wetting the seed before being discharged into the separation tank, surface tension is released on the seedcoat and therefore limiting air bubbles that might affix themselves to the seed. Bubbles adhering to good seed can cause undesirable events to occur such as a seed floating to the surface or extended travel in the water current, causing it to end up in alternate compartment with poorer quality seed. If bubbles adhering to seedcoats are a problem for you, devise a pre-wetting routine prior to separation.

Each seedlot will have its own sink characteristics with different fractional components. This means a seedlot could have a B1 and Floaters only while another could be made up of a B1, B2, B3-6 and Floaters. This type of segmentation in certain cases is a judgement call and relies solely on the experience of the individual doing the treatment. Separated fractions can become too fine and can end up creating problems for a seeding system that originally they were intended to provide enhancement to. Don't get too fine, keep it operational !

Once the separation is completed, samples are removed from each fraction for moisture testing in order to calculate new dry weights and germination testing to validate the separation work completed. Seedlots have a moisture management routine, to ensure the seeds are at a moisture level to accommodate transportation to far ranging destinations or short hops and storage/handling prior to set seeding schedules.

How to Calculate Moisture Content

Moisture Charting Calculations - eliminates a dependence for Electronic Moisture meters (weighing accuracy a prerequisite)

Steps:

1) standard oven test, 1 or 2, 5gm. sample(s) to obtain moisture content (mc)of seed.
2) weigh seed and record at this point. = "eg. - 240 gm." - becomes the fresh weight (FW)
3) after MC has been determined, calculate Dry Weight for bulk lot -" DW "
4) calculate Target Fresh Weight - TFW and if desired calculate and construct a moisture chart for the desired Target Moisture Content range - (TMC)

Calculating moisture content and dry weight

a) Moisture content for the 'bulk lot' (MC)

MC = (fw - dw)/fw x 100 (17 hrs at 103° C.)

b) Dry Weights

- Total dry Weight for the 'bulk lot' (DW)
  DW = [1-(mc/100)] x FW
- Total 100-seed dry wieght (DW100)
  DW = [1-(mc/100)] x FW

c) Target Fresh Weights

- Target fresh weight for the 'bulk lot' (TFW)
  TFW = DW/[1-(TMC/100)]
- Total dry Weight for the 'bulk lot' (DW)
  TFW100 = DW/[1-(TMC/100)]

A Short cut to all of this goes like this; moisture test and calculate dry weight(s) as indicated. Determine your target moisture content desired and record the weight to dry the seed back to. Seedlot (seed) moisture content can be obtained at any time by dividing the present weight of the seed being dried into the calculated dry weight and then subtracting that value from 100. The difference is the current moisture content for the seedlot (seed).

Table 1. "Moisture Chart"

Moisture (%)	Weight (g)	100-seed weight (g)
14.92	240.000	.657
14	237.432	.650
13	234.703	.642
12	232.036	.635
11	229.429	.628
10	226.888	.621
9	224.386	.614
8	221.947	.608
7	219.561	.601
6	217.225	.595

Prepared by; Mishtu Banerjee; Scientificals Consulting/Kim Creasey; Nature's Common Elements

Results By Example Successful & Not

It is a fact that most of the species and the corresponding seedlots treated through these upgrading procedures and protocols have very positive results and enable nurseries to utilize single sow applications. A small percentage of the seedlots treated for many and some undetermined reasons respond negatively to the processes.

The species that tends to return the most variable response is White Spruce and more specifically originating from NW Ontario and parts of NE Ontario. It is very interesting to observe the varying characteristics and to try to hypothesize the question of "WHY". Many thoughts can come to mind depending on individual seedlot information and circumstances.

Questions like to name a few;

- degree of dormancy vrs. modified stratification period - enough or too much
- correctness of initial germination information supplied
- pathogenic problems and corrective measures
- adequate moisture levels - too much or not enough

- inhibitory effects attributed to decreased water permeability (Baron 1978) (Downie 1999)
- decreased oxygen permeability (Koslowski & Gentile 1959) (Downie 1999)
- restriction of expansion of the megagametophyte and embryo (Asakawa 1956) (Downie 1999)

Table 2. Summary of test results for various species

Species	Crop year	Original Germ. (%)	Prevac G Germ (%)	Fraction	Rtn Germ. (%)
White pine	1996	81.0	na	B1 B2 B3-6 Fltrs	96.0 94.0 95.0 31.5
Red pine	1989	89.0	na	B1 Fltrs	98.0 11.0
Red pine	1998	37.0	39.0	B1 Fltrs	87.5 5.5
Red pine	na	94.0	na	B1 Fltrs	94.5 8.0
Jack pine	na	87.3	92.5	B1 Fltrs	99.0 14.5
Jack pine	1991	86.0	74.5	B1 Fltrs	97.0 35.0
Lodgepole pine	1992	94.0	na	B1 B2 Fltrs	99.0 97.0 48.5
Lodgepole pine	1996	91.0	na	B1 B2 Fltrs	95.5 92.0 47.5
White spruce	1980	88.3	na	B1 Fltrs	81.0 7.0
White spruce	1982	90.0	na	B1 B2 Fltrs	96.5 88.0 18.0
White spruce	1982	90.0	na	B1 B2 Fltrs	88.5 74.0 23.5
White spruce	1995	91.0	na	B1 B2 Fltrs	98.0 97.0 65.0
Black spruce	1984	96.0	na	B1 Fltrs	100.0 0.0
Black spruce	na	97.5	na	B1 B2 Fltrs	98.5 96.5 6.5
Englemann spruce	1985	62.5	na	B1 B2 B3-6 Fltrs	85.0 79.5 68.0 34.5

As difficult as it may be the best one can do is "Read The Seed" to the best of your ability and to gain an intimate understanding of what is taking place biologically. Certain species tend to be very open to interpretation while others are very discrete and subtle. Exampled by the following;

Summary

This presentation was designed as a practical and operational approach with the intent of sharing some handy tricks and tips that you may find useful in your own program. Equipment used on our operation has evolved through a combination of imagination/necessity, the mother of all invention.

Reading the seed and understanding what is in front of you is your key to unlocking a multitude of secrets. "Follow and Observe Nature and you'll find the Common Elements" Treat the upgrading task as a challenge and have fun with it.

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Downie, B. 1999. Upgrading seed quality of conifer seedlots: The how and glimpses of the why. Proc. of the 19th Annual meeting, Forest nursery Association of British Columbia

UPGRADING CONIFER SEED QUALITY - WHAT WORKS BEST FOR YOU.

[The following is an excerpt from "Seed Sense, Quick Note #6" produced by Wendy and Kim Creasey] Ed note: It contains some interesting discussions related to the above article.

Seed upgrading encompasses a large realm of treatment processes from simple air aspiration to address some purity concerns through to IDS applications to adjust seed vigour and germination characteristics.

The focus here is to direct attention to Prevac and IDS treatments. Responses to any or all of these treatments can be quite variable in accordance to the species and seedlot characteristics. Certain species in general exhibit a continuous positive response with the application of Prevac and IDS treatments. Red Pine, Jack Pine, Lodgepole Pine and Black Spruce are examples of good response candidates.

White Spruce, Interior Spruce, Engelmann Spruce and Sitka Spruce would be examples of candidates exhibiting irregular response tendencies. Some seedlots respond very well in improving both the seed vigour and germination capacity, while other seedlots exhibit only improvement in vigour. ***"Why we ask?"*** Many reasons or theories can be highlighted but one common thread to all reflections would be ***"Age"***. As with all of us biological entities age has quite an impact on how we function over the course of our lives. These particular Spruce species certainly present this aspect and in some cases very dramatically. Working with these Spruce species can be likened to the roll of dice, you are never sure how the numbers play out when related to germination capacity until the final results are in. Improved vigour seems to always be with out question, bettered.

Older Spruce seed can brandish the following undesirable attributes;

a) reduced vigour / reduced ability to germinate under the most optimal conditions

b) the resistance to radicle protrusion through the testa, nucellus, megagametophyte and the embryo root cap (Downie et al. 1997a).

c) abnormal germination - increased mutants, reverse germination being the most common

d) seed death due to the breakdown of critical metabolic pathways

e) depleted food reserves due to long term or improper storage initially or later in time

f) tissue damage due to rapid water uptake through the seedcoat - water temperature could be a key factor here, the colder the water the slower the uptake. O2 levels are also higher in the colder waters

g) water retention and the relationship to imbibition treatments

h) the amount of resin present in the testa (seedcoat)

As with all species in general, collection timing, handling, post harvest maturation, processing and storage environments are some of the initial factors than can affect seed dynamics when drawing relationships of germination capacity, vigour and storage longevity and ultimately, if required, how the seed accepts enhancement treatments. Immaturity within the seed structures - ie. embryo, can create major problems along the way.

Many positive responses have been attained through upgrading procedures but everything has its eventual limits. It may come to pass that the best procedure is to simply refresh your seed supply due to the excessive waning of seed vigour and germination capacities that even enhancement treatments can't get to the acceptable levels for container or other seeding program uses.

SEED HANDLING GUIDEBOOK

Dave Kolotelo
B.C. Ministry of Forests

The Seed Handling Guidebook has been completed and is currently being printed. The authors of the Seed Handling Guidebook are: David Kolotelo, Eric Van Steenis, Michael Peterson, Robb Bennett, Dave Trotter, and John Dennis. The guidebook is 106 pages in length with 101 colour figures and 14 tables. It covers the introductory topics of seed condition, cone and seed insects and seed fungi and then fully covers the seed handling system. This spans all activities from cone collection to the sowing of seed in the nursery. An additional section on the germination micro-environment and its manipulation is also included. A distribution list for the guidebook is being put together. If you have not received a guidebook by mid-January.

Please contact Dave Kolotelo for information on obtaining a copy (1-604-541-1683 ext. 228) or by email at: Dave.Kolotelo@gems7.gov.bc.ca.

Did you Know About?

"The Flowering Newsletter"

Published by the International Working Group of Flowering, this newsletter, although weighted to the molecular side, is an extremely informative and current publication and is a must read for anyone conducting 'flowering' research . It provides an excellent forum for discussion papers on various topics related to the control of flowering in plants.

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WESTERN WHITE PINE SHATTERS A BASIC ASSUMPTION!!

Dave Kolotelo
B.C. Ministry of Forests

I'd like to discuss a very basic assumption in seed technology: that **the results of lab testing are a good predictor of results with larger quantities of seed.** At the BC Ministry of Forests Tree seed Centre we have been struggling with the duplication of lab results in operational seed preparation (OSP) for several years. The most significant pretreatment difference is the sample size. In the Lab 100 seeds are used per replicate and up to a maximum of 1000 grams (approximately 50 000 seeds) are used in OSP. Lab methodology for western white pine (Pw) is somewhat different from other species as seeds are placed on top of an accelerated aging (AA) tray with moistened kimpack beneath during stratification as opposed to be placed directly on filter paper. The current methodology for Pw in both the LAB and OSP includes a 14-day running water soak followed by 98 days of cold stratification (germination test type=G55).

A total of nineteen western white pine (Pw) 2001 sowing requests (SRQ) had grams added to allow for a direct comparison in germination capacity (GC) (effectiveness in breaking dormancy) between the OSP and LAB methods sampled and pretreated at the same time. The moisture content of seed was also monitored, by weight a) after draining, just prior to surface drying; b) after surface drying; c) after 7 weeks of stratification and d) at end of stratification = 14 weeks. The LAB samples also had similar moisture content estimates performed, but since surface drying does not occur in the lab only a, c and d was quantified for the lab.

Results

Germination

Even with our efforts to mimic the Lab procedures in OSP, the results indicate that our OSP techniques are inferior in breaking dormancy to lab procedures. The germination capacity (GC) of the OSP requests averaged 58%, while the Lab averaged 91% based on 19 samples. The falldown in germination ranged from 6 % to 60% indicating that the individual seedlot may have a large impact on the way white pine responds to OSP techniques (Figure 1).

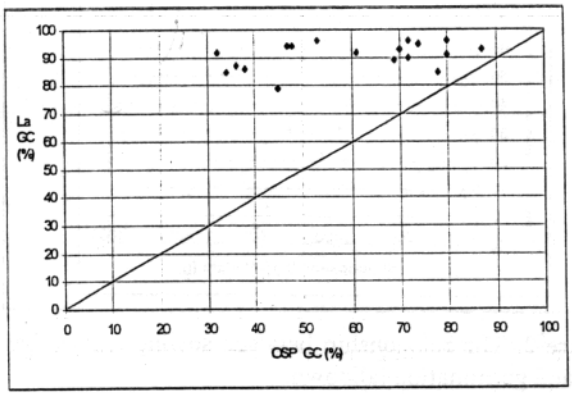

Figure 1. Plot of operational seed preparation (OSP) germination capacity (GC) versus the lab.

Extended Stratification

For three sowing requests, the nursery requested that we hold the seed for an additional two weeks of stratification. Sampling and germination testing were performed after 14 weeks stratification (pretreatment completion) and after 16 weeks stratification. The additional two weeks stratification resulted in a 5% average increase in GC (71 to 76%). An additional request was tested after 15 and 16 weeks stratification with a 3% gain in GC. These results indicate that stratification may not have been of a sufficient duration (or moisture content – *covered later*) to totally overcome dormancy.

Stratification Unit Size

For white pine, sowing requests are divided into stratification units of 1000 grams or less (i.e. a 3200 g request is divided into 4 units of 800 grams each). It has been suggested that smaller 'requests' may have higher moisture contents and this may result in greater germination. The coefficient of determination (r^2) between seed quantity (g) and the moisture content i) after draining and ii) after surface drying both was 0.60. The moisture contents during stratification were not as well correlated with bag size [» 0.10 at 7 and 14 weeks] indicating that bag size has much less influence on stratification moisture content (at least after 7 weeks). The relationship between bag size and nursery germination falldown (Lab minus Nursery GC) was weak (r^2 =0.25), but it did indicate that smaller bag sizes are experiencing smaller falldowns in GC (Figure 2).

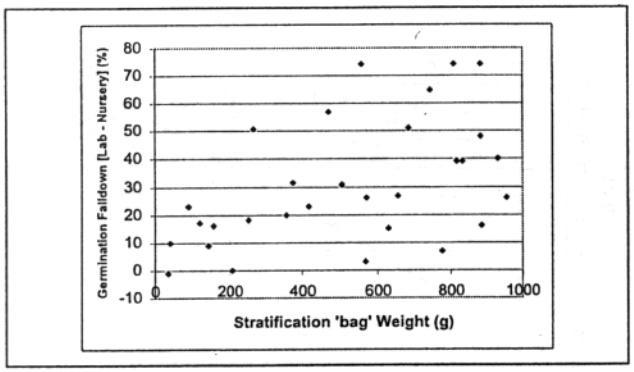

Figure 2. The relationship between sowing request bag size and germination falldown.

Moisture Content

For OSP the average moisture of the seed following a 14-day soak and drainage of excess moisture was 40.6%. After surface drying the moisture content was reduced to 35.5% indicating that surface drying removes 5.1% moisture from the seed. This was fairly consistent across seedlots and the r-squared value between drained and surface dry moisture content was 0.89. The OSP samples appear to lose moisture during stratification in comparison to lab samples (Figure 3). This appears to be a significant difference in the two treatments: lab samples are maintained in stratification at a moisture content approximately 3.4% greater than in OSP!

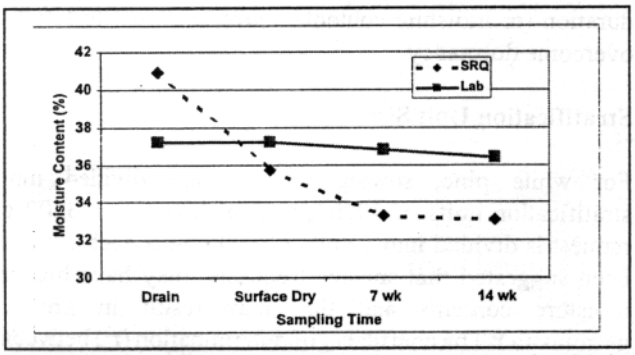

Figure 3. Comparison between moisture content after Drain, Surface Drying and 7 & 14 weeks of stratification for lab samples and operational sowing requests (SRQ) [n=19].

Discussion

The results clearly show that the conditions provided to pretreat LAB samples is not being replicated for OSP. The LAB prepared samples had an average GC 33% greater (91% vs. 58%) than that achieved with OSP. The most significant pretreatment difference is the size of the sample pretreated. In the Lab 100 seeds are used per replicate and up to a maximum of 1000 grams (approximately 50 000 seeds) are used in OSP. In the lab, seeds are not touching during stratification and there is a large air: seed ratio. The container is closed during stratification in the lab. In OSP adjacent seeds are touching (from all directions) within the one Kilogram seed mass and the air:seed ratio and the kimpack:seed ratio is reduced relative to the lab. To provide an equivalent air: seed ratio in OSP one would need an air volume of 60 to 75 litres within the stratification unit for one Kg of seed [totally impractical

The most obvious physiological difference between the Lab and OSP is the moisture content of the seeds during stratification. The average OSP moisture content of 33.1% appears insufficient to efficiently overcome dormancy compared to the 36.5% level experienced in the Lab. This relatively high moisture requirement is considered to be critical and will be the focus for improvements in OSP. For other species (i.e. interior lodgepole pine and spruce) the optimal moisture content for stratification is 30%.

The strategy adopted has been to try and mimic the accelerated aging tray system used in the lab. This may not be appropriate as a container to precisely mimic this environment is probably too large to be practical. The tray system is also problematic as it occupies a large area and makes it difficult to monitor and 'manipulate' seeds. The tray system in OSP has not provided improved germination in the two years in which it was implemented (2000 and 2001).

Feedback from some nurseries stratifying their own requests indicates that our problems are not unique, but some growers are quite successful at stratifying Pw. They emphasize that the seeds must be kept "moist" during stratification and that seed "manipulation" or the movement of seed within the stratification unit is required and is performed by some on a daily basis.

It appears that Pw does violate the basic assumption of "the results of lab testing are a good predictor of results with larger quantities of seed". For most species we are not faced with having large germination differences between LAB and OSP procedures. Problems with achieving consistent and high GC with Pw are well documented and may partly be explained by this lack of agreement between lab test results and the results of OSP using much larger quantities of seed. It is possible that there is no one pretreatment that will produce equivalent results with small (100 seeds) and large (up to 50 000 seeds) quantities of seed in Pw!

Other than documenting our experience with Pw, the main message I'd like to send is that we would not have had the information to adequately address this issue without good quality assurance monitoring. In competitive times a quality assurance program will keep you ahead – it should not be the first thing you drop. It may need to be prioritized to your local problems, but monitoring of seed quality at the nursery is important to maintain a feedback loop to testing procedures allowing us to ask the question "Why are we not meeting lab results". There are many explanations and in the case of white pine the most obvious reason appears to be associated with the moisture content of seeds in stratification. Stay tuned and see how our 2002 sowing requests perform with the following recommendations.

Recommendations

Several changes are being recommended for 2002 sowing of western white pine. The testing of recommendations is problematic due to the need to have operational quantities of seed available (» 1 Kg) for trial purposes and the time required to obtain results with Pw pretreatments (approximately 5 months). These recommendations are directed specifically at OSP and no changes are being recommended for the lab testing of Pw.

1. Operational stratification of Pw requests should revert to being performed in polyethylene bags. Smaller sized stratification units (500 g) will be tested on a limited scale in 2002 to evaluate potential benefits.

2. The moisture content of Pw requests stratified in OSP should be increased to better correspond to the moisture content experienced in the lab. The increased moisture content can be accomplished by instituting the following:

   a) Eliminate surface drying performed on Pw sowing requests.

   b) Monitor moisture content during stratification. All sowing requests stratified at the TSC should have fresh weights recorded following draining and after one month of stratification.

   c) I am recommending that the target moisture content range of Pw should be between 35 and 38% during stratification. Moisture content adjustment should occur if the moisture content is less than 34% or greater than 40%.

3. All Pw sowing requests should be monitored and 'handling' during stratification every Monday, Wednesday and Friday. This involves a visual inspection for fungal growth and moisture status (excessively wet or dry), and handling of the seed within the bag to break up any fungal colonies and redistribute moisture within the stratification unit.

4 **We should volunteer to extend stratification to our clients up to a maximum of 120 days.** All OSP results indicate that increased stratification will increase GC and 120 days is the standard duration used in the US to stratify Pw.

NATIVE WOODY PLANT SEED COLLECTION GUIDE FOR BRITISH COLUMBIA

Mishtu Banerjee, Kim Creasey and Diane Douglas Gertzen

Native plants provide beauty and utility in the context of maintaining natural and managed ecosystems. As people continue to utilize native plants, there is a need to develop standard practices for seed collection, vegetative propagation, and nursery culture of these species.

The goal of this guide is to address the issue of woody plant seed collection by presenting information on collection practices, species descriptions, and photographs that aid the collector in identifying key features of flowers, fruits, and seeds during the stages of flowering, forecasting, and collection.

146 pages, extensive colour photographs, colour coded sections for easy reference make this an extremely useful guide for the professional and amateur seed collector. ISBN # 0-7726-4340-7

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BUTTERNUT CANKER IN QUÉBEC : A 5-YEAR HISTORY THAT LED TO SEED TREATMENTS

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Introduction

In Quebec, the butternut canker, caused by the fungus Sirococcus clavigignenti-juglandacearum Nair, Kostichka & Kuntz, was first detected in 1990 on butternut (*Juglans cinerea* L.), in a natural stand located in the south-western part of the province. Four years later, the disease was detected in two natural stands located east of the first point and, for the first time, in a plantation in the Eastern Townships. During the same year of 1994, the inclusion of butternut in the list of threatened and endangered species by the USDA and the rapidity of propagation and virulence of the disease, led to the start of a project on the evaluation and preservation of the genetic diversity of the species in our province. The first strategy was oriented towards the cryopreservation of tissues obtained by somatic embryogenesis from mature and immature seeds. The second strategy was to establish *in situ* plantations outside of the distribution range of the fungus. Thus, it would prevent contamination from surrounding affected trees. Nuts from 11 provenances collected in Québec and 2 from Ontario were grown to produce seedlings.

This paper presents the work conducted between 1995 and 2000 through observations and tests on seeds and seedlings, and clarifies the role of butternut and black walnut (*Juglans nigra* L.) fruits in the propagation of the disease. Suggestions of decontamination treatments for butternut seeds are also included

First detection of butternut canker on seedlings in Québec nurseries

In the spring of 1995, an inspection of one year-old container seedlings of black walnut and butternut, grown at the Duchesnay nursery (near Québec city), revealed. the presence of black cankers at the base of the seedlings. Laboratory tissue cultures of these infected parts confirmed the presence of *Sirococcus clavigignenti-juglandacearum*. In the fall of the same year, some of the bareroot seedlings of both species, produced for the butternut conservation project, were also infected at the Berthier nursery. Cankers were present at the base of the seedlings. *Sirococcus clavigignenti-juglandacearum* was one of the pathogens. Two fungi, *Fusarium* spp. and *Cylindrocarpon* spp., usually associated with root rot, were also isolated (Innes and Rainville 1996). Infected seedlings were culled.

These observations confirm the hypothesis that the disease can be present on seedlings in a nursery, and that black walnut can also be affected. Since there is no known butternut tree in and around the Duchesnay nursery (where the container seedlings were produced), the presence of the disease on seedlings is attributed to its presence on the seeds, as fructifications with spores, at the time of sowing. The disease is transmitted from the infected fruit to the seedling at the time of its emergence, via the scar left by the detached nut.

Confirming the hypothesis

In 1996, three conservation plantations of butternut trees were established outside the natural range of the species where there was, evidently, no source of contamination. Two inspections were then performed, one in mid-summer and the other at the end of the summer, aimed at the detection of pathogens. This was done to ascertain that trees were disease-free, since the goal of these plantations is conservation; it also enabled us to verify the efficiency of a visual phytosanitary inspection in the nursery. Trees with symptoms (canker on trunk, discoloured or dead parts) were sent to the laboratory for confirmation of the pathogen.

We found and confirmed the presence of *Sirococcus clavigignenti-juglandacearum* on diseased trees in all three conservation plantations. Even after the elimination of seedlings presenting symptoms in the Berthier nursery, 4 % of the plants were still infected in the field. This demonstrates that a visual examination after extraction in the nursery is insufficient to ensure the health of the plants. Although they presented the same symptoms, numerous cankers were rather caused by another pathogen, *Fusarium*; in fact, this is the first mention of the pathogenicity of *Fusarium* in Québec, on young or mature butternut trees.

In the fall of 1996, we began the second part of the study, which consisted in collecting and examining fifty

nuts from each of six provenances of butternut and nine of black walnut, from both natural stands and plantations. All provenances were kept in separate containers. The presence and the size of the lesions, on and in the husk, were noted. Fruiting bodies associated to these lesions confirmed the nature of the pathogens; if none were present, infected tissues from the lesions were placed on potato dextrose agar (PDA) plus streptomycin, for 10 days at room temperature (Innes, 1998).

We found that butternut and black walnut fruits were infected by a number of pathogenic fungi. The most frequent were *S. clavigignenti-juglandacearum*, *Fusarium* spp., *Cylindrocarpon* spp. and *Marssonina* spp. The butternut canker fungus was detected in all of the six butternut provenances and in eight of the nine black walnut provenances. The fungus causes lesions of various sizes, on and inside the husk of both species. Pycnidia can be found fruiting directly on the surface of the affected area. These observations confirm that the disease is seed-borne.

Decontamination of butternut fruits

In view of these observations, the Ministry of natural resources decided in 1997 that no butternut production would receive a phytosanitary inspection certificate, essential for shipment in the field, unless proven to be disease-free. Following this decision, the forest nursery production of the species was completely stopped. In an effort of rehabilitation, we started a research project to evaluate different methods of decontaminating butternut seeds before sowing.

Unfortunately, laboratory inspections of the 1997 nut production in plantations and natural stands showed a complete absence of the pathogen, as tested by fruiting bodies on the husk or by tissue cultures. Nonetheless, as we had collected nuts from different provenances, it was decided to perform a preliminary study to measure the effect of potential decontamination treatments on the viability of seeds. Eleven treatments were tested, including soaking in peroxide hydrogen, sodium hypochlorite, boiling water and methanol, with and without prior laceration of the husk, followed by a 1 minute cold water soak. Viability was then determined by a TTC (tetrazolium salt) test (International Seed Testing Association, 1999). Of the 11 treatments, 3 gave good results in terms of seed viability:

1. soaking in boiling water for 1 minute,
2. soaking in 3 % hydrogen peroxide by volume for 4 hours,
3. soaking in 70% methanol by volume for 15 minutes, following laceration of the husk.

The other treatments were too toxic for the nut. In 1998, the same three treatments were repeated on naturally infected seeds, and compared with a control (soaking in cold water). Results are presented in terms of the efficiency of these treatments to eliminate all of the pathogens present on the husk. The best treatment is to soak the seeds in boiling water for one minute ; the second best is soaking in 70 % methanol for 30 minutes. The 3 % peroxide treatment for four hours was not as efficient, since it was not possible to eliminate *Fusarium*. The soaking treatment in cold water (control) is not recommended because many pathogens remain on the husk after treatment. We sowed the seeds after treatments and measured their speed and rate of germination. Treatment 1 (boiling water) and treatment 2 (peroxide) were the two best methods of killing *Sirococcus* ; they both also enhanced the speed of germination. However, peroxide was not effective in repressing *Fusarium* and *Phomopsis*. Methanol (treatment 3) was also very effective against every pathogen, but unfortunately no seed germinated during the observation period.

The Tree seed centre staff told us that all three treatments were considered both impractical and dangerous for the workers ; a 1 minute soak is relatively short, with consequent imprecision, and a 100 °C water temperature represents a potential hazard for workers.

In the spring of 1999, we tested treatments using only hot water at different temperatures. Hot water treatments at 60°C and 80°C during 5 and 10 minutes have no negative effect on the seed germination. Unfortunately, we could not evaluate their efficacy to eliminate the pathogens, since the material used in this experiment was not fresh seeds (the husk was already rotten).

For the second time in the project, the nuts collected in 1999 were not infected. We therefore initiated an experiment in which healthy nuts were inoculated with the pathogen, by inserting pellets of fungal mycelium grown on agar in small holes manually made on the side of the nuts. The technique gave good results and enabled us to artificially inoculate the amount of nuts needed for our decontamination assays. Using this method, the project of decontamination can go on even without natural contamination.

Conclusions

These research projects on the conservation of the genetic diversity of the species and on the decontamination of butternut and black walnut nuts, with their application in the nursery and in the field, helped in acquiring knowledge on the disease. We found that :

a) Fructifications with spores of *S. clavigignenti-juglandacearum* can be found on butternut and black walnut seeds ;

b) The disease can be transmitted from the infected fruit to the seedling via the scar left on the detached nut ;

c) A visual phytosanitary inspection of the seedlings in the nursery is not enough to assume that the seedlings are disease-free ;

d) Preliminary treatments have been proven effective to decontaminate butternut seeds prior to sowing (mainly those involving soaking in hot water), but still need to be refined.

Since 1994, when the Canadian forestry service suggested investing efforts for the conservation of butternut, the Québec Ministry of natural resources has acted in this field, despite budget restrictions, mainly by the collaboration between the Berthier nursery and the Ministry's Direction de la conservation des forêts and Direction de la recherche forestière . Observations taken in the three conservation plantations have given some indications on the variation of susceptibility within and between butternut provenances. This will be the subject of a future article. However, because butternut and black walnut do not rank high in the government's present reforestation program, the present research efforts will soon come to an end.

Unfortunately, we were unable to combine all the conditions needed to ensure a complete success in the production of healthy butternut seedlings. Some years, nut production was insufficient while in others, nuts were not naturally contaminated.

If we had to start the project over again, the following steps would have to be done in the fall of the same year:

1. Collect butternut seeds at the end of August ;
2. Inoculate nuts with the fungal pathogen if they are not naturally infected ;
3. Decontaminate nuts in September ;
4. Sow the nuts in nursery before the end of October ;
5. Protect seedlings from predators (squirrel and raven)
6. Collect data on germination (percentage and vigour)
7. Inspect regularly the production, particularly at the collar in autumn.

We encourage readers to contact us for more detailed information about what has been done, hoping that they will go further in the research of seed treatments against *Sirococcus clavigignenti-juglandacearum*.

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SEED PELLETING

Carl Happel

For the last four years, most of the western redcedar in British Columbia has been pelleted by me, Carl Happel. In late 1997, I bought the seed pelleting business from Dr. Paul Trussel. Paul had developed this seed coating process and ran the business for eight years before he sold it to me. I moved the business to Vernon, BC in 1998 where it remains today.

Most seed coating (pelleting) operations use clay as the bulking agent. However, we have found that by using silicone we get superior looking pellets and a more even break up of the pellets during germination.

To date .we have successfully pelleted western red cedar, eastern white cedar, alder, aspen, and Ranunculus. The smaller the seed, the larger the minimum amount of seed is required for pelleting. For example, western redcedar has a minimum of 10 g, but aspen has a minimum of 100 grams.

Some of the eastern white cedar that I pelleted in the past has been stratified. This presents no problem as long as the seed is dried to 20% moisture content.

Pelleting allows for fertilizer, fungicide, and herbicide to be added to the coating. However, to date, all nursery operators have not used these services, as they wish to control these things themselves. Most pelleting is done to save the labour cost in the handling and planting process.

If you have any questions or require additional information on seed pelleting, please contact Carl Happel at (250) 558-0746 or e-mail at seed-pelleting@telus.net

OPERATIONAL METHODS FOR SEED STRATIFICATION IN QUÉBEC

Fabienne Colas and Michèle Bettez
Direction de la recherche forestière
Forêt Québec

At the Berthier seed Centre we stratify the majority of the seedlots of white spruce, white pine and balsam fir before the shipping to the nursery. Our methods are inspirited by the BC method.

Concerning hardwood seeds, we stratify some species (*Acer saccharum, Acer rubrum, Prunus serotina, Fraxinus pennsylvanica, Fraxinus americana, Betula alleghaniensis, Quercus rubra*). For each species, we have a different method of stratification. We present in this paper the *Prunus serotina* method.

White spruce (*Picea glauca*)

- Priming 24 hours in running tap water
- Spin drying and surface drying
- Stratification in polyethylene bags for 21 days (maximum 4 litres of seeds per bag). The bag has an opening of 8 cm. Temperature 3 °C.
- Seeds are stirred once a week.
- After 3 weeks, seeds are dried to reach a wter content of 8 ± 2 %
- If the seedlot is contaminated by fungus pathogens, seeds are disinfected with a solution of 3 % hydrogen peroxide Same quantity of peroxide and seeds
- Treatment last 3 hours. Each 15 minutes, stir the solution 15 seconds.
- At the end, seeds are rinsed during 5 minutes in running tap water, and spin dried.
- Seeds are shipped to nurseries in coolers.

Eastern white pine (*Pinus strobus*)

- Priming 24 hours in running tap water
- Spin drying and surface drying
- Stratification in polyethylene bags for 28 days (maximum 4 litres of seeds per bag). The bag has an opening of 8 cm. Temperature 3 °C.
- Seeds are stirred once a week.
- After 4 weeks, all seedlots are disinfected with a solution of 3 % hydrogen peroxide (same procedure as white spruce).
- Seeds are dried to reach a water content of 8 ± 2 %
- Seeds are shipped to nurseries in coolers.

Balsam fir (*Abies balsamea*)

Same instructions as Eastern white pine, except that seeds are not disinfected with hydrogen peroxide.

Black cherry (Prunus serotina)

- Priming 24 to 48 hours in running tap water
- Stratification in polyethylene bags during 17 to 19 weeks (maximum 0,75 litre of seeds per bag). The seeds are mix with moist peat moss and sand.
- The seeds are submit to an alternate stratification temperature (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 the seedlot)
- At the end of the stratification period, the medium is removed and the seeds are washed with running water before sowing.

The following information was taken from the IUFRO Seed Physiology and Technology Newsletter No. 57

1. The first circular letter of the IUFRO Symposium on Populatin and Evolutionary Genetics of Forest Tree Species which will be organized in Stara Lesna, Slovakia on August 25-29, 2002, can be found at http://www.tuzvo.sk/~paule/conference

2. Tropical Sylvics, the newsletter of the Tropical Forest Research Institute, is published twice a year. Free copies are available upon request from the Director, Tropical Forest Research Institute, PO-RFRC, Mandla Road, Jabalpur - 482 021, Madhy Pradesh, India.

REVISED 2001 B.C. MINISTRY OF FORESTS SOWING GUIDELINES

Dave Kolotelo
B.C. Ministry of Forests

The BC Ministry of Forests sowing guidelines have been revised for this coming (2002) sowing season. The guidelines calculate grams of seed required to fulfill a sowing request of x number of seedlings based on the germination capacity (GC) and seeds per gram of an individual seedlot. The guidelines also calculate the potential seedlings for a quantity of seed and for a seedlot, presents the potential trees per gram.
A full outline of the revised sowing guidelines can be found at:
http://www.for.gov.bc.ca/TIP/publications/updates/vol5no2.pdf

The previous (1999) sowing guidelines, including instructions on adjusting grams and fractional sowing can be found at:
http://www.for.gov.bc.ca/TIP/publications/updates/vol3no4.pdf

The new sowing guidelines allocate less seed to seedlots with a GC > 88% and more seed to seedlots with a GC< 74% as illustrated below (Figure 1).

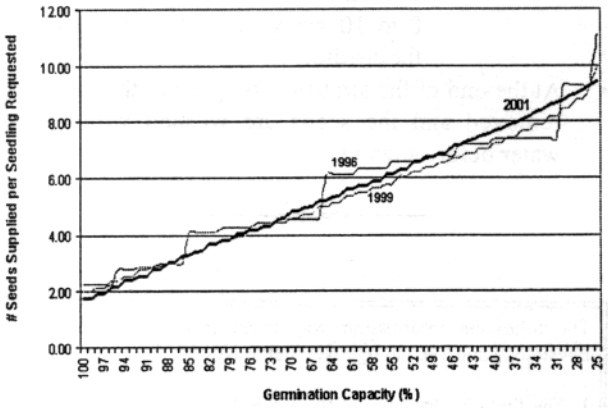

Figure 1. Summary of recommended seed sowing guidelines based on seed quality (germination capacity).

A variety of issues were considered in the development of the new sowing guidelines. It was decided that unique sowing guidelines would not be developed based on species, genetic class, genetic worth, growing environment or stock type. Client feedback indicated that seed allocation should be a function of seed quality (namely germination capacity) An important factor in formulating these guidelines was the large amount of variability found between nurseries in seed-use.

The first step to gains in seed efficiency is an understanding of how the sowing guidelines work. This will allow informed discussions (or negotiations) between the seed owner and nursery. In some situations large seed-use efficiency gains can be made (i.e. single-seed sowing of lodgepole pine), but not all nurseries will have the appropriate combination of geographic location, type of growing environment, stock type, equipment available, labour issues and individual nursery policy to meet every need. These new sowing guidelines are considered the best 'average', but efficiency gains can be made by going beyond average performance considering each nurseries unique situation.

NATIONAL TREE SEED CENTRE

It was an off-year for fruit and seed production in the Maritimes. This was not surprising because of the good crops produced in 2000. The notable exceptions this year were red maple (*Acer rubrum*) and white elm (*Ulmus americana*). Both species had very heavy seed crops. Collections from these species focused on individual trees. We have found, for hardwoods in particular, significant tree-to-tree variation in seed quality and germination. Therefore, it has become prudent to collect from single trees in most instances.

We tried something different with the elm seed collected this spring. Elm seed has a large wing which occupies a significant volume when storing seed. One means of storing more seed in a given volume is to remove the wing without damaging the seed. Winged seed was dry rubbed by hand in a cloth bag. A trial was set up and germination tests conducted comparing winged and de-winged samples from each of the trees seed was collected. On average, germination of winged seed was 89% compared to de-winged samples at 98%. Clearly, de-winging facilitated the removal of inferior seed. In order to assess whether de-winging will affect seed storability, winged seed was also stored for each of the collections. These will be tested periodically over time. The seed is stored at -20° C.

Two undergraduate forestry students from the University of New Brunswick started senior thesis projects to develop germination test protocols for striped maple (*Acer pensylvanicum*) and sugar maple (*Acer saccharum*). Results will be reported in the next newsletter.

The Seed Centre will be going online soon! Development of a web site has been progressing for some time. The site will be useful to people interested in knowing more about the Seed Centre as well as for those wanting to acquire seed. In addition, it will serve to provide basic information about seed to the general public. Pages provide an overview of the Centre, a summary of the previous year's activities, and the seed list. The site will enable us to provide regular updates of the seed list. A photo gallery of seed and fruit of the various species as well as seed processing from collection to storage is a work in progress. It is anticipated the web site will be up by January 2002. Come visit us at www.atl.cfs.nrcan.gc.ca Comments and feedback are welcome.

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SOLID MATRIX PRIMING DURING MOIST CHILLING IMPROVES DORMANCY BREAKAGE AND SEED GERMINATION IN TRUE FIR SPECIES

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Abstract

The ability of solid matrix priming (SMP) to promote dormancy breakage of seeds of *Abies* species was examined. Twelve seedlots representing four species (*Abies amabilis* [BA], *Abies lasiocarpa* [BL], *Abies grandis* [BG] and *Abies procera* [BN] were subjected to treatments that combined moist chilling and SMP; for the latter six solid matrices were used. SMP with peat moss improved the germination rate and germination percentage of BA by 20% and 25%, respectively. Likewise, BN responded positively to this treatment; in particular, its germination percentage was increased by 24% in comparison to a control with no SMP. Agro-Lig Greensgrade improved the germination rate and percentage of BL by 21% and 25%, respectively. The best SMP medium for BG proved to be sand which improved the germination rate and percentage by 12% and 28%, respectively, as compared to the control. The most rapid and uniform germination was achieved with 8 weeks SMP using peat moss (BA) or Agro-Lig Greensgrade (BL), and by 4 weeks SMP using sand (BG) or peat moss (BN). The water contents of the solid matrices that were optimal in terms of eliciting the highest germination performance were 320% for peat moss, 40% for Agro-Lig Greensgrade and 5-15% for sand. Conducting SMP at chilling temperatures (4°C) is a practical approach to shorten the time required for effective dormancy termination; treatment times were shortened by 30 d for BA and BL and more vigorous seedling growth was observed for BG and BN.

Introduction

Seeds of true firs (including *A. amabilis*, *A. lasiocarpa* and *A. procera*) exhibit deep dormancy at maturity; as a result, dormancy termination generally requires prolonged moist chilling (i.e. 3 months or longer) (Edwards, 1986, 1996). Not only are the seeds deeply dormant but they can be overcome by seed borne pathogens and many of the seedlots have a high proportion of empty seed (Kolotelo, 1998, Edwards 1996). Thus, tree seed nurseries can encounter significant problems with *Abies* species and operations can be inefficient as a result of poor seedling emergence related to ineffective dormancy breakage. As a result of extensive testing (Edwards, 1986, 1996, Leadem, 1986; Tanaka and Edwards 1986), the current practice for dormancy breakage of *Abies* (e.g. that used by the Tree Seed Center in B.C.) involves soaking of seeds (2d, room temperature), followed by moist chilling (2°C) at 45% m.c. for 4 weeks. At this point, seeds benefit from a dry-back (to 35%-40% m.c.) followed by an additional 9 weeks of moist chilling (2°C) in a loosely-tied plastic bag. Thus the total protocol is approximately 3 months in duration.

A chemical treatment using the anaesthetic 1-propanol promotes high germinability of yellow-cedar seeds, when combined with a three day warm water soak (30°C), a two day GA_3 treatment and 30-60 days of moist chilling (Xia and Kermode, 2000; Xia et al., 2001). Variations of this treatment (including extending the moist chilling period to 75 and 90 d), have not generally yielded beneficial effects on *Abies* seed germination (e.g. BL and BA) as compared to the controls (Xia and Kermode, unpublished data). Other relatively ineffective treatments include 2-chlorethyl-phosphonic acid (an ethylene releasing agent), 1-aminocyclopropane-1-

carboxylic acid (ACC) (an ethylene precursor) and polyethylene glycol (PEG) (an osmotic agent) (Ma and Kermode, unpublished data).

Solid matrix priming (SMP), conducted with or without prior moist chilling has positive effects on the germination of loblolly pine (Wu et al., 2001). SMP is similar to osmotic priming, allowing the seed to attain a threshold moisture content and pre-germinative metabolic activity but preventing radicle emergence. However, it has the advantages of allowing aeration, incorporation of biological agents to combat soil-borne pathogens, and improved ease of handling (Taylor *et al.*, 1988). In the present study, SMP treatments (using a number of different solid matrices) were assessed for their ability to enhance the germination rate and percentage of *Abies* seeds. Water contents of the matrices that elicited the best germination performance were also determined.

Materials and Methods

Seeds. All *Abies* seeds were obtained from the B.C. Ministry of Forests, Tree Seed Center, Surrey, B.C. This included 3 seedlots each of 4 species: *A. amabilis* (Dougl) (BA), *A. lasiocarpa* (Hook) Nuth (BL), *A. grandis* (Dougl) Lindl (BG) and *A. procera* Reed (BN).

Matrices. The six solid matrices tested included: (1) Agro-Lig Greensgrade (America Colloid Company); (2) Agro-Lig Micro Fine (America Colloid Company); (3) Sand (Target Products Ltd.); (4) Cat litter (Magic Pearl, EDA Industries Corp.), 5) Peat Moss (Lakeland Peat Moss Ltd.) and (6) Sphagnum (living moss collected from Simon Fraser Univ.). The sand and peat moss were sieved with a 14-mesh screen before use.

SMP Protocol. Moist chilling was combined with SMP. Seeds were imbibed in aerated running de-ionized water at room temperature (22°C) for 72 h. Seeds were then sterilized in 3% H_2O_2 for 30 min, washed twice with sterile water and surface dried. For SMP, 50 seeds were mixed with 30 ml of matrix in a 150-ml sample bag closed with a wire twist tie. SMP with sphagnum was conducted by rolling 50 seeds into the moss (Wang et al., 1998) For treatments that combined moist chilling, a dry-back and SMP, seeds were first moist chilled (4 °C for 4 weeks) by placing them on a mesh screen within a seed box (Hoffman Man.) containing 100 ml water. Following a dry-back to 35-40% water content (Edwards, 1996), seeds were mixed with the solid matrix as described above. All SMP bags were kept in a sealed carton stored at 4°C in the dark.

Germination Conditions. The seed boxes were maintained in a growth chamber (21°C days, 15°C nights; 8-h photoperiod, light intensity at 25 m mol/s/m^2). Germination was counted every 3 d for a total of 30 d. Seeds with healthy radicles of 15 mm or longer were considered germinated and removed from the seed box. Germination data were based on total seeds including empty ones. Germination rate (GR) expresses the speed of germination. The formula is GR=(T x G_1 + [T-1] x G_2 + [T-2] x G_3 + É1 x G_T)/T where T is the number of d of the germination test (T=30) and G_1, G_2, G_3ÉÉ G_T are the percentages of germination on d 1, 2, 3ÉÉT (Xu, 1993, Ren and Kermode, 2000). Data analyses. The analyses of variance (ANOVA) to determine the least significant difference value among means at 5% level and interaction among treatments was processed by Minitab.

Results

Effects of Matrix Type: As indicated in Table 1 and Figs. 1 and 2, seeds of *Abies* species (BA, BL, BG and BN) primed at 4°C in all selected solid matrices generally showed an enhanced germination performance compared to those seeds without SMP. The positive effects were not limited to the germination percentages after the 30-d test period, but were also apparent with respect to germination speed. For example, the best matrix for BA was peat moss. Seeds of BA (seed lot 24904) subjected to peat moss-SMP for 8 weeks, exhibited 79% germination which is very close to its Germination Capacity (80%) considering the number of filled seed. Likewise, the germination percentage (GP) and rate (GR) of BA (seed lot 24904) were increased by 35% and 20% respectively compared to those of the control (Table 1 and Fig.1) and statistical analyses (ANOVA) for these germination parameters indicated significant differences (Table 1.). However, within the same species, not all the matrices had the same degree of promotion of germination performance. Peat moss proved to be the best matrix for BA and BN, Agrolig Greensgrade was the best matrix for BL and sand was the best matrix for BG (Table 1, Figure1).

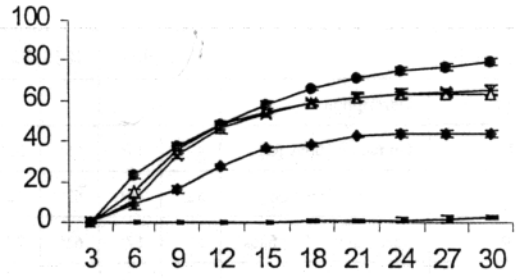
Effects of SMP Duration: SMP for 8 weeks yielded the best results for BA and BL, while BG and BN benefited more from 4 weeks. When SMP was extended for greater periods, both the germination percentage and rate decreased substantially (Table 1). In addition, extending the SMP period (e.g. to 13 weeks for BA seed lot 24904) led to 15-20% germination during priming, prior to the transfer of seeds to germination conditions.

Effects of Matrix Water Content (WC): Water contents set up in the first experiment were based on previous literature (Wu et al., 1999). Some (e.g. 25% w.c. in sand and 40% w.c. in peat moss), were far from optimum for dormancy termination. Table 2 indicates the moisture contents close to optimal in 3 matrices and ANOVA results of the germination they elicited. There were no differences in germination performance between the three controls (treatments currently used in nurseries or in research labs). However, there were large differences in germination rate and percentage elicited by different moisture contents maintained in the matrices during the SMP eriod. The best germination performance of BA and BL was elicited by SMP in which Agro-lig Greensgrade was at 40% w.c. during the 8 weeks, while peat moss and sand were best when at 320% and 15% w.c. respectively (Table 2).

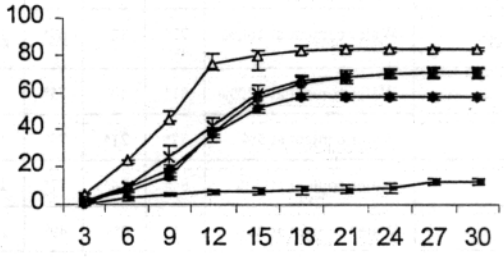
Table 1. Summary of the effects of matrix-type and the length of time of priming on total germination (GP) and germination rate(GR)

sp.	Matrix	4 wks SMP		8 wks SMP		13 wks SMP	
	Air control	39[a]	13[a]	44[a]	26[a]	45[a]	20[a]
	Agro-Lig Fine	51[b]	19[b]	59[b]	33[b]	45[a]	23[a]
	Agro-Lig Green	47[b]	18[b]	64[b c]	40[c]	44[a]	22[a]
BA	Sand	61[c]	29[c]	65[c]	39[cd]	57[b]	27[b]
	Cat litter	63[c]	24[d]	67[c d]	37[d]	56[b]	27[b]
	Peat moss	62[c]	28[c]	79[d]	46[e]	56[b]	28[b]
	Sphagnum	61[c]	27[c]	71[c]	43[e]	55[b]	28[b]
	Soaking only	3[d]	0.5[e]	3[f]	0.5[f]	3[c]	0.5[c]
	Air control	41[a]	12[a]	58[a]	35[a]	63[a]	28[a]
	Agro-Lig Green	63[b]	29[b]	83[b]	56[b]	70[b]	44[c]
BL	Sand	51[c]	21[c]	71[c]	41[c]	62[a]	33[b]
	Peat Moss	55[c]	19[c]	71[c]	39[ac b]	68[a b]	36[b]
	Soaking only	12[d]	6[d]	12[d]	6[e]	12[c]	6[d]
	Air control	53[a]	16[a]	79[a]	36[a]	71[a]	41[a]
BG	Sand	81[c]	24[b]	81[a]	44[b]	85[b]	56[d]
	Soaking only	29[d]	4[d]	29[b]	4[d]	29[d]	4[e]
	Air control	35[a]	13[a]	46[a]	21[a]	47[a]	23[a]
BN	Peat moss	59[d]	21[d]	59[b]	27[b]	29[c]	17[c]
	Soaking only	24[b]	6[e]	24[c]	6c	24[b]	6[b]

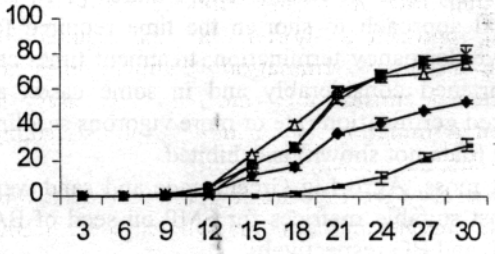
Abies amabilis



Abies lasiocarpa



Abies grandis



Abies procera

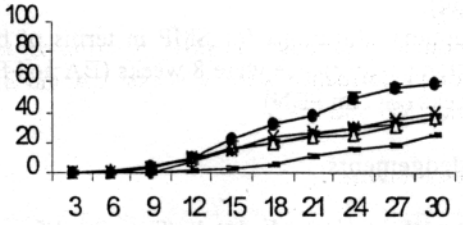


Figure 1. Germination percentages (over 30 days) of seed from Abies amabilis (BA), A. Lasiocarpa (BL), after 8 weeks and A. granda (BG) and A. procera (BN) after 4 weeks of solid matrix priming. air -◆- ; agro-Lig green -▲- ; sand -✖- ; peat moss -●- ; and no chilling —.

Table 2. The mean germination percentage for seeds of Abies amabilis (BA) and A. laciocarpa (BL) after SMP by various matrices in different water contents. Means followed by different letters are significant at 0.05.

Species/seedlots		BA24904		B 35573	
Treatment	Description				
control 1	On rack@100% RH	49^a	17^a	66^a	32^a
control 2	Seeds in Plastic Bag	52^a	19^a	63^a	30^a
control 3	Seeds in wet Kimpack	50^a	17^a	62^a	27^a
Agro-Lig Green	Water content at 40%	63^b	28^b	78^b	45^b
Agro-Lig Green	Water content at 70%	55^a	23^a	65^a	36^a
Agro-Lig Green	Water content at 100%	21^c	9^c	50^c	26^c
Peat moss	Water content at 80%	62^b	30^b	68^a	32^a
Peat moss	Water content at 160%	72^c	32^b	69^a	36^a
Peat moss	Water content at 320%	81^d	40^d	75^b	39^b
Sand	Water content at 5%	57^a	21^a	75^b	35^a
Sand	Water content at15%	64^b	24^a	77^b	37^a
Sand	Water content at 25%	26^c	9^c	49^c	22^c

Conclusions

Conducting SMP at chilling temperatures (4 C) is a practical approach to shorten the time required for effective dormancy termination; treatment times can be shortened considerably and in some cases, an enhanced germination rate or more vigorous seedling growth (data not shown) is exhibited.

1. Peat moss, Agro-Lig Greensgrade and sand were the most suitable matrices for SMP on seed of BA, BN, BL and BG respectively.
2. The moisture contents of the solid matrices that yielded the best germination performance were 320% (peat moss), 40% (Agro-Lig Greensgrade) and 5-15% (sand).
3. The optimal durations for SMP in terms of best germination performance were 8 weeks (BA and BL) and 4 weeks (BG and BN).

Acknowledgements

We are grateful to Dave Kolotelo (Tree Seed Centre) for his advice and help in obtaining mature seeds of *Abies* and to Reg Renner (Pacific Regeneration Technologies Inc.) for his advice and supply of resources in the nursery greenhouse. This research was supported by an NSERC Strategic Grant awarded to A.R.K.

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TSWG WORKSHOP TOPIC?

The Canadian Tree Improvement Association (CTIA) has recently announced that its forthcoming 2002 meeting will be a joint meeting in conjunction with the Poplar Council of Canada and the Western Forest Genetics Association. The meeting will take place from July 22-25, 2002 in Edmonton Alberta and the theme of the plenary sessions is "Integrating Tree Improvement with Sustainable Forest Management Practice". For further information please check the website www.poplar.ca

The Tree Seed Working Group has traditionally had a workshop associated with the CTIA meeting and we do have a place saved for 2002 also. A summary of past workshop themes is enclosed below and I have also included some potential topics for 2002. I would appreciate feedback on any additional potential topics or the one that appears best suited to this meeting. I am asking for all correspondence by January 18th, 2002 so that future mail-outs can reflect the topic (and hopefully speakers).

TSWG Workshop Topics

2002. ??????????????????
1999. The role of ex-situ germ plasm storage in gene conservation
1997. Artificial pollination in seed orchards
1995. Seed orchard management and cultural options for quality seed production
1993. Seed testing
1991. Crown management
1989. Cone and seed crop monitoring / Cone induction: responses to practice

Potential 2002 Topics

a) **Hardwoods** – We have discussed this option for some time, but have not dedicated a workshop or Newsbulletin to this 'theme'. This would tie in well with one of the joint sponsors – the Poplar Council of Canada.

b) **Seed Deployment Options** – This topic would pertain to the use of wild seed, bulked orchard seed, and half-sib and full-sib families. Questions pertain to how these materials can be deployed in a 'sustainable' fashion. Other complications such as orchard location or 'after-effects" may also be part of this theme.

c) **Seeds: Special Agents of Diversity** – I like the topic, but it is quite close to our 1999 topic. I envision a review of genetic diversity in trees; genetic control of seed characteristics and possibly (hopefully) a mixture of information from quantitative and molecular genetics.

Those are the three ideas that pop into my head. Please forward your thoughts on these and others to either myself, Ron– or better yet send them to the TREESEED listserver.

Dave Kolotelo

UPCOMING MEETINGS

Seventh International Workshop on Seeds, Salamanca, Spain, 12-16 May 2002.

Topics included are seed development, seed germination and dormancy, desiccation and other stress tolerance factors, seed ecology, and seed biotechnology. For more information see the website at:
http://www.geocities.com/workshop_on_seeds/

Contact: Gregorio Nicolás (chairman) at gnr@gugu.usal.es
or
Delores Rodriguez at mdr@gugu.usal.es

Tree Seeds 2002
The Annual meeting of IUFRO RG 2.09.00
Chania, Crete,
Sept. 11-15, 2002

Topics will include all aspects of tree seed science and technology. Both oral and poster presentations are welcome. Preliminary registrations and titles of contributions must be submitted by November 30, 2001.

The following website will soon be operational and provide further details:

http://www.cc.uoa.gr/biology/TreeSeeds2002.htm

Contact: Dr. Costas Thanos at cthanos@biol.uoa.gr
or
Dr. Jack Vozzo at jvozzo@cfr.msstate.edu

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SELECTED REFERENCES -SEED TREATMENTS

Dave Kolotelo

These selected references represent some papers picked from my files to address the theme of 'seed treatments'. The topic of dormancy is not strictly a treatment, but the reason for the treatment in many cases. Our understanding of seed dormancy is incomplete, but these references illustrate the 'current' thinking on seed dormancy and various seed treatments. Enjoy.

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