TREE IMPROVEMENT

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Seed and Seedling Extension Topics

Robb Bennett– Editor

Mike Carlson's paper "Seed Orchard Seed and Seedlings: Genetic and Non-Genetic Implications and Operational Considerations," published in the last number of this newsletter (Vol. 5 #2), has generated considerable interest and some comment. We pursue this issue further in this number with articles on nursery opinions on seed orchard seed (Clare Kooistra), variability in spruce seed orchard seedlots (Chris Hawkins), and an extract from a Forestry Chronicle paper on domestication and genetic diversity (Yousry El-Kassaby).

Hugh Schooley (Petawawa National Forestry Institute) expressed interest and notes he is working on the effects of gibberellins and nitrogen fertilizers on jack pine reproductive structures. During a literature search he found only one report on gibberellin effects that went beyond observations of strobili to examine effects on seeds in mature cones. This paper noted significant reductions in seeds per cone, percent germination, and 1000 seed weight in Sitka spruce after treatment with GA4/7. Hugh notes that reports on the effects of nitrogen fertilizer on cones and seed are much more numerous. Copies of Hugh's literature search citation list are available from him at Forestry Canada, PNFI, P.O. Box 2000, Chalk River, Ontario K0J 1J0 (613) 589-2880, Fax: (613) 589-2275

Ontario Ministry of Natural Resources News Release "Announces Major Refocus of Forest Renewal Program to Achieve Full Regeneration of Ontario's Forests"

This announcement is not particularly good news for Ontario's forest nursery industry. Over the next five years OMNR is planning to steadily decrease its reliance on planting seedlings on Crown land and switch over to lower cost options such as aerial seeding and natural regeneration. In 1993 OMNR plans to plant 120 million seedlings on Crown land in northern Ontario, a reduction of about 10 million plantings. The new strategy will provide for an increase in manual tending and thinning of forest stands. OMNR plans to work with growers, planters, and other affected industry workers to develop new markets, products and/or skills.

New and Not so New Publications

"Seed Manual for Forest Trees," edited by A. G. Gordon, is published by the Forestry Commission (United Kingdom) and contains 12 chapters (each written by a specialist in that field) on all aspects of commercial forestry tree seed usage. This text can be ordered from HMSO Publication Centre, P.O. Box 276, London, England, SW8 5DT.

"**Western Forest Insects**" (R. L. Furniss and V. M. Carolin) is once again available. The USDA Forest Service has reprinted (but unfortunately not revised) this valuable publication.

Dioscorides Press (9999 SW Wilshire, Suite 124, Portland, Oregon 97225) has published a revision of "Seeds of Woody Plants in the United States" (1974) entitled "**Seeds of Woody Plants in North America**." The new edition doubles the number of genera covered (in less than half the number of pages), lists over 1,000 new literature citations and compiled them all in one section at the end of the book (most pre-1974 references have been deleted), deletes much taxonomic data, increases coverage of vegetative propagation and introduces tissue culturing, adopts the use of standard nomenclature for germination standards, and has a new appendix listing general germination requirements for genera. One major complaint with the latest edition concerns the quality of many of the photographs and figures. Most are poor

(continued...)

British Columbia
Ministry of Forests

reproductions of plates in the 1974 edition: photograph contrast is generally very poor and resolution of detail in figures is reduced.

There is still much good information on taxonomy, seed biology, production, harvesting, marketing, pollen handling, et cetera in the 1974 edition and the USDA is currently preparing an "official" revision of it to be published in about three years in two volumes. It may be worthwhile waiting for its appearance as opposed to buying the Dioscorides edition. Suggestions of new genera and species and/or unpublished data that could be included in the revision are invited by the USDA. Send your suggestions to Frank Bonner, USDA Forest de Groot) is now available from Ministry of Natural Resources, Ontario Forest Research Institute, P.O. Box 969, 1235 Queen St. East, Sault Ste. Marie, Ontario P6A 5N5, (705) 946-2981, fax: (705) 946-2030. This excellent, spiral bound publication has sections covering crop monitoring, insect detection, impact prediction, management tactics and assessment, and provides keys to cone damage and informative fact sheets on beetles, flies, bugs, seed wasps, and moths of importance to eastern cone and seed crops. Get yours while supplies last.

"And the Envelope Please..." (Nursery Extension Services Brings Home the Gold)

Gwen Shrimpton and Dave Trotter, Nursery Extension Services (BC Ministry of Forests, Silviculture Branch), travelled to Toronto in April as nominees for a national award of excellence from the Conference Board of Canada. The nomination arose from their participation in a very successful pilot program that brought high school seniors out to the workplace under the supervision of university Co-operative Education students. This mentorship program was conducted with the co-operation of the West Vancouver School District.

Co-operative education programs of one form or another have been around for years at several BC universities and colleges. In general, these programs co-ordinate on the job experiences as part of academic programs leading to a degree or certificate. Employers co-operate by hiring these students for terms of 4-8 months to work on special projects relating to their field of study. The students are required to complete a number of work terms during the course of their studies and they generally complete written reports for each of those terms. This gives the students practical experience in their chosen field before they graduate.

The most recent innovation in co-operative education is the co-op mentorship program. This pilot project brings high school seniors out to the workplace for several afternoons a week during the fall of the school year. They are supervised by university co-op education students employed at the worksites and assist with project technical work, as well as project reports.

Gwen Shrimpton and Dave Trotter acted as hosts for the program last year at Nursery Extension Services in Surrey. From November to December 1992, their co-op student from Simon Fraser University, Brent Wilson, supervised 2 students, Mike Pellatt and Matt Lyne, from West Vancouver Senior Secondary School. They collected and measured seedlings treated with citricide (a product derived from grapefruit seeds) and determined if the treatments had any effect on seedling growth. They presented their results in a seminar for Nursery Extension Services staff in December. Gwen and Dave hosted a project in 1992 as well, with West Vancouver students Morgan Cowan and Jessica Stipp.

There were a number of "co-op teams" across Canada and, of these, the team that Gwen and Dave hosted was presented with a national award of excellence by the Conference Board of Canada in April 1993. Congratulations are in order for an innovative and successful project to assist students in making a career choice in science.

Don Summers
Nursery Extension Services, Surrey

Advances in Study of Resistance to Spruce Weevil, *Pissodes strobi*, in BC Spruce

***Ed. note**: the following is condensed from "Information Forestry, Pacific and Yukon Region" (March 1993) and a presentation by Tara Sahota at the 13th Annual Forest and Tree Related Research Colloquium, March 4, 1993 in Victoria, BC.*

For years the spruce terminal weevil, *Pissodes strobi*, has devastated young spruce plantations throughout BC, frustrated efforts to bring it under control, and played havoc with spruce reforestation particularly on the coast. Recently, Tara Sahota, John Manville, Michael Hulme, and Eleanor White of the Pacific Forestry Centre reported some exciting new findings in spruce weevil research.

Some spruce trees have always been observed to be free of weevil damage, even within otherwise heavily attacked stands, but the mechanism of this resistance has remained unknown. It has now become apparent that resistant trees directly affect the reproductive biology of weevils attempting to oviposit on them. The researchers at Pacific Forestry Centre have shown that when placed on resistant spruce 1) females with immature ovaries fail to mature and oviposit, 2) females with mature ovaries and ripe eggs reabsorbed most of the eggs, and 3) eggs hatch but do not produce viable larvae.

Researchers have long known that many plants produce compounds in response to feeding by insects (or other forms of damage) that can dramatically affect the biology of the herbivore. The discovery that this is apparently the case with spruce and *P. strobi* is a great stride towards developing an effective reforestation program for spruce in BC.

Gene Pool Preservation of Lowland Spruce in the Fort Nelson Planning Zone

Since 1982 concerns regarding the potential loss of natural genetic variation of lowland spruce (white spruce restricted to the floodplains of the Liard and Fort Nelson Rivers) have been expressed by resource managers. However, in the past, the undertaking of a full-scale tree improvement program for lowland spruce (including selection of parent trees, progeny testing, and the establishment of seed orchards) has been deemed a lower priority than other ongoing programs.

In 1992 staff from Prince George Region, Fort Nelson District, Research Branch, and Silviculture Branch resumed discussion of the possibility of losing much of the local lowland spruce gene pool in the Fort Nelson zone. Careful consideration of effects of ongoing harvest in the area and means of capturing most of the available natural variation led to the decision that parent tree selection should be carried out.

In the winter of 1992/93, 150 lowland spruce parent trees were selected. Scion material (twigs) was collected and the trees were marked and mapped for possible future cone collection. The scion material of these parent trees has now been grafted at Skimikin. These grafts will be established in the spruce clone banks at the Prince George Tree Improvement Station. This will ensure capture and preservation of a good representation of the genetic variation of Fort Nelson lowland spruce and that a breeding program will be possible in the future.

Maarten Albricht
Interior Seed Orchards, Vernon

Grower's Notes

Machinery Development in Alberta and Ontario

Ed. note*. The following is reprinted from the Newsbulletin of the Tree Seed Working Group, #19 (March 1993)*

A cone harvester, developed by Canadian Cone Collectors of Edmonton, successfully picked lodgepole pine cones in 1992. The use of this machine for white and black spruce collections will be tested in 1993 along with improved delivery systems. The Alberta Forest Service Drag Seeder successfully distributed seed and was refined with sensors to monitor seed dispersal. Axle weaknesses will be improved for the 1993 trials. For further information on these machines contact: Dave Patterson, Alberta Forest Service, 9920-108th St., Edmonton, Alberta T5K 2M4, (403) 427-8474.

A simple and effective roto-seeder, designed for close-coupling behind a scarification drag, accurately places seeds into the furrow. This seeder has a very simple, and sturdy, metering mechanism activated by its own rotational motion, and functions in both forward and reverse directions so as not to be affected by roll-overs. Further design improvements are planned. For more information on this machine contact: Clyde Corser, 4806-17th Ave., Edson, Alberta T7E 1G5, (403) 723-6957.

The Bartt MkV Direct Seeder is a simpler, easy to install, and considerably less expensive model of the Bartt precision seeder. It is used for precise seed placement behind disc trencher scarifiers. The seeder outputs single seeds at a constant rate, as determined by the desired seed spacing (20 to 119 cm) and average forward ground speed of the prime mover. A swivel plate assembly allows easy in-field adjustment of seed placement position within the furrow (side or bottom location). For further information contact: Tom Ratz or Jeff McKnight, KBM Forestry Consultants Inc., 360 Mooney St., Thunder Bay, Ontario P7B 5R4, (807) 344-0811, 1-800-465-3001, fax: (807) 345-3440.

Looking for a Goldmine? Try Planting Eastern Hardwoods

In recent years agroforestry, the integration of trees with herbaceous crops and/or farm animals on the same land, has been rediscovered and has attained a high profile in southern Ontario. A major research program investigating agroforestry systems such as intercropping (planting trees within crop rows), windbreaks, riparian and stream bank plantations, woodlots, and silvipasture (trees planted on livestock pasture) is in place at the University of Guelph under the guidance of Andy Gordon.

Among several factors for the renewed interest in agroforestry, the potential for economic gain is not insignificant. The high value, rapid growth rate on suitable sites, and scarcity of quality local sawlogs (see table 1) has fuelled a drive by farmers and other landowners in southern Ontario to plant valuable hardwood species such as black walnut, red oak, and white ash. These species can and do grow well in areas of southern British Columbia. Currently, in Victoria, black walnut and red oak are selling at $5.25 and $3.50 per board foot respectively ($4,200.00 and $2,700 per thousand). On suitable sites black walnut can reach marketable size in 35 years and produce nuts worth over $6,000 per year per acre (40-foot spacing) while they are growing. Plant now for your retirement income. For more information on agroforestry systems including cost/benefit analyses, contact Dr. Andy Gordon, Agroforestry Research Group, Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1, phone (519) 824-4120 ext. 2415.

	m³	%	000's$	$/m³
LOGS				
Red Oak	66,901	26.9	11,893	177.77
Cherry	10,961	79.0	5,619	512.64
Black Walnut	1,462	93.2	1,370	937.07
Ash	2,568	21.0	919	357.87
LUMBER				
	m³	%	000's$	$/m³
Red Oak	124,968	50.2	64,017	512.27
White Oak	62,968	77.4	27,421	435.48
Black Walnut	3,580	64.0	2,639	737.15
Ash	26,452	59.0	11,283	426.55
VENEER				
	m³	%	000's$	$/m³
Oak	6,642,738	70.8	10,444	1.57
Cherry	1,285,790	89.3	2,122	1.65
Black Walnut	1,406,787	80.4	2,997	2.13

Table 1. Imports of valuable hardwood commodities into Ontario from the US in 1989. % is percentage of all US impotrs to Canada (of that species) going to Ontario. Adapted from a table compiled by A.M. Gordon (University of Geulph) from Statistics Canada, International Trade Division Annual Summaries.

Cultural Control of Pests in Conifer Seedling Nurseries

Conifer seedling nurseries have a unique complex of pests. Young, succulent seedlings can be hosts to a number of insects and diseases that would not normally attack mature conifers. Many of these organisms are also general pests of agricultural crops. Pests directly affect the quality and quantity of nursery stock. Monetary losses include the unrecovered cost of producing dead or culled seedlings and the cost of control procedures. Complications arise when seedlings are not available for prepared field planting sites. This can delay reforestation for one or more years, during which time weeds may become established and the site will have to be prepared again, greatly adding to the cost. Furthermore, infested stock can disseminate pests to new areas and the survival of this stock in the field may be reduced.

Site selection

Cultural pest control in nurseries is practised at all phases of production and begins with the selection of the nursery site. The following factors should be considered.

- For bare-root nurseries, soil type is very important: sandy, well-drained, moderately acid soils favour seed germination and seedling emergence and growth, but hinder the establishment and survival of many pests.
- Water supplies should be of an acceptable pH and free of toxic chemicals and water-borne pathogens such as *Pythium* and *Phytophthora*.
- Sites with high levels of nursery pests in the surrounding areas should be avoided, including sites with plants that could

serve as pest alternate hosts such as *Populus* spp (rusts) and *Picea* spp (gall aphids, *Adelges* spp and *Pineus* spp).

- Established quarantine zones for pests such as the Balsam woolly aphid, *Adelges piceae*, and the European pine shoot moth, *Rhyacionia buoliana*, should be considered.
- Adverse weather conditions such as severe winds, frost pockets, shading from surrounding mountains, and flooding, can severely affect seedling survival and should be avoided.

General maintenance

Management of nursery pests at established facilities begins at the time of seeding and continues throughout the growing season. General maintenance of the site year round is crucial for the reduction and control of many pest populations. The following practices are recommended.

- Grasses serve as alternate hosts for both the Cranberry girdler, *Chrysoteuchia topiaria*, and the European marsh crane fly, *Tipula paludosa*. Reduction or removal of grassy areas in and around the nursery site will help to reduce populations of these insects. Alternatively, if grass must be present, frequent mowing and/or planting of less suitable host grasses will help to reduce the numbers of these pests if present.
- Removal of weeds throughout the nursery area will help to reduce populations of pest insects such as noctuid cutworms, tarnished plant bugs (*Lygus* spp) and root weevils (*Otiorhynchus* spp). These insects are attracted to various weed species to feed and reproduce. Populations can build up in weedy areas and then migrate to the seedling crop.
- To reduce populations of the European pine shoot moth, *Rhyacionia buoliana*, and Western gall rust, *Endocronartium harknessii*, ornamental pines should not be planted and adult pine trees on site should be re-moved.
- Greenhouses and open compounds should have good drainage to reduce pools of standing water. These areas encourage the growth of algae and serve as breeding grounds for sciarid fungus gnats. Larval sciarids can become pests in the container plugs. Adults can spread spores of some diseases such as *Botrytis*. At some nurseries copper sulphate is applied to the floors of the greenhouses to reduce build up of these pests.
- In bare-root culture, all production panels should be well drained. Low lying wet areas will encourage the survival of soil pathogens such as *Phytophthora*.
- Chlorination of the water supply is currently practised at several facilities. This will help to reduce or eliminate water-borne pathogens and may help to prevent the establishment of other diseases throughout the growing season.
- Properly dispose of culled or diseased trees. Large cull piles serve as sources of inoculum for current crops and should be burnt or buried.
- Liverworts and mosses can become established on gravel under the greenhouse benches and compound pallets and then spread onto the container blocks where they may be a serious problem. Asphalt or plastic ground covers will prevent the growth of these small primitive plants.
- In container culture, some styroblocks have been introduced that hold a lower number of seedlings thereby reducing the crop density. This allows better aeration, lowers the humidity, and generally reduces conditions that favour the development of *Botrytis*.

Sowing

Sowing is probably the most critical time in the crop history especially for container culture. Mistakes made when styroblocks are loaded with the peat/vermiculite mix or when seeds are placed in the cavities will often be carried through the life of a crop.

- The quality of peat used in containers is important in root rot management. Coarse fibers will promote healthy root growth through better root aeration and drainage. Low pH will reduce the growth and establishment of root pathogens and, of course, the peat used must be free of inoculum.
- Pathogens such as *Fusarium* and *Sirococcus* can be seedborne. Seedlots with histories of these diseases are recorded and lists distributed. Methods of cleaning seed including bleach, fungicide, heat, and running water treatments are currently being investigated.
- In container culture, root pathogens can be transmitted from one crop to the next when uncleaned styroblocks are reused. Effective block sanitation is essential especially at nurseries with a history of root disease. Currently hot water, bleach, Safer's demoss, and sodium metabisulphite are used.
- Effective sanitation of greenhouses between crops is important. Once stock is removed many nurseries wash the house with high pressure hoses and bleach.
- In bareroot culture, seedlings are sown into panels that have been left fallow for one year. Fallowing between crops combined with disking and cultivation helps to reduce levels of most soil pests including pathogens such as *Fusarium*, *Phytophthora*, and *Pythium*; nematodes; and insects such as white grubs, root weevils, and leatherjackets. Perennial deep rooted weeds such as horsetail are also reduced.

Operational procedures

Operational practices throughout the growing season are being modified and new procedures and techniques introduced to help discourage and manage pest populations. Control by cultural means is being emphasized and in many cases pesticides are only applied when other measures have failed.

- A pheromone trapping program has been developed for the Cranberry girdler. Traps are set among susceptible stock from June to August and checked once a week. If a predetermined threshold number of moths is caught, an insecticidal spray is applied to reduce oviposition on the seedlings by adult moths.
- At nurseries within the quarantine zone, a pheromone trapping program for the European pine shoot moth has been established. Traps are placed among pine seedlings and if moths are caught the necessary controls are applied according to regulations.
- In bare-root culture, populations of the strawberry root weevil are monitored using board traps. This program determines the length of the adult emergence period, the distribution of weevils throughout the nursery, and the effectiveness of control measures.
- Populations of adult fungus gnats are monitored in some greenhouses using yellow sticky traps. These help growers monitor relative numbers of other innocuous or pest insects as well and some reduction in the number of adult fungus gnats is achieved.
- Irrigation regimes throughout the growing season are crucial to the development of most diseases. Overwatering encourages growth of *Botrytis* and all root rots as well as mosses, liverworts, and algae. Many nurseries now water less frequently but more thoroughly allowing the crop to dry out between irrigations. Misting for heat protection has also been reduced.
- Greenhouse roofs are routinely removed around mid-June. Full sun encourages waxes to build-up on needle cuticle making seedlings less succulent and less susceptible to disease.
- The colour of the grit used on the surface of the container plugs has been changed from grey to white. This can reduce the temperature at the surface of the styroblock by up to 5ºC. Less misting for heat protection is required and heat lesions on the stems where pathogens can enter are reduced.
- Many insect pests such as cutworm and tussock moth (*Orgyia antiqua*) larvae are hand-picked and destroyed throughout the growing season.
- Any cultural conditions that favour rapid germination will reduce loss to pre-emergence damping-off. Examples include spring sowing of stratified seed, covering both bare-root and container sown seed with non-compacting sand or grit, and sowing when the temperature and moisture are optimum for germination.
- In greenhouses, when the sides and roofs are on at the beginning of the growing season, screens placed over the fans and keeping the doors closed will help physically exclude pest insects.
- Several biological control agents have been tested in nurseries with limited success to date. Nematodes have been used against root weevil larvae, Virtuss (NPV) against rusty tussock moth larvae, and BT for cutworms. Predaceous mites are currently being tested for control of the spruce spider mite.
- Whenever possible, diseased seedlings are hand-pulled from container styroblocks and bare-root beds and removed from the growing site. Increased worker training and awareness has helped in the early detection and removal of these infection sites.
- There has been a general improvement in crop nutrition: fertilizer regimes are more balanced, growth is controlled, and trees are healthier and more disease resistant. Rates of nitrogen have been reduced to discourage soft, succulent, *Botrytis*-susceptible top growth. Calcium levels have been increased to promote the development of woody tissue and roots.
- Storage moulds have been significantly reduced through the post-lift storage of seedlings of many of the interior species at freezing temperatures.

Gwen Shrimpton
Nursery Extension Services, Surrey

Tech Talk

Review of 1992 and 1993 Operational Trials at Saanich Test Nursery

The following 1993 SX trials are under way at Saanich Test Nursery:

1. **Copper root pruning comparison trial**. Lodgepole pine, interior spruce and interior Douglas fir are being grown in standard vented styroblocks, Beaver Copperblocks, and in standard blocks with an application of copper carbonate in latex paint. Two subtrials will compare the effects of different lime rates and fertilizers with different amounts of calcium and magnesium on copper availability and toxicity.
2. **Long term slow release fertilizers**. Several new slow release fertilizers (release times of one year and longer) will be incorporated into the growing media of white spruce seedlings. Growth differences after outplanting will be assessed. The outplanting phase will be conducted in co-operation with the Regeneration section of Silviculture Branch.
3. Alternate container types. Container types being tested include: 410A vented styroblocks, First Choice Nature Root 415B, Lannen Plantek 63F (a hard plastic container with vertical slits, 63 cavities/block, 90 ml/cavity), Elvinco 313B Airbasket prototype (a hard plastic container with vertical slits, same dimensions as a styroblock), Beaver Cedarblock 313B and 415B (special coating promotes root pruning of cedar), and Jiffy pellets #96.
4. **Development of sub-irrigation methods**. Various techniques will be used to improve the sub-irrigation regime first tested in 1992. Higher supports to promote air pruning, Agribrom to control algae, ultraviolet light to kill root pathogens, and a wetting agent to facilitate uptake of the fertilizer solution will be evaluated.
5. **Alternative growing media components**. Beaver Plastics' Styrolite, produced from recycled styroblocks, will be compared with vermiculite as a growing medium component. The recommended mix of 70% peat, 20% styrolite and 10% vermiculite will also be evaluated.
6. **Early sow 1-0 western redcedar as an alternative to 2-0**. Keithia blight continues to be a major problem on 2-0 cedar. The objective of this trial is to produce 1-0 cedar seedlings which meet 2-0 stock specifications but are not so succulent as to encourage deer browsing.
7. **Resistance development of western redcedar against Keithia blight using increased levels of copper, zinc and manganese**. This trial will test the theory that increased foliar concentration of heavy metals will inhibit the fungus that causes Keithia blight.
8. **Production of western larch stecklings**. This trial will evaluate feasibility and test production methods. Donor stock was sown in early 1993. Production of cuttings will begin in 1994.

1992 Trial Reports

Following are summaries of results from the 1992 trials. Complete reports are available by request from Saanich Test Nursery.

SX92203Q — A Comparison of Conifer Seedlings Grown in Two Growing Media (Cellulose Acetate and Peat/Vermiculite) Using Different Container Types

In an ongoing effort to locate alternate growing media components which could be used in container conifer nurseries cellulose acetate, an alternative growing media product, was tested for a third and final year at Saanich Test Nursery. Peat moss is a limited natural resource; potential supply and quality problems could lead us to the use of alternative products in the future.

Cellulose acetate (CA) is a wood fibre (produced by Celanese Canada) used to produce cigarette filters and other materials. Its supply is potentially unlimited and it is a uniform product which does not vary in quality. CA, being quite different from peat based media, requires a different approach in terms of nursery culture. Due to the low cation exchange capacity of CA, the grower fertilizer level was increased to 125 ppm N. The top halves of CA plugs dry out and saturate quickly, making daily, very short, fertilization a requirement. The bottom halves of the plugs retain more water and nutrients causing the root systems to develop more in the lower portion of the cavities.

Treatments tested in 1992 included higher density CA, CA in shorter styroblocks (310B's) as opposed to standard 313B's,

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and CA in Copperblocks. CA was compared with control treatments (peat/vermiculite media) in 313B's, 310B's and 313B copperblocks.

Six species (lodgepole pine, interior spruce, western redcedar, coastal Douglas-fir, western hemlock, and amabilis fir) were tested, with varying results between species. In all species, there was a lag in growth in CA treatments during the establishment and exponential growth phases when compared with peat/vermiculite (P/V) treatments. By the end of the growing season, interior spruce and lodgepole pine in CA media produced seedlings comparable to P/V. In all treatments (except CA in copperblocks), Sx and Pli seedlings were close to target specifications for height and root collar diameter, and all exceeded target root weights.

With western red cedar the slower growth curve of CA treatments produced shorter seedlings (20 cm.) which met target specifications, as opposed to P/V treatments, which were all overheight (mean heights 27-30 cm). Root collar diameters were 2.6 to 2.8 mm in CA, while dry root weights were well above target at 1.0+ grams.

CA growth lag affected coastal Douglas fir, western hemlock and amabilis fir more than the other three species. While all CA treatments in Fdc and Hw (except CA in copperblocks) met specs at the end of the growing season, P/V treatments were superior in all morphological parameters measured. Ba in CA was borderline in development.

Root growth capacity testing showed comparable results between CA and P/V treatments in all species. Nursery outplanting tests from previous trials have also demonstrated comparable growth between treatments. Depending on Celanese Canada's ability to find a distributor for their product and the product cost, cellulose acetate could prove to be a useful growing media in certain applications.

SX92202Q — The Effects of Fertilization with Five Different Ammonium/Nitrate Ratios on Conifer Seedling Growth

Ammonium and nitrate are the two main forms in which nitrogen is taken up by plants. Ammonium is toxic to plants and, therefore, must be incorporated into amino acids and related compounds immediately as it enters the plant roots and then transported to the shoots for plant growth. Nitrate can be stored in the plant's vacuoles until required. This difference in metabolism suggests that nitrate fertilization may be a useful tool in controlling plant height growth.

Results of studies on conifers and other higher plants have been contradictory. A 1990 trial conducted at Saanich Test Nursery compared the effects of five different ammonium/nitrate ratios, applied at 100 ppm total nitrogen, on the growth of four conifer species. It was expected that seedlings receiving 100% ammonium would be taller than those receiving 100% nitrate. The latter produced short trees for coastal Douglas-fir, lodgepole pine, and white spruce, but the tallest trees were those treated with a mixture of ammonium and nitrate. Western redcedar showed nearly identical growth under all treatments.

The 1992 trial compared the same five ammonium/nitrate ratios, at 75ppm and 50 ppm total nitrogen each (for a total of ten treatments) in the belief that lower levels of nitrogen would amplify the results and avoid possible ammonium toxicity. For each species, treatment with 1:1 ammonium and nitrate at 75 ppm N produced the tallest seedlings. Seedlings treated with 75% nitrate and 100% nitrate at 50 ppm N were the shortest. Treatment height rankings were consistent among species but the differences were not statistically significant for any species except interior spruce. All Douglas-fir and western redcedar seedlings were taller than the maximum BCFS stock specifications. The use of nitrate fertilization to control height growth may be possible theoretically but we did not find it to be operationally successful in this trial.

SX92201Q — A Comparison of the Effects of Six Proprietary Fertilizers, Amino Acid Supplements, and a Micro-organism Amendment on Conifer Seedling Growth

Fertilizer manufacturers and distributors are constantly developing new fertilizers and other nutritional amendments which they feel will benefit the container conifer industry. In 1992 we compared fertilizers produced by Plant Products, Smith and Ardussi (S&A), and Dynagro and tested a series of synthetic amino acid nutrients produced by LBE Inagrosa of Madrid and a media amendment, Biorgan, composed of micro-organisms meant to increase the fertility of the media.

The six proprietary fertilizers tested were: Plant Prod 20-8-20 Forest Seedling Special and Plant Prod 12-17-29 Forest Seedling Grower with recommended $CaNO_3$ and $MgSO_4$ amendments (both distributed by Westgro), S&A 20-8-18 Conifer Grower and S&A 12-17-29 Conifer Special (both distributed by Coast Agri), Dynagro 7-9-6 liquid formulation; and Dynagro 9-3-6 liquid formulation. They were used at 100 ppm nitrogen (grower) and 50 ppm nitrogen (finisher). The synthetic amino acids, Fosnutren, Aminol Forte, and Humiforte were applied at specific intervals to one treatment which received Plant Prod 20-8-20 throughout the season. The eighth treatment included

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Biorgan as a growing media supplement.

Only minor differences in growth throughout the season and final morphological assessments were found between the six proprietary fertilizer treatments in interior spruce, lodgepole pine, and coastal Douglas-fir. Overall, Plant Prod 12-17-29 with $CaNO_3$ and $MgSO_4$ amendments produced the tallest seedlings and highest tissue levels of calcium and sulphur in all three species, and the best root collar diameters and dry root weights in the spruce and pine. Tissue analyses of the foliage conducted throughout the season showed few other differences in most major and minor elements. The Dynagro 9-3-6 treatment consistently showed lower nitrogen content in all species.

Growth in the amino acid supplemented treatment was not significantly different from the Plant Prod 20-8-20 treatment without supplements. The Biorgan treatment was discarded because it suffered from poor germination and chlorotic growth and most seedlings died during the initial growth phase. Biorgan is designed for field soil application and may not be suitable for container stock. It was probably used at too high a rate in this trial.

Overall, the six fertilizers tested in this trial produced acceptable stock and were usable formulations. Most growers know what fertilizer regimes work best for specific species and stock types in their nurseries and have preferences for particular brands and formulations. Since new fertilizers (many of which are specifically formulated for container forest nursery use) are continually being developed and marketed, it is a good idea to be aware of new, potentially valuable developments.

SX92204Q — A Comparison of Sub-irrigation and Overhead Irrigation on the Development of Conifer Seedlings

The environmental issues of water conservation and groundwater contamination have contributed to an increase in the use of sub-irrigation in North America, particularly in the horticultural industry. Several US states have already passed legislation regulating nursery runoff.

Sub-irrigation systems such as ebb and flow greatly reduce runoff because the fertilizer solutions are collected and reused.

Sub-irrigation was used by the BC Forest Service early in the development of the container program but was eventually rejected for a number of reasons, including the prevalence of root disease. The reuse of fertilizer solutions facilitates the spread of pathogens throughout the crop. Also, sub-irrigation may result in reduced oxygen levels in the soil mix, making the seedlings more susceptible to disease. Advantages of sub-irrigation include control of foliage diseases such as *Botrytis*, and the cost and ecological benefits of recycling fertilizer solutions.

In this trial we compared two sub-irrigation regimes (2-3 times per week and daily) with standard overhead boom irrigation. Ebb and flow benches were used, with styroblocks raised one half inch above the surface of the benches. The fertilizer solutions were re-circulated until plugs were saturated (usually several hours). Six species were used in the trial.

All treatments produced seedlings that met BCFS stock specifications. Generally, in comparison with controls, sub-irrigated seedlings were shorter but had similar root weights and significantly less *Botrytis*. Subirrigation provided better height control of Douglas fir and western redcedar than did overhead irrigation.

Root disease was a problem in sub-irrigated treatments. Root assays showed high incidence of *Pythium* and *Fusarium* in sub-irrigated seedlings, but no *Pythium* and very little *Fusarium* in controls. Other problems included inadequate air pruning of roots, algal growth in flood benches and reservoirs, and the inordinate length of time required for fertilization. We are conducting trials in 1993 that will address these problems.

Bevin Wells, Susan Zedel
Saanich Test Nursery, Saanichton

Yellow Cypress Stratification Trial

Introduction

Yellow cypress, *Chamaecyparis nootkatensis* (Yc), is a valued tree species commanding the highest stumpage value of BC conifers ($10.49/ m^3). In BC, the reforestation effort for this species is currently restricted to the Vancouver forest region and accounts for about 360,000 trees being planted annually (Miller, 1992). At present there are 23 Yc seedlots (5 from seed orchards) available for reforestation use. The average germination of Yc is the lowest of BC conifers at 34 %. Vegetative propagation of this species is an attractive alternative, but because we have three cypress seed orchards and some foresters have misgivings about clonal forestry, the need for improvement of Yc germination is critical to the reforestation effort for this species. The reasons for such poor Yc germination performance include:

1) the need for two full growing seasons following pollination for seeds to mature in BC (maturity in one year is possible in seed orchards) provides a large window for pest and/or environmental degradation of embryos (average yield/cone is only 2 seeds — Owens & Molder, 1984),
2) one and two-year-old cones may occur on the same branch resulting in immature seeds being included in collections (but these are thought to be fairly easily removed during processing),
3) low temperatures at time of pollination may cause abortion or arrested development of ovules or young cones (Owens and Molder, 1984),
4) feeding on the overwintering pollen cones by mites (*Trisetacus chamaecypari*) can result in destruction of up to 60% of the pollen cone crop (Colangeli, 1991),
5) "considerable variability in stage of embryo development at seed shed exists in all stands" (Colangeli, 1991), and
6) the species appears to have compound dormancy consisting of embryo dormancy (need for moist chilling) and seed coat impermeability (which restricts water entry into the seed).

Methods

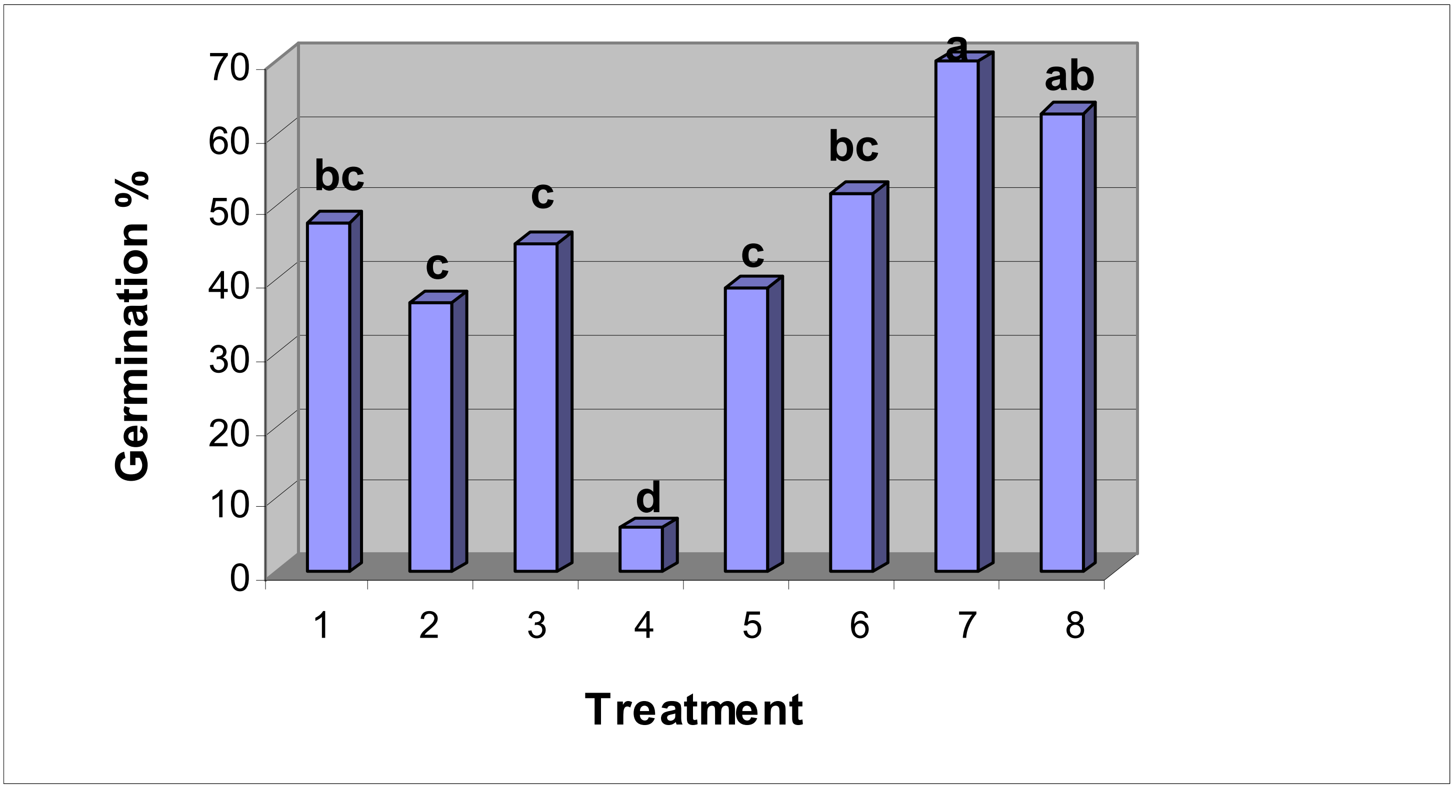
Yellow cypress is currently tested and pre-treated using a 48-hour running water soak and 1 month warm conditioning (20°C) followed by 2 months stratification (2°C). This trial compared this treatment with other treatments which may produce better germination in a comparable amount of time (3 months). Six seedlots (9539, 14659, 32454, 32879, 35130, and 35134) were selected and subjected to six treatments (table 1). In each treatment 400 seeds (4 replicates X 100 seeds) from each seedlot (5 of the 36 combinations used 50 seed replicates due to a shortage of seed) were placed in a CONVIRON germinator for 8 hours light (at 30°C) and 16 hours dark (at 20°C). Germination counts were performed Monday, Wednesday, and Friday over 28 days to obtain estimates on germination capacity (GC) and rate.

Treatment	Soak	Warm	Cold
1	48 hours	28 days	60 days
2	until seed sinks	28 days	60 days
3	until seed sinks	28 days + IS*	60 days
4	until seed sinks	IS*	60 days
5	14 days	28 days + IS*	60 days
6	28 days	28 days + IS*	60 days

Table 1. Treatments applied to six yellow cypress seedlots.
**IS (interrupted stratification) — seeds were placed in room conditions (20) for 8 hours once a week during the cold stratification period.*

The use of extended soaks (14 and 28 days) was based on promising unpublished results obtained with this treatment by Forestry Canada and the Tree Seed Centre (TSC). In both cases a 28-day soak provided the best results. It is generally considered that high moisture is critical to any Yc treatment and "drowning" of seeds is unlikely as seeds have been observed to germinate while immersed in water. As a moisture imbibing guideline, many use the simple criteria that when the seed sinks it has imbibed adequate water. Imbibition variability exists within any seedlot, but it is felt that no damage (due to lack of aeration) will occur in Yc seeds which sink quickly within a seedlot. Interrupted stratification has been used by both Industry and the Ministry of Forests, although there does not appear to be any reference or justification for its use in the literature and therefore its effectiveness, compared to other treatments should be investigated.

(continued...)



Results

GC results for the various treatments averaged over all 6 seedlots are presented in Figure 1. Treatments 1A and 2A represent the results of remaining seed (from 5 of the 6 seedlots) from treatments 1 and 2 which had an additional 30 days of stratification. Sample sizes for these treatments are smaller (due to limited quantities of seed) averaging 254 seeds.

The most obvious result is that **interrupted stratification is a poor substitute for warm conditioning** (treatment 3 vs. treatment 4). The removal of warm preconditioning accounted for an average 35% decrease in germination and is the only treatment of the original six which is significantly different (= 0.05). Trials in Juneau, Alaska on varying durations of warm/cold stratification produced similar results: absence of warm stratification resulted in almost total failure of the seedlot to germinate. The best germination was obtained with 60 days warm and 90 days cold stratification (USDA, unpublished results).

The effect of interrupted stratification in conjunction with warm conditioning (treatment 2 vs. treatment 3) resulted in a modest average increase of 3.7% in GC. The best response of the original six treatments was the 28 day soak (treatment 6) which resulted in a small (1.7%) increase over the control. Neither of these differences is statistically significant. In earlier trials at the TSC with 10 Yc seedlots, comparison of these treatments yielded an increase in germination of 13.4% with the 28 day soak. The discrepancy between these two trials remains unanswered and although the 28 day soak results in higher germination the additional month required may not make it a viable option for production purposes given the relatively low level of improvement found in this trial.

The smaller samples that received the extra month of stratification (1A and 2A) produced the best results. The additional month increased the germination of treatment 1 by 19.2% and treatment 2 by 21.1%. It appears that an additional month is more efficiently used in prolonging the stratification period rather than introducing a 28 day soak. For the future preparation of Yc seed the following points are considered critical:

- insure exposure of Yc seed to adequate moisture and maintain high moisture content throughout pre-treatment and
- extend cold stratification period to break dormancy of as many seeds as possible.

Extending the stratification period is basically a problem of logistics — seedling requests need to be submitted to SPAR in time to meet the sowing date with an extended pre-treatment. Yc requires 14 weeks (12 weeks of pre-treatment and approximately 2 weeks administrative and withdrawal time) from request approval to sowing. Addition of an extra month of stratification brings the total to 18 weeks. Early planning and submission of sowing requests will create a larger window for extending the stratification period and therefore providing flexibility and enhancement of germination. Sowing requests can be approved through SPAR after July 1 of the year prior to sowing. It is recommended that for Yc seed the additional one month of cold stratification be used whenever possible. Future Yc work will investigate the optimal stratification period. More details on germination rate and variability between seedlots as determined in this trial can be obtained by contacting David Kolotelo, Cone and Seed Improvement

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David Kolotelo
Tree Seed Centre, Surrey

Forestry Canada in Prince George

Forestry Canada's presence in British Columbia has been expanded to include a district office in Prince George with a staff of six. Programs have been evolving for about a year and a half. Their development has been based upon the information needs of a client group including the forest industry, the Ministry of Forests, and other natural resource interest groups.

The Prince George Office emanated from a perception that information needs of resource users in British Columbia's northern interior had to be met with additional effort. Following consultation with a broad range of clients, a number of areas were defined and included; regeneration of cold soils, vegetation/site interactions, silviculture impacts on growth and yield (ESSF and SBS), mixed-wood silviculture, site productivity, stock production physiology and site interactions, and technology transfer. To address adequately each of these areas would require the effort of a large team of researchers. For this reason, we have encouraged the "joint venture" approach: we encourage the client to become actively involved. There are two major advantages to this approach. First, the client's problem is clearly defined by both parties. It is then determined whether the problem can be solved by applying existing information, making some development effort, or taking a formal research approach. Second, the results are easily adopted into practice because the client is involved with the project from the beginning. The old adage "seeing is believing" plays a large part in the technology transfer process. This is crucial if advances are to be made in achieving sustained resource productivity.

The following seedling physiology projects are joint ventures:

1. **Hollow dibble**. Planting trials were established in the spring of 1992 to evaluate growth differences resulting from the use of two different planting tools: a traditional planting shovel and a hollow dibble. The hollow dibble is thought to have inherent planting advantages but its biological impact on seedling establishment is not well defined. Studies being conducted include seedling condition and survival, shoot growth, root development, and site interactions. (Collaborator: Lakeland Mills Ltd.)
2. **Stock requirements for cold soils regeneration.** Preparatory work is being conducted to define problems associated with the regeneration of cold, wet sites. Forest industry representatives are central to this work. When limitations to seedling establishment are identified, work will continue towards the production of site specific planting stock. (Collaborators: northern interior forest industry representatives.)
3. **Production of spruce planting stock for under planting**. Intensive monitoring of microsite conditions under aspen canopies by the Ministry of Forests, Forest Science Section, Prince George, defined light conditions for spruce planting stock. Seedlings so produced should be more suitable for lower light conditions and hence, survive and exhibit better growth from the outset of being planted in an aspen understory. (Collaborator: Ministry of Forests and Red Rock Research Station.)

4. **Secondary needles**. Depending on nursery cultural regime, container grown lodgepole pine seedlings can develop a stem that has mostly primary needles and few, if any, auxiliary secondary needles. Many local nurseries are now producing both morphological types. Little is known about field performance differences that occur between these types. Experience plays a fundamental role in assessing the suitability of either type for different site and microclimatic conditions. The purpose of this trial is to investigate relative field performance differences over a range of site conditions of 1+0 container grown lodgepole pine seedlings with and without secondary needles. (Collaborator: Northwood Pulp and Timber Ltd.)
5. **Field performance of hail damaged seedlings**. Occasionally, hail damages bare root planting stock. The value of seedlings encourages utilization of this damaged stock. A study initiated in 1990 examined the possibility of performance reductions in hail damaged stock. Preliminary results show that hail induced multiple leadered seedlings switch to single-leadered seedlings after two years and appear to exhibit acceptable growth. Continued monitoring will provide additional information on damage and form criteria for discarding planting stock. (Collaborator: Pacific Regeneration Technologies.)
6. **Root egress and field performance of short day seedlings**. The use of short day treatments for the production of seedlings is commonplace, but reports on outplanting performance of these seedlings are inconsistent. Studies have been initiated to examine establishment mechanisms (primarily root growth) and field performance. Of special concern is seedling ontogeny relative to non short day treated seedlings. Modifications to cultural regimes to promote desirable post planting growth patterns are anticipated. (Collaborators: Prince George Region, Rustad Brothers, Pelton Reforestation Ltd., Red Rock Nursery.)

For further information, contact Andrea Eastham or Roger Butson at Forestry Canada, Prince George District Office, Prince George, B.C. (604)963-2200.

Roger Butson
Forestry Canada, Prince George

Forestry Canada Seed-Borne Fungi Assays — 1992

Fungi found on seed continue to cause disease problems in nurseries. Experiments done by Forestry Canada (BC), Ministry of Forests, and BC Research have shown that, not only are some seedlots heavily infested with fungi, but there is a link between these seed-borne pathogens and seed decay, damping-off, and root disease. With increased seed and sowing costs and the move towards reduced pesticide use, controlling seed-borne disease is becoming increasingly important to BC reforestation nurseries.

Preventing a disease is more effective than correcting an existing problem. Disease not only kills seedlings but also increases culls through growth reduction. The main line of defence in disease prevention is knowing what organisms to expect and how to discourage their development. Screening seed for pathogenic fungi is an excellent method of detecting which seedlots should be treated in a special manner and identifying crops which require increased monitoring in the nursery.

The BCMF Silviculture Branch provided funds in 1992 for pathogen assays on over 1600 seedlots in storage at BCMF Tree Seed Centre (Surrey). The work was performed at the Pacific Forestry Centre and results have been distributed to BC nurseries. Listed below is a summary and explanation of how to interpret the results.

Interpretation

The following are recommendations based on our understanding of each fungus.

a) *Caloscypha fulgens* (the cold or seed fungus) is found in BC on spruce, Douglas-fir, and grand fir. It is especially prevalent in cones collected from squirrel caches or cones that have been in contact with the ground. When levels in a particular seedlot exceed 5%, disease prevention recommendations are:
   1) do not store moist seeds above freezing;
   2) keep stratification time as short as possible or sow unstratified seed;
   3) do not sow outside if there is a possibility of slow germination due to cold weather (C);
   4) single sow in containers (*Caloscypha* cannot travel between cavities).

b) *Sirococcus* blight attacks spruce, pine, Douglas-fir, and western hemlock. It is seed-borne at least on spruce and hemlock. To date, orchard seedlots of spruce have not been found to contain *Sirococcus*. When levels of *Sirococcus* are above 1%, disease prevention recommendations are:

1) keep humidity low and sow when sunny weather is expected;
2) monitor germinants for any sign of disease (remove and burn infected seedlings);
3) apply a post-germination fungicide following the "Nursery Crop Production Guide for Commercial Growers".

c) *Fusarium* causes damping-off, hypocotyl rot, tip blight, and root rot on all BC conifers. Seed borne *Fusarium* has been linked to damping-off and root disease in Douglas-fir. Because levels of *Fusarium* can increase during stratification, the BCMF Seed Centre has incorporated a running water soak for Douglas-fir seedlots to help reduce fungal levels during water imbibition. It is not known what levels of *Fusarium* need to be exceeded to produce a disease condition, but levels of 5% on seedlots from storage have increased tenfold during standing water imbibition. For all seedlots the general disease prevention recommendations are:

1 stratify the seed to promote uniform, rapid germination;
2) sow stratified seed as soon as possible (if the seed must be stored before sowing, handle it carefully and keep it cold in a refrigerator);
3) water in the morning so the soil has a chance to warm and the atmosphere dries before night cooling;

Species	Total # of Seedlots	*Siroccus* # infected % infection	*Caloscypha* # infected % infection	*Fusarium* # infected % infection
Douglas-fir (coastal)	247	**-	-	167 0.2–75.4%
Douglas-fir (interior)	105	-	-	90 0.2–100%
Spruce (Sw, Se, Ss, SxS)	315	45 0.2–2.4%	17 0.2–16.0%	24 0.2–22.0% (inside sterilized seed)
	126	-	-	73 0.2–100%
western larch	85	-	-	67 0.2–100%
lodgepole pine	489	-	-	28 0.2–4.2%
western white pine	3	-	-	1 0.8%
yellow pine	7	-	-	5 0.2–0.8%
Abies (amabilis, grand, alpine)	230	-	-	76 0.4–11.6%

Summary
*Pathogen assay results on seedlots tested in 1992, giving the number of seedlots containing *Sirococcus, Caloscypha, and Fusarium, as well as the range in percentage infection.*
**Other fungi were found in small numbers in some seedlots. Cylindrcarpon and Botrytis have caused disease problems and were included in the detailed listings send to nurseries.*
***Dash (-) indicates this assay not performed*

4) remove and destroy diseased germinants;
5) prevent seedling stress from drought, saturated soil media, heat, chemical burn, etc.

The importance of seed-borne diseases has been recognised by the nursery industry and its supporters (BC Ministry of Forests, Forestry Canada, BC Research). Identifying seedlots that have high levels of fungi known to cause disease and making prevention recommendations reduces pesticide use and cuts the cost of producing quality seedlings. Assays for seed-borne fungi will continue in 1993. For further information on the assays, type of fungi, % infection, and significance contact John Dennis at the Pacific Forestry Centre (604) 363-0655.

John Dennis, Win Zhong, and Jack Sutherland
Pacific Forestry Centre, Victoria
Heather Rooke
Tree Seed Centre, Surrey
Dave Trotter
Nursery Extension Services, Surrey

Pesticide Usage in BC Seed Orchards

The BC Seed Orchard Pest Management program has grown from an investigation of one insect in coastal Douglas-fir in 1969 to the province-wide management of an assortment of insects and diseases on 12 hosts in 1993. Early in the program, most of the work focused on obtaining registrations for spray and injection application methods for several petrochemical-based pesticides, determining application thresholds, and designing monitoring schemes. Subsequent new pests have been added regularly to the management roster and integrated into already established cultural and pest management regimes. In recent years concerted efforts have been made to decrease the usage of high toxicity pesticides through the refinement of delivery methodology and monitoring techniques, and the exploration of less toxic alternatives including both chemical and biocontrol management options.

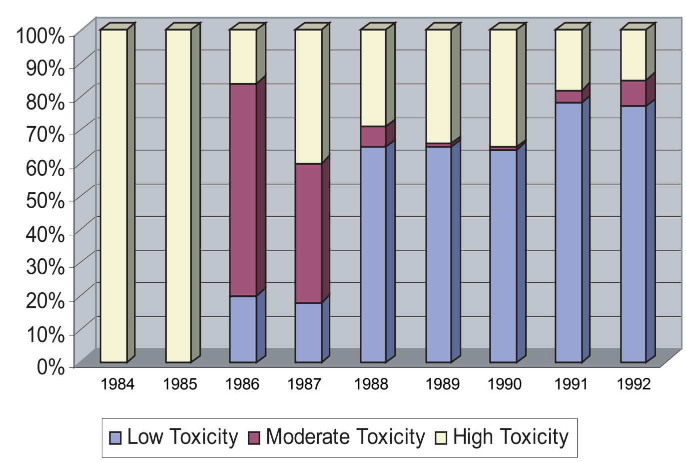
Early in 1993, the BC Ministry of Environment, Lands and Parks conducted a survey of pesticide use in BC and chose our program to be assessed. We approached 14 of the seed orchards which we regularly monitor to assist us in compiling data for the survey. Eleven of these facilities responded and some of our findings with a few suggestions based on them follow. Evaluation of our data is continuing.

In 1984 (fig. 1) all insecticides used in surveyed BC seed orchards were of high toxicity (oral LD_{50} less than 50 mg/kg). By 1992, high toxicity insecticides had dropped to less than 20% of total usage and low toxicity insecticides (oral LD_{50} greater than 500 mg/kg) accounted for over 70%.

Herbicides annually account for a large percentage of total seed orchard pesticide usage. This is an area in which we have done no work. As the Seed Pest Management group has little expertise in this area, we have approached a vegetation management specialist to discuss current practices in other industries at our summer staff meeting.

Some pesticide usage has been directed towards non-pest organisms. Damage attributable to such perceived pests may be minimal or economically insignificant even if populations are high. Active management of these "problems" is a waste of time and resources and has the potential to create future environmental and/or management problems (if it ain't broke, don't fix it). We are making a stronger effort to identify non-pests for our clients and eliminate them from their management rosters. Established management practices need to come under regular review in order to trim wasted effort and cut pesticide usage.

Bev McEntire and Michelle Hall
Seed Orchard Pest Management, Saanichton



Western Conifer Seed Bug, *Leptoglossus occidentatis* (Hemiptera, Careidae): **Some Ecological Considerations**

INTRODUCTION

Leptoglossus occidentalis is a potentially serious pest of Douglas-fir in British Columbia (1). Nymphs and adults feed by piercing cone scales with the proboscis, penetrating the nutrient-rich seeds and consuming the contents (2). Seed bug feeding on white pine cones can reduce filled seed by 70-80% and the total yield per cone five fold (3). Attempts to reduce this damage with toxic or abrasive insecticides have not proven successful (4). The overall objective of my work is to understand the chemical ecology of this pest and eventually to develop an environmentally sound management program. As the potential damage caused by L. *occidentalis* in Douglas-fir has not been previously reported, assessing its impact and determining host selection mechanisms may provide a better basis for implementing a future management program.

METHODS

An intensive sampling program to determine pest numbers was carried out in 1992 in two Douglas-fir seed orchards on Vancouver Island, BC: Mount Newton (Fletcher Challenge Canada, Ltd.) and Nootka (Canadian Pacific Forest Products Ltd.) Seed Orchards. Several trees representing all clones within each orchard were examined for seed bugs throughout the summer. Cone samples were obtained from these trees as well as other trees chosen at random. Seed was extracted and x-rayed and the number of full and empty seeds present was determined. Insect numbers and seed data were analysed by means of a Chi-Square test and an ANOVA at P respectively. Percentages of empty seed were regressed on mean numbers of L. *occidentalis* per ramet (tree) to determine if there was a significant relationship between numbers of seed bugs and damage to seeds.

PRELIMINARY RESULTS

Leptoglossus occidentalis distribution was significantly associated with host clone (X2 = 360, df = 66, P.0001), possibly reflecting a host selection preference (fig.1). However, this distribution was not associated with percentage of empty seed (r2=0.012) (fig. 2), indicating that other factors override any damage by L. *occidentalis.*I speculate that certain clones are preferred early in the season, probably for oviposition followingoverwintering, while other clones are fed upon intermittently during dispersal flights. Figure I shows results from Mount Newton only, but this trend was observed in all orchards examined, including second generation trees. Also not shown in fig.1 are 55 additional clones which had no seed bugs on them at any point throughout the summer. Future orchard surveys will reveal if this trend is real or if the bugs inhabit different clones from one year to the next. Research is planned to examine this clonal preference, determine the mechanisms of host selection, and separate damage caused by L. *occidentalis* from other causes of seed abortion to determine the relative impact of this pest.

A monitoring system using preferred trees as indicators could provide an estimate of orchard seed bug population size and potential damage. This could enable growers to determine if control measures are required and to treat only those clones which are known to be preferred by L. *occidentalis.*

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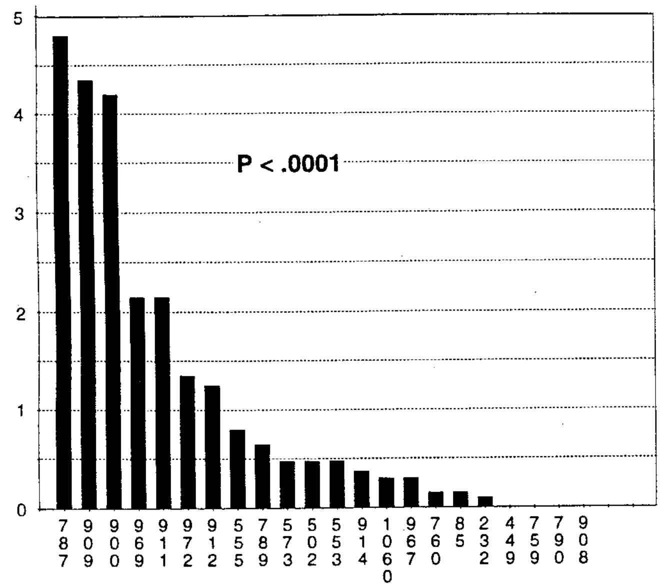

Figure 1. Average number of seed bugs per ramet of Douglas-fir at Mt. Newton Seed Orchard in 1992.

References

1. Hedlin, A. F., *et al.* 1981. Canadian Forest Service, 122 p.
2. Koerber, T. W. 1963. Ann. Entomol. Soc. Amer. 56:229-234.

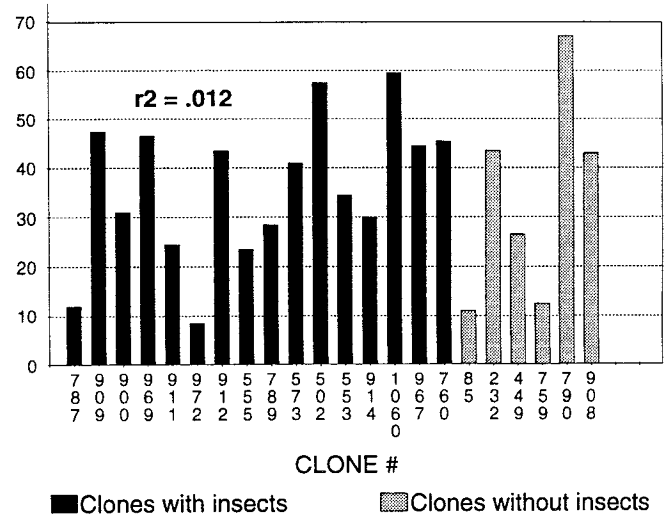

Figure 2. % empty seed per ramet of Douglas-fir at Mt. Newton Seed Orchard in 1992.

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4. Summers, D. pers. comm. BC Ministry of Forests, Green Timbers, Surrey.

Suzie Blatt
Simon Fraser University, Burnaby

The Nursery Experience with Spruce Seed Orchard Seed

Considerable concern has been expressed over growth differences between Seed Orchard and natural stand spruce seed. In an attempt to give expression to these concerns I have interviewed the staff from three nurseries:

- Bill Taylor and John Watson - Skitnikin Nursery (BCMF)
- Kent Stralbiski - K & C Silviculture Farms
- Dave Swain and Grant Cummins - Harrop Nursery (PRTI)

I thank these gentlemen for their time and efforts to provide some light of experience on this topic. The comments from these growers are not based on research results but their records and experiences. These interview results should be viewed with this in mind and may help guide more thorough investigations into important topic area.

1. **Does seed orchard seed appear different?**
   All replies were that seed orchard seed varies little from natural stand seed in appearance and size, especially when compared with more recent natural stand collections. Handling characteristics of the seed was similar and **all** spruce seed is fairly clean.
2. **Do germination characteristics appear similar to natural stand seed?**
   a) Time from sowing to start of germination: no differences noted.
   b) Speed of germination: germination of orchard seed was substantially complete (95%) 14 days from sowing. Many natural stand seedlots perform this well, also.
   c) Germination %: both natural stand and seed

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orchard seed have very good germination rates. The Seed Centre lists the average germination % as 92% for natural stand seed and 91% for orchard seed. Nursery experience shows orchard seed has usually a 2-4% higher germination rate compared to lab rate and natural stand seed usually achieves lab rate.

3. **Does early growth appear faster in orchard crops?** Nurseries responded that there was very little in early growth to distinguish orchard spruce from natural stand spruce seedlots. Some noted slightly longer stern development. There was very little difference in seed coat sheddinf and the development of cotyledon leaves and secondary foliage.

4. **Was the exponential growth phase of seedlings similar?**

Harrop: growth appeared similar but variability increased with some vigorous plants well above the canopy average.

K & C: orchard lots tend to behave more like wet belt seedlots or Rocky Mountain provenances (Golden-Invernere area). Orchard lots are within the range of growth of natural stand seedlots but at the top end of this range.

Skimikin: growth was similar until approximately 12 weeks of age. From 12 to 16 weeks natural stand seedlots grew 3 crn (mean), orchard seedlots grew 6 crn (mean). Also some reflushing in orchard lots was experienced.

5. **Is bud set and frost hardiness/dorinancy development similar?**

a) Cessation of foliage growth, maturation of foliage and budset: all nurseries noted that seedlings from seed orchard seedlots generally take longer to set buds and achieve frost hardiness.

Harrop: orchard seedlots generally exhibit later bud set, longer growth period, lighter colour, and less waxy cuticle on foliage resulting in frost protection occurring later in the fall. Some seedlings in the population set buds early.

K & C: seed orchard seedlots are variable, some seedlings setting buds early but over 50% growing and hardening later than wild seedlots. The 2+0 summer seedlots were shipped at 2 times because of this. In the same seedlot, the early budsetters were shipped out 6 to 7 weeks earlier than the late budsetters.

Skimikin: seed orchard lots develop buds and off in both 1+0 and 2+0 crops one month later than natural stand seedlots. In 1+0 crops, natural stand seedlot seedlings start bud set in early August, orchard seed seedlings start bud set in late August to early September. There is little height growth (stretching under the bud) following budset but root collar diameter can still increase by 0.4 to 0.8 nun to time of lift in 1+0 crops.

b) Dormancy: most nurseries suspect dormancy development occurs later in orchard seedlots as a result of late season growth and later bud set. Storability testing of the late budsetters in seed orchard seedlots supports this: foliar damage was greater for these late growers than in the normal budset population in the mid to late October test (at time of lift results were similar).

6. **Are there morphological differences?**

a) Dry weight and shoot/root ratios: nursery responses here range from no observations to acknowledgment that orchard stock generally has greater dry weight. However, these weights are within the range for natural stand seedlots, albeit at the upper end of this range. Shoot/ root ratios in natural stand seedlots were more favourable at Skimikin: 3.0 to 3.2 (8 seedlots) as compared to 3.2 to 3.8 (8 seedlots) for orchard seedlots.

b) Height: **all** nurseries responded that height was very variable. Harrop observed that because of some early budset, the height range in orchard seedlots is greater in comparison to other late season growers, such as Golden- Invermere Rocky Mountain spruce.

c) Root collar diameter: root collar diameters were acceptable in most crops although some growers experienced diameters closer to minimum than to target.

7. **Did you experience difficulties with seed orchard crops and how would you manage for these difficulties?**

All nurseries responded that they did experience difficulty in growing orchard seedlots generally because the seedlings grew longer and therefore taller. Current standards were not perceived to be a great problem but there is some concern due to variability of crops.

All nurseries agreed that growing of orchard seedlots would be best accomplished in larger size cavities. For root collar diameter at Skimikin

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only 10% achieved target in PSB313A compared with 40% in 313B. Harrop suggested 410 and 415D were more appropriate than 313B and 415B. The investment in improved seed has been substantial and this should not be lost through the use of inappropriate cavities.

Management strategies include:
a) possibly sow orchard crops later than natural stand seed,
b) lower nutritional feeding program (i.e. 80 ppm N), c) grow under drier, cooler conditions (remove side walls and poly to allow full ligGt and good air circulation, and
d) to set buds use black out system (however some vigorous natural stand lots did not respond to black out). Some experimentation with hours of darkness and duration of black out may be required.

Any **other comment on spruce from seed orchard seed?**

Harrop: it would be useful to have access to the histories and make up of the seedlots through the local Nursery Services office. Knowing the crosses and what characteristics the trees were selected for could help in understanding and planning in the nursery phase.

K & C: despite difficulties seed orchard seed appears easier to grow than SxS.

Skimikin: collections may also make a difference in orchard seed. What is blended to make a seedlot? Will this blend appear again as a different seedlot next year? Block size is an option to handling orchard seed. Timing of delivery could still be a problem for summer 2+0 crops.

C. M. Kooistra
South Zone Administration, Vernon

Variability in Spruce Seed Orchard Seedlots

In the late summer and fall of 1992, attention was drawn to the vigorous 1+0 spruce seed orchard seedlots growing at Skimikin Nursery without the benefit of blackout screens for height control. It was perceived that:

- spruce seed orchard seedlots exhibited a greater range of morphology in comparison to natural stand seed- lots (phenotypic differences);
- greater developmental variation in seed orchard seed- lots was also greater (many seedlings were still grow- ing and had not set bud (vigorous) while the others had set bud and were becoming glaucous (physiologi- cal and morphological differences)); and
- the observed within seedlot morphological variability was reduced when it was grown in blocks with larger (415B), rather than smaller (313A), cavities.

Such observations could lead to increased reluctance in some silviculture foresters to use seed orchard stock.

These observations were tested by examining a portion of the 1992 seed orchard spruce crop at Skimikin Nursery. A random sample of 200 seedlings was collected in mid-September for each selected 313A and 415B seed orchard and natural stand seedlot (table 1). Height, root collar diameter (RCD), and coefficient of variation (CV) were determined on the uncuued sarnples for each seedlot. Samples were then culled to BC Forest Service specifications, percentage recovery, height and RCD with CV, and proportion of overheight acceptable seedlings (height maximum height but RCD target) were calculated. Estimates of recovery may be conservative as there was time for RCD growth prior to hft and storage of the seedlots.

At fortnightly intervals commencing one week after initial sampling, sub-samples were collected and sent to Red Rock for frost hardiness assessment to -18’C. If, after subjective assessment by Skimikin staff, seedlots had considerable numbers of seedlings at different stages of budset, they were divided into “normal” and “vigorous” groups. Normal seedling bud development was similar to that of natural stand seedlots. Vigorous seedlings were still growing and at an earlier stage of bud development. Seedlings were pooled when subjective assessment suggested most seedling of a seedlot were at a similar stage. As bud development progressed and normal and vigorous seedlings could no longer be visually differentiated, samples from these seedlots were also pooled prior to freezing. This assumes morphology, development, and physiology are closely related at that time of year.

Two seed orchard seedlots were sampled from both 313A and 415B blocks (table 2). Although morphologically smaller (by about 20%) and with greater CV (particularly for height), 313A stocktypes had similar recoveries and height to RCD (sturdiness) ratios to 415B stocktypes in the same seedlot.

(continued..

Culling did not appreciably change the morphological description of the seedlots, except to reduce the CV for RCD. Changing stocktype did not change relative nursery morphological performance of seedlots. The inherently larger seedlots were larger regardless of stocktype. The proportion of overheight but acceptable seedlings was greatest in the 415B stocktype. In the absence of an effective means of height control (blackout screens), growing seed orchard seedlots as larger stocktypes appears to result in significant increases in overheight but acceptable seedlings. However, this does not affect the percentage of seedlings recovered. Overheight stock could be an issue on high snowfall sites, droughty sites, and sites prone to vegetation press because generally the increase in height was not paralleled with a similar increase in RCD.

Seedlots subjectively divided into normal and vigorous classes for frost hardiness assessments had more overheight but acceptable seedlings than did seedlots pooled for frost assessment (tables 3 & 4). Although natural stand seedlots generally had a larger CV for height, there were no apparent developmental differences within them. The data suggest a wide range of growth potentials for seed orchard seedlots. There was no difference among 313A samples for foliage browning (FB), bud damage, and root growth class (RGC, latter two not shown). However, there were large differences in upper and lower stem tissue damage between normal and vigorous 313A seedlings of SL 6916 (table 4) suggesting a physiological development difference between the two groupings of that seedlot.

Within the two normal/ vigorous classed 415B seedlots, the vigorous (slow to set bud) group showed greater FB and more upper and lower stem tissue damage. Pooled natural stand and seed orchard seedlots had similar low temperature stress responses (table 4). As was observed for 313A seedlings, there was little bud damage and RGC (not shown) difference between 415B normal and vigorous groupings. These data indicate there are physiological differences between the “normal” and ‘vigorous” subjective groupings of stock. The differences may be more pronounced in the 415B stocktype. This suggests care should be taken to ensure all population groups within the seedlot are suitably represented when sampling seed orchard seedlots for storability (physiological) tests.

Variations in frost hardiness development (dormancy induction is implied, too) could lead to seedlings with different physiological qualities from a single seed orchard spruce seedlot being placed into storage at the same time. This, in turn, could lead to phenological differences between “vigorous” and “normal” seedlings during storage and at planting and increased risk of environmentauy-induced seedling damage. These hypotheses are untested at this point.

It is not known if the range of variability displayed by some of the seed orchard seedlots exceeds that observed for any natural stand spruce seedlot collections. The information available on natural stand origin, spruce seedlot nursery variability is minimal. Such information is necessary to make sound decisions about nursery culture and field deployment strategies for spruce seed orchard seedlots.

The variation in vigour among seedlings shown by some of the seed orchard seedlots could be a result of the way the seedlots are constructed. Perhaps, a small number of parents are contributing the bulk of the genetic variability that causes the concerns related to nursery culture. If different nursery cultural practices were employed (eg. blackout for all spruce seed orchard seedlots), the observed seed orchard seedlot variability might be overcome. The impacts of such regimes on nursery recovery and future field performance are not known. It may be better to identify those parents contributing the seedlot outhers (nursery “undesirables”), collect and process cone crops separately by parent vigour class, and construct seedlots specifically for the nursery phase. Prior to planting, seedling crops could be reconstructed. This could make nursery culture and seedling deployment more efficient operationally and biologically.

A trial has been initiated this year at Red Rock Research Station to document nursery phase variability (both morphologically and physiologically) in spruce grown from natural stand, seed orchard, and controlled cross seed.

Thanks to the staff at Skimikin and Red Rock, particularly Bill Taylor and Bonnie Hooge, for their assistance and support, and to M. Carlson, M. Krasowski, K. Thomas and J. Wong for their helpful suggestions.

#	Name	Elev (m)	Lat (°N)	Long (°W)	Germ (%)
		Seed orchard seedlots			
6271	Shuswap Adams Low	1160	51:05	119:20	87
6913	Shuswap Adams Low-low	750	51:08	119:15	93
6914	Shuswap Adams Low-mid	1270	51:03	119:18	93
6915	Shuswap Adams High	1660	51:16	119:22	94
6916	Mica East Kootenay	1240	51:02	117:06	93
		Natural stand seedlots			
4320	Blowdown Creek	1490	50:22	122:14	85
8227	Headwater Lake	1150	49:49	120:00	73

Table 1. Description of seedlots used in this report.

				Unculled			
#	Type	Ht	CV	RCD	CV	Ht/RCD	REC
6913	313	27.1	28.7	2.92	20.2	9.83	70.4
	415	34.0	19.4	3.63	17.8	9.37	71.5
6914	313	23.1	22.3	2.99	18.4	7.33	79.0
	415	29.7	17.1	3.67	15.7	8.09	81.0
				Culled			
#	Type	Ht	CV	RCD	CV	Ht/RCD	AccOHt
6913	313	28.6	25.9	3.19	12.8	8.97	57.9
	415	35.3	19.1	3.92	12.9	9.01	81.8
6914	313	23.8	19.1	3.18	13.4	7.48	32.3
	415	29.8	17.1	3.83	13.0	7.78	58.0

Table 2. Comparison of unculled and culled morphology (seedlot — #, height (cm) — Ht, root collar diameter (mm) — RCD, coefficient of variation (%) — CV, height to diameter ratios — Ht/RCD), % recovery to B.C. Forest Service specifications — REC, and % of overheight but acceptable seedlings — AccOHt (Ht maximum Ht and RCD target RCD) in September 1992 for seedlots grown in both 313A and 415B containers at Skimikin Nursery.

(continued...)

#	Type	Ht	CV	RCD	CV	Ht/RCD	REC	AccOHt
4320	313	22.6	23.0	3.16	23.4	7.15	82.5	35.4
6916	313	28.3	21.1	2.90	20.0	9.76	57.0	70.2
8227	415	28.0	21.7	3.61	21.4	7.76	79.0	54.4
6914	415	29.7	17.1	3.67	15.7	8.09	81.0	58.0
6913	415	34.0	19.4	3.63	17.8	9.37	71.5	81.8
6271	415	31.3	22.7	3.87	23.0	8.09	82.5	73.9

Table 3. Comparison by seedlot and stocktype of unculled seedling morphology, recovery to specifications, and overheight but acceptable seedlings in September 1992 between seedlots grown in either 313A or 415B containers at Skimikin Nursery and subjected to frost hardiness (storability) assessments at -18 °C. Labels as in Table 2.

#	Stage	% Foliage Browning 1	2	3	4	%Stem Tissue Damage (U/L) 1	2	3	4
					313A				
4320	P	50	1	1	0	41/46	20/0	0/-	8/0
6916	N	45	1	0	0	4/20	16/0	0/-	0/0
	V	43	5	-	-	44/48	40/0	-	-
					415B				
8227	P	46	6	4	0	16/8	12/0	0/-	0/0
6914	P	51	3	1	-	24/24	12/4	0/-	-
6913	N	73	9	0	0	24/36	8/0	0/-	8/0
	V	86	17	-	-	92/88	40/88	-	-
6271	N	70	4	<1	-	32/40	4/0	0/-	-
	V	90	28	-	-	96/96	28/4	-	-

Table 4. Frost hardiness assessments by seedlot and stocktype (percentage foliage browning and upper and lower (U/L) stem tissue damage)following one hour exposure at -18°C for seedlots that were split by stage of bud development (normal (N) or vigorous (V)) or pooled (P) prior to freezing at times 1, 92/09/25; 2, 92/10/09; 3, 92/10/20; and 4, 92/11/03. By October 20, as bud development progressed, all seedlots were pooled.

Chris Hawkins
Red Rock Research Station, Prince George

Domestication and Genetic Diversity - Should We Be Concerned?

Ed. note. The following abstract and conclusions are reprinted from an article of the same title published in The Forestry Chronicle, Vol 68 #6, p. 687-700, Dec. 1992.

Abstract. Despite the fact that forest trees are in their early stages of domestication, there has been little direct evaluation of the genetic diversity throughout this process. The dynamic changes in the genetic structure of wild conifers were monitored through several bottlenecks, namely: phenotypic selection, seed orchards, seed processing and storage methods, and seedling production. The genetic structure of phenotypically vs. randomly selected individuals of two conifers with known contrasting diversity levels is compared. The biology and management methods practised in seed orchards are evaluated, and seed extraction and storage procedures are assessed to evaluate common practices on biological peculiarity. Finally, the cultural practices of container nurseries were monitored and their impact on the genetic structure of future forests is evaluated.

CONCLUSIONS

This report summarizes the results of several studies that were designed to systematically assess the genetic variation level during the early domestication process of forest trees. It is concluded that: 1) phenotypic selection successfully captured most of the variation present in natural populations, 2) seed orchard management practices have the potential to affect genetic diversity, 3) knowledge of seed biology is needed to support seed collection and storage methods, 4) growing of seedlings from bulked seedlots requires further evaluation, and 5) tree improvement should be considered in the framework of a total delivery system, to maintain acceptable levels of genetic diversity.

Yousry El-Kassaby
Canadian Pacific Forest Products Ltd., Saanichton

Larch Adelgid, *Adelges lariciatus,* at Kalamalka Seed Orchard: Effects on Seed Production and Observations on Life Cycle

In Volume 5, #1 of this newsletter I reported on an adelgid, new to the Okanagan Valley, which is infesting western larch cones at the Kalamalka Seed Orchard site (Vernon). Last year (1992), with the help of seed orchard staff at Kalamalka, Seed Pest Management Services monitored the development of this adelgid population from mid-June until cone harvest (early August). Subsequently, Chris Walsh reviewed the monitoring data, tested the effects of the adelgid on larch seed production, and compiled a brief report on his findings. This is summarized below along with some observations on the biology of *A. lariciatus at* Kalamalka.

Throughout the 1992 monitoring period, adelgid levels were fairly constant and consistent with about 60% of examined cones showing low or no infestation (around 40% were "clean"). The remaining cones suffered infestation levels from moderate (some adelgids on most scales per cone) to severe (large numbers on all scales and visible on cone surface). The adelgids were not feeding directly on seeds but were attached mostly to the scales in the vicinity of the seed wings. Adelgid activity was associated with pitch production in the cones (although uninfested cones could also be "pitched up") and often the seeds in infested cones were gummed up with pitch.

After the cones were harvested and dried, among other trials, Chris tested the effects of the adelgid on ease of seed extraction, filled seed per cone (FSPC), and germination. Cones were subjected to a sequence of three extraction procedures: 1) shaking to release loose seed; 2) heating, cooling, then shaking again; and 3) manual breaking of cones to extract stuck seed. The seed fractions were individually tested for FSPC and germination and the results compared back to observed adelgid levels.

Chris concluded that: 1) there was no apparent correlation between FSPC and adelgid level, 2) higher adelgid levels were related to increasing difficulty of seed extraction (70% of seeds in clean cones extracted by shaking in comparison to 42% in well infested cones), and 3) seeds stuck in cones had the lowest germination capacity (41% for the "break" fraction versus 75% and 69% **for** the 'shake" and "bake and shake" fractions).

(continued...)

This year (1993), monitoring commenced in early April when reproductive buds were identifiable and vegetative buds had just burst. At that time overwintering sistentes (parthenogenetic females) were already mature and actively producing large numbers of eggs at the bases of buds mostly on two year old branches. Some sistentes were observed on one year old branches and very few eggs had yet hatched. Within two weeks many eggs had hatched and nymphs were rapidly colonizing scales and bracts of developing conelets. By early May sistentes had mostly disappeared and many of their progeny were nearing maturity. Infested cones were already pitchy, uninfested cones were not. When cones were last examined (third week in May) the sistente progeny had matured into winged sexuparae (parthenogenetic females which migrate to spruce) and some progredientes which were laying eggs on cone bracts.

Cones will continue to be collected and monitored on a biweekly basis until the 1993 harvest. At that time further trials will be initiated to examine the effects of *A. lariciatus* on larch seed production. Through our monitoring program we will be able to pinpoint effective window(s) in the life cycle of this adelgid for exercising least toxic control measures should this option be called for.

Robb Bennett
Seed Pest Management Services, Victoria

EVENTS

Saanich Seed Orchard and Test Nursery Open House
June 21, 1993, 3:00-5:00 pm
BC Ministry of Forests
7380 Puckle Road
Saanichton BC
For more infornwtion contact:
David Reid, (604) 652-5600

BC Seed Orchard Staff Group Annual Meeting
June 22-24, 1993, Victoria BC
Sherwood Park Inn
123 Gorge Road East
For more information contact:
Patti Brown (604) 885-5905

American Seed Trade Association Annual Convention
June 26-july 1, 1993
Kansas City, Nlissouri
For more information contact:
ASTA (202) 638-3128

Canadian Seed Trade Association Annual Convention
July 6-10, 1993
Chateau Whistler Resort
Whistler, BC
For more information contact:
CSTA (613) 829-9577

International Symposium on Replant Problems
July 21-23, 1993
Summerland, BC
For more infornwtion contact:
Raj Utkhede (604) 494-7711

Joint Meeting- Northeastern Area State, Federal and Provincial Nurseryman's Assoc.; Intermountain Conservation Nursery Assoc.; Midcontinent Nursery Pathologists
Aug. 2-5, 1993
St. Louis, NEssouri
Topics include soil compaction, organic matter management, IPM/biocontrol
For more information contact:
Bill Yoder (314) 674-3229

(continued...)

Canadian Tree Improvement Association 1993 Meeting
17-19 August, 1993
Fredericton, NB
Theme: "The Future Forests - Options and Economics"
For more information contact:
Kathy Tosh (506) 453-9101, fax 453-1741

Forest Nursery Association of BC 1993 Annual Meeting
13-15 September 1993
Florence Filberg Centre
Courtenay, BC
Theme: "Changing Forestry Practices - Nurseries Meeting the Challenge"
For more information contact:
Drew Brazier (604) 387-8936, fax 387-1467

Seed Testing Workshop
Sept. 21-23, 1993
Dry Branch, Georgia
For more information contact:
National Tree Seed Laboratory (912) 744-3312, fax 744-3314

Intermountain Container Seedling Growers' Meeting
Sept. 23-24, 1993
Lewiston, Idaho
Topics include pesticides, chernigation, new EPA Worker Protection Standards, nursery culture and equipment.
For more information contact:
Kas Dumroese (208) 885-7017, fax 885-6226

Insect Pest Management in Seed Orchards: A Mini-Symposium
in conjunction with the Joint Annual Meeting of the Entomological Societies of Canada and Ontario
Sept. 29, 1993
Water Tower Inn
Sault Ste. Marie, Ontario
For more information contact:
Jean Turgeon
FC-FPMI
P.O. Box 490
Sault Ste. Marie, Ontario P6A 5M7
(705) 949-9461, Fax (705) 759-5700

IUFRO Working Party S2.-7-09 (Diseases and Insects in Forest Nurseries)
Oct 3-10, 1993
Dijon, France
For more information contdct:
Robert Perrin
INRA, 17, Rue Sully, B.P. 1540
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France (fax 33-80-63-3232)

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