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Seed and Seedling Extension Topics

Eric van Steenis - Editor

Well, another year, another editor! I won't bore you with long introductions but get right on with what is new and exciting for 1994. The first major local event was the 'Conifer Seedling Workshop of the Century", held in Langley and Kelowna, B.C. in April. Attendance was at the maximum allowable, with only 5 nurseries in B.C. not represented. However, attendees from Alberta and various other disciplines more than made up this shor-t-fall. The evaluations showed overwhelming support for the "hands-on" mode of presentation, and found the shift from chronological to phenological based management a refreshing perspective. Development of Lodgepole Pine rated the highest, with Spruce and Fir bud/ dormancy induction a close second. Still a major question is the development of various needle types on 1-0 Lodgepole Pine. My suggestion is to consider the meristems involved and how/which we attempt to manipulate with our cultural treatments. Photoperiod, drought, etc. acts on more than just the shoot apical meristem! How does shoot apical meristem activity influence activity of other meristems? I am looking forward to some interesting brain-storming sessions with you in the future. Our job now is to apply this new knowledge to the betterment of reforestation in Western Canada and...

Eric van Steenis
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Abies Spp. Workshop a Success!

Approximately 80 persons attended a workshop on *Abies* spp. regeneration February 8,1993, in ParksviUe. The one day workshop focused on problems and solutions associated with *Abies* spp. seed, seedlings and reforestation. Presentations were largely directed at the coastal *Abies* spp., but owing to the increased interest of *Abies* in the interior *A. lasiocarpa* also received some attention.

Thirteen speakers provided an interesting overview of current knowledge and practices employed with respect to *Abies* spp. regeneration. The presentations were followed by Working Group Discussions. The consensus of these groups was that the *Abies* spp. do not receive the attention that they warrant. *Abies* spp. now account for over 8 million seedlings sown annually in B.C. *A. amabilis* ranks fourth on the coast in terms of number of trees planted by species. Despite success with many other tree species we still have a limited understanding of *Abies* spp. silvics, genetics, Ireproductive biology, seed, seedling development, pests, microsite requirements, stand dynamics and growth and yield. Reconunendations from these working groups are to be used to direct *Abies* spp. research in the future. Abstracts of the presentations and recommendations of the working groups are presently being compiled into a Proceedings. If you did not attend and wish a copy please contact:

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Province of British Columbia
Ministry of Forests

GROWERS NOTES

1994 Provincial Sowing Requests

Over 250 million seedlings were sown for in the spring of 1994. This represents a 16% increase over last year's sowing request total of 217 million. The use of seed orchard seed (A Class) has remained constant at 11% of the provincial total, but its total number increased 9% over the previous year. There were also significant' increases in the amount of *Abies* spp. sown for in 1994.

The use of seed orchard seed and natural stand *Abies* spp. is expected to be even higher next year owing to the large cone crops produced in 1993.

The following table summarizes the 1994 sowing requests by species and source. This information was current at the time of extraction from the Seed Planning and Registxy System (SPAR).

Table 1. 1994 provincial sowing requests by species and source. (000s of seedlings)

Species	Total (000s)	Natural Stand Seed (B Class)	Seed Orchard Seed (A Class)	Percent A Class (%)
Lodgepole pine*	102,484.9	99,777.0	2,707.9	3
Interior spruce*	97,738.7	88,404.4	9,334.3	10
Western red-cedar*	10,604.4	5,405.8	5,198.6	49
Western hemlock*	7,838.0	4,576.1	3,261.9	42
Douglas-fir - Interior (interior)	7,630.8	7,630.8		
Douglas-fir - Coast*	7,312.8	1,958.6	5,354.2	73
Pacific silver fir*	4,975.6	4,975.6	0.0	0
Interior x Sitka spruce	1,626.4	1,626.4		
Western larch*	3,141.8	3,141.8	0.0	0
Sub-alpine fir	3,090.3	3,090.3		
Sitka spruce*	1,598.9	540.5	1,058.4	66
Yellow-cedar*	1,075.0	1,075.0	0.0	0
Lodgepole pine (c)	1,034.0	1,034.0		
Ponderosa pine	850.5	850.5		
Mountain hemlock	411.1	411.1		
Grand fir*	346.3	346.3	0.0	0
Noble fir	203.0	203.0		
Paper birch	7.1	7.1		
White pine*	188.7	175.1	13.6	3
Tamarack	30.0	30.0		
Red alder	23.0	23.0		
TOTAL	**252,211.3**	**225,282.4**	**26,928.9**	**11**

* *Indicates species for which there are established seed orchards.*
Source Seed Planning and Registry System (SPAR), April 1994.

Province of British Columbia
Ministry of Forests

Pest Management Practices that have Reduced Reliance on Chemical Pesticides in B.C. Reforestation Nurseries

Over the last 10 years, there has been a concerted effort on the part of B.C. reforestation nursery managers to reduce or eliminate chemical methods of pest control. Developments have been made in conjunction with Nursery Extension Services, other agencies and the horticultural industry. This has translated into more effective timing of traditional pesticide applications coupled with new trapping and monitoring methods, a shift away from more toxic pesticides to ones that exhibit more specificity with dramatically lower levels of toxicity, the introduction of biologicals, and in some cases the elimination of chemical methods altogether. Following are just a few areas where advances to modify or reduce pesticides have proven successful.

INSECT PESTS

1) Cutworms and Caterpillars

Nursery personnel are encouraged to hand remove and destroy small infestations. Weed control programs to reduce the number of weeds in and around nursery sites are common. Many moths are attracted by various weeds to oviposit and feed, and populations that build-up in weedy areas can migrate to seedling crops. At the beginning of the growing season, when sides and roofs of greenhouses are still m, placing screens over fan intakes and diligence at keeping greenhouse doors dosed have helped to physically exclude these insect pests.

Ambush, a new synthetic pyrethroid, has been registered for control of cutworms and replaces Sevin, a carbamate compound. Ambush is more effective at controlling caterpillars and has a lower mamalian toxicity, ie. an oral LD5o of 4,000 compared to 400 for Sevin.

Trials with a Neem tree extract have shown it to be very effective at controlling a cutworm species conunonly found in B.C. conifer nurseries with no phytotoxic effects. Further testing and registration of this product are ongoing.

2) Aphids

Safer's soap was registered for conifer seedlings and nurseries are encouraged to use it.

To control the cooley spruce gall aphid on Douglas-fir seedlings, nurseries are encouraged to remove mature spruce trees in and around the nursery site that serve as the alternate host for the gall forming stage.

Populations of the Balsam woolly aphid are regulated under a B.C. plant protection act.

Nursery and field studies on the conifer root aphid have shown it to have no negative impact on seedling quality or performance. Nursery managers have been advised to eliminate any control measures for this insect

3) Root Weevils

In bare-root culture, monitoring programs for adult weevils have been established to determine if control measures are necessary and to indicate most effective treatment times. Belmark, another new synthetic pyrethroid, has replaced Orthene, an organophosphate, for control of these pests.

Since 1983, a number of trials have been established to test entomogenous nematodes as a biocontrol agent for root weevil larvae. To date nematodes have not been effective, but technology is improving in this area and new products will be tested as they are developed.

4) Fungus gnats

Educational programs have been conducted to ensure growers can distinguish between innocous shore flies and potentially damaging fungus gnats. A monitoring program using yellow coloured sticky traps has been established. This program helps monitor populations of pests and reduces the numbers of flyin adults. Better drainage in greenhouses is encouraged to reduce pools of standing water that serve as breeding grounds for fungus gnats. At several nurseries, copper sulphate is applied to floors to reduce algae build-up, a preferred food source for these pests. A few facilities are applying with success, both predatory niites *(Hypoaspis* sp) and entomogenous nematodes to control fungus gnat larvae.

5) European pine shoot moth

To reduce populations around the nursery, planting of ornamental pines is discouraged and any mature trees already present are identified for removal. A pheromone trapping program has been discontinued as the quarantine regulations were rescinded.

6) Cranberry girdler

Grasses serve as alternate hosts for both the Cranberry girdler and the European marsh crane fly. Reduction or removal of grassy areas in and around nursery sites has helped reduce populations of these pests. Alternatively, if grass must be present, frequent mowing and planting of less suitable host grasses is beneficial.

A pheromone trapping program has been developed for the Cranberry girdler. Traps are set out amongst susceptible stock from June to August and checked weekly. Only when a predetermined threshold number of moths is caught is an insecticidal spray applied to reduce oviposition on seedhngs.

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7) Lygus Bugs

A control program that miniinizes insecticide applications has been developed. In the U.S., many nurseries spray every 2 weeks throughout the growing season to reduce Lygus damage. In B. C., work with the insect's biology and crop susceptibility has shown that one or two well timed Cymbush (a synthetic pyrethroid) applications are adequate.

Tests using various coloured sticky traps to monitor populations have been unsuccessful but a vacuum trap has been tested and shows promise although the cost may be prohibitive. Trials are planned to test a potential pheromone for the Lygus bug.

DISEASES

1) Grey Mould

Use of fungicides to control *Botrytis* or grey mold in nurseries has been significantly reduced over the past few years, due primarily to changes in cultural methods that have promoted plant health and made environmental conditions unfavourable for this disease.

After extensive trial work, the ventblock (styroblock modified with vertical ventilation holes) was designed to allow air movement through the seedling canopy. In combination with underbench heating, this system has helped reduce grey mold incidence and severity.

In B.C. container culture, the trend towards larger stock types has shifted the emphasis to styroblocks holding lower numbers of seedlings thereby reducing crop density. This has allowed for better aeration, lower canopy humidities and a general reduction in conditions favouring Botrytis development.

Greenhouse roofs are routinely removed around mid-June. Full sun results in more wax build-up m needle cuticles, rendering seedlings less succulent and susceptible to diseases.

There has been general improvement in crop culture. Ferfflizer regimes are more balanced, growth is controlled and seedlings are healthier and more able to resist diseases. Rates and forms of nitrogen have been changed, resulting in the reduction of soft succulent growth susceptible to *Botrytis.* Calcium levels have been increased to promote development of cell wall integrity.

Applied Forest Sciences, in cooperation with the Ministry, has been conducting research to develop a decision model for *Botrytis* control. The model uses environmental parameters to indicate threshold levels of disease progress. Growers will be able to determine if fungicide applications are necessary and the most opportune treatment times.

2) Storage Moulds

The most controversial pesticide application used on seedlings in B.C. nurseries has been the pre-storage fungicide spray. There is an active program to reduce or eliminate it as almost all seedlings are now stored at sub-freezing temperatures. Studies have shown that by the time treated seedlings are lifted, placed in storage, thawed and then transported to the planting site, little or no fungicide residue can be detected on the foliage.

3) Root Rots

In container culture, root pathogens can be transmitted from one crop to the next when containers are re-used. Effective container sanitation is essential, especially at nurseries with a history of root disease. Extensive trials testing various sanitizing agents have been conducted to find products and methods that effectively control pathogen inoculum without risk to nursery workers, seedlings or the environment. The Ministry has produced a booklet titled: "Guidelines for Sanitizing Styroblocks to Control Algae and Seedling Root Rot Fungi".

Quality of peat used in containers has been shown to be important in managing root rots. Most nurseries have switched to coarser peats as they provide better drainage and root aeration thus promoting healthy root growth.

Proper water management throughout the growing season is crucial. Overwatering encourages growth of *Botrytis* and root rots, as well as moss, liverworts and algae. Many nurseries now water less frequently but more thoroughly, and allow crops to "dry down' between irrigations. Misting for heat protection has also been reduced. Sanitation procedures and chlorination of the water supply are currently practiced at several facilities. These help reduce or eliminate water born pathogens, and reduce the establishment of other diseases throughout the growing season.

4) Seedborne pathogens

A variety of pathogenic fungi have been isolated from conifer seed, including Alternaria spp., *Cladosporium spp., Cylindrocarpon spp., Fusarium* spp., Penicillium spp., and *Trichothecium* spp. These can, under certain conditions, cause seed or seedling disease. Because it is impractical to try to protect seed from contamination throughout the entire period from cone harvest to nursery sowing, seed is treated for pathogens before stratification or sowing. Seedlots with histories of these diseases are recorded and lists distributed. Methods of cleaning seeds using running water have been successful and have been adopted operationally.
No fungicides are used to treat seeds.

WEEDS

In container culture there is no large scale use of herbicides; nurseries rely on hand-weeding for control. Herbicides are still a necessary practice in bare-root culture, but ff-ds stock type presently constitutes less

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than 5% of the seedhng market.

Liverworts and mosses can be a serious problem in containers; many herbicides and fungicides have been tested and shown ineffective. Current control programs ernphasize cultural techniques such as modffymg irrigation regimes, using extra layers of grit, choosing appropriate ground covers and general nursery sanitation.

The success of these programs and improvements in culture regimes has resulted in a dramatic reduction in pesticide use in the B.C. reforestation nursery industry. A study conducted in 1992 on pesticide use patterns in Ministry nurseries over the past 10 years found an 80% reduction in overall pesticide use. Currently, over 30% of all container seedlings grown in the province are considered pesticide-free and the number is increasing. The industry as a whole continues to strive to eliminate or reduce pesticide use with increased awareness of the nursery pest complex, further incorporation of IPM techniques, and the availability of biologicals.

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Glossary of Some Plant Disease Terms

Researchers working on seedling diseases have identified a need to standardize disease terminology to improve communication a3nong interested parties. The following definitions are from two publications: A *Dictionary of Plant Pathology,* 1989, by P. Halliday. Cambridge University Press. *Ainsworth and Bisby's Dictionary of the Ftingi,* 1983 (7th edition), by D.L. Hawksworht, B.C. Sutton and G.F. Ainsworth. Commonwealth Mycological Institute, Kew, Surrey, Great Britain.

INFECT - (A Dictionary of Plant Pathology; 1989) to enter and establish a permanent or temporary parasitic relationship with an organism. - (Dictionary of the Fungi; 1983) (of a pathoghen), to enter and establish a pathogenic relationship with an organism; to make an attack on an organism; (of an agent) to make infection of an organism take place.

INFECTION - (A Dictionary of Plant Pathology;1989) penetration of a plant, now the host, by an organism and the establishment of a parasitic or pathogenic relationship. - (Dictionary of the Fungi, 1983) the act of infecting.

COLON1ZATION - (A Dictionary of Plant Pathology;) the growth of a pathogen, particularly a fungus, in the host. Infection is the early stage of colonisation.

DISEASE - (A Dictionary of Plant Pathology; 1989) a condition where the normal functions are disturbed and harmed; may be divided into infectious, i.e. caused by a pathogen, and noninfectious, caused by other factors. A plant infected by a pathogen may not show any symptoms, i.e. it is not obviously diseased; but since such a plant may be a source of inoculum it is probably best described as diseased.

PARASITE - (Dictionary of the Fungi, 1983) an organism living on or in, and obtaining its nutrients from, its host, another living organism.

SAPROPHYI'E - (A Dictionary of Plant Pathology; 1989) an organism obtaining nutrients from dead, organic matter, hence being saprophytic. - (Dictionary of the Funge, 1983) an organism using dead organic material as food, commonly causing its decay.

FACULTATIVE PARASITE - (A Dictionary of Plant Pathology; 1989) a facultative parasite can live as a saprophyte and grows readily in culture on laboratory media.

OBLTGATE PARASNT - (A Dictionary of Plant Pathology; 1989) an organism that occurs in an intimate association with, and which is wholly dependent for its nutrition on, another living organism.

PATHOGEN - (A Dictionary of Plant Pathology; 1989) an organism, often a micro-organism, which causes a disease. It can be applied to a species, race, strain or isolate. A pathogen may be avirulent and a host may be tolerant of a pathogen. - (Dictionary of the Fungi, 1983) a parasite able to cause disease in a particular host or range of hosts.

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TECH TALK

Keithia blight of western redcedar: effect of styroblock configuration and seedling density on disease severity

Keithia blight, caused by the fungus *Didymascella thujina* (Durand) Maire, is presently the most important disease of container-grown, western redcedar (nuja *plicata* Donn.) in B.C., with over 0.5 and 1.0 niimon seedlings being discarded in 1988 and 1991, respectively. Since very little information is available on the relationship between nursery cultural practices and blight occurrence and severity (Kope and Sutherland, 1994), fungicides are mainly used to control the disease on container-grown seedlings. However, it is known that high humidity is an important factor favouring disease epidemiology (Porter, 1957). Cultural practices such as growing seedlings at high densities prolong foliage wetness and increase blight severity, especially on large, crowded stock. This study was inititiated to determine the effect of styroblock type (individual growing cavity size) and seedling growing density (seedlings/rn on blight occurrence and severity.

Nine VENTBLOCKS[R] (Beaver Plastics Ltd.) each of three configurations, i.e., 313B, 415B and 615A were sown with nonpelletized western red cedar seed (seedlot 20202) on May 13-15, 1992. On June 10, 1992, the seedlings were thinned to three growing densities (100, 50 or 25%) for each styroblock type. To provide blight inoculum, two potted, bhght-affected cedar seedlings were placed in the center of each half of each styroblock. The styroblocks were placed in a completely randomized design in the greenhouse at the Pacific Forestry Centre, Victoria, for 1 growing season (1992). During the second growing season

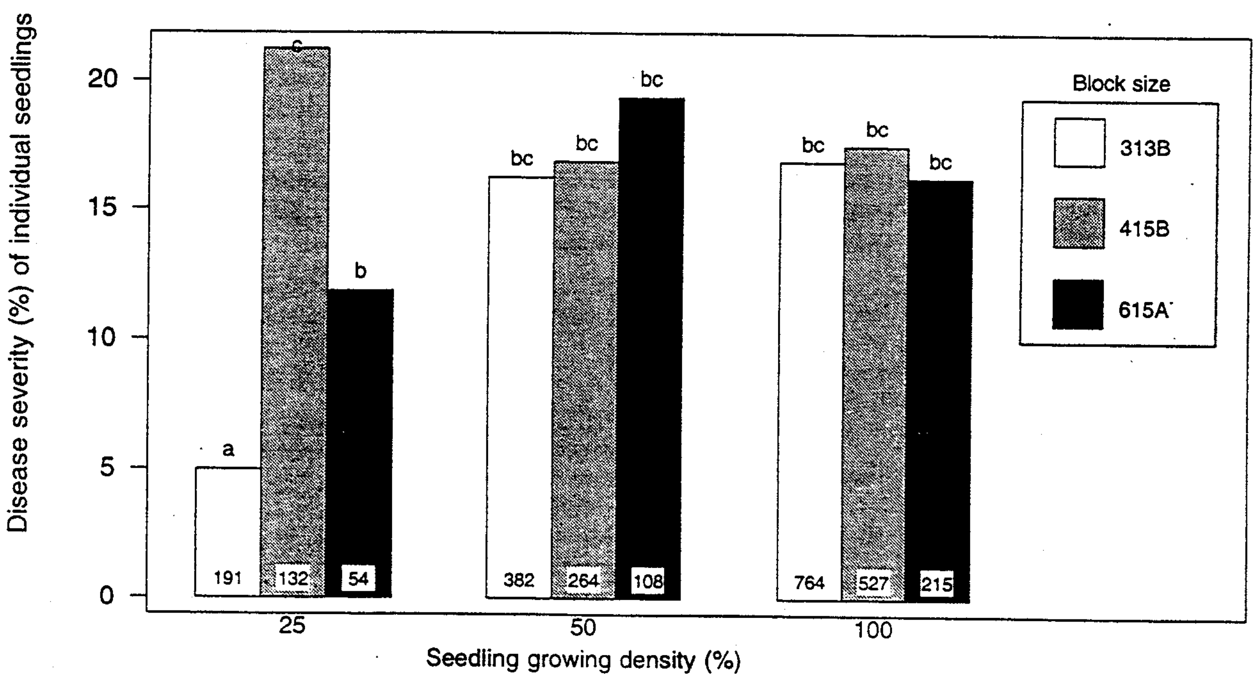

Figure 1. Effect of styroblock configuration and seedling density of Keithia blight. Columns with the same letter are not significantly different (p=0.05).
(Numbers within columns give the seedlings/m)

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(1993) the styroblocks were placed outdoors and the inoculuni-source seedlings were transferred singly to 4.5 L pots and arranged so that four pots surrounded each styroblock. In Noveinber-Decenıber 1993, the seedlings were assessed (Kope, 1992) for Keithia blight severity.

Results show that regardless of styroblock type, an average of 5.0 - 21.3% of the foliage on individual seedlings was affected by blight (Fig. 1). A comparison of the three styroblock types shows that blight severity (average % of foliage affected/seedling) was greatest in 415B blocks, intermediate in 615A blocks, and least in 313B blocks (p=0.05). Regarding seedling densities, blight severity was greater at the 50% than 100% growing density and least disease occurred at the; 2.5% growing density (p=0.05). Figure 1 shows that blight severity increases with growing density, e.g., blight severity in the 615A-100% growing density treatment was 3 times the severity in the 313B-25% treatment (16% vs 5.0%, respectively), although seedhngs/m^2 was roughly equivalent (215 seedlings/m^2 and 191 seedlings/m^2, respectively). This suggests that seedling crowding resulting in high, within canopy humidity, favours blight.

We conclude that growing western red cedar in different blocktypes and at different densities within the blocks can alter Keithia blight severity. Selecting an optimum blocktype and sowing density will depend on required seedling height and caliper specifications, and the amount of greenhouse/open compound space available. Representative seedlings will be outplanted in 1994 to determine the effect of blocktype, seedling density and blight severity on seedling survival.

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Alternate Container Types Trial (SX93203Q) - Saanich Test Nursery

INTRODUCTION

The quest for improved root form in containerized conifer seedlings has led to the evolution of **a** number of different container designs. The purpose of this trial was to grow seedlings to B.C. Ministry of Forests specifications in a number of alternate container types, and compare the seedlings produced to controls grown in styroblock PSB313B, PSB415B and PSB410 containers.

Alternate Container Types:

1. First Choice Nature Root (NR) 415B (styroblock with "steps" to encourage root tips at three levels in the plug)
2. Lannen Plantek 63F (a hard plastic container with vertical slits in the sidewalks, 63 cavities/block, 90 mL/ cavity)
3. Elvinco Airbasket prototype (a hard plastic container with vertical slits in the sidewalls, dimensions similar to styroblock 313B)
4. Jiffy pellet 96PIus (96 'meshwau" peuets per tray, 90 mL/pellet)

Coastal Douglas fir, interior spruce and interior lodgepole pine were sown in each of the container types on the same date in February, 1993, and grown as regular 1+0 spring plant stock. All seedlings were fefflized with Plant Products 12-17-29 with the recommended additions of calcium nitrate and magnesium sulfate. Containers were irrigated and fefflized according to their individual needs. The Elvinco, Jiffy and Plantek containers tended to dry out more quickly than the styroblocks, requiring about ten percent more irrigations over the course of the growing season. All Douglas fir seedlings were moved outside May 14. All pine seedlings were moved outside May 27. The spruce seedlings were moved outside on two separate dates: PSB313B, PS3410, and Lannen Plantek on June 15; PSB415B, NR415B, Elvinco and Jiffy on June 24. Drought stress was used to induce budset and dormancy in all seedlings.

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MORPHOLOGICAL ASSESSMENT RESULTS

Tables 2-4 show results of morphological measurements at the end of the growing season for each species.

Table 2. Interior spruce (seedlot 4205): average of morphological measurements taken 36 weeks from sowing in various container types (n = 50).

Container Type	Height (cm)	RCD (mm)	Top weight (g)	Root weight (g)	Top/Root Ratio
PSB313B	20.7	3.3	2.3	1.4	1.6
PSB415B	23.8	3.7	3.2	2.0	1.6
PSB410	20.7	3.6	2.8	2.0	1.4
NatureRoot 415B	23.2	3.8	3.2	2.2	1.4
Plantek 63F	20.5	3.8	3.1	2.1	1.5
Elvinco	13.1	2.9	1.6	1.2	1.3
Jiffy 96Plus	18.0	3.9	2.9	1.6	1.9

Table 3. Interior lodgepole pine (seedlot 32587): average of morphological measurements taken 35 weeks from sowing in various container types (n = 50).

Container Type	Height (cm)	RCD (mm)	Top weight (g)	Root weight (g)	Top/Root Ratio
PSB313B	17.5	3.3	2.2	1.3	1.7
PSB415B	17.2	3.8	3.0	1.9	1.6
PSB410	19.9	3.7	3.0	1.3	2.3
NatureRoot 415B	17.7	3.9	3.1	1.7	1.8
Plantek 63F	16.9	4.4	3.8	1.8	2.1
Elvinco	11.8	3.5	2.2	1.4	1.5
Jiffy 96Plus	15.6	4.8	3.3	1.9	1.8

Table 4. Coastal Douglas fir (seedlot 6943): average of morphological measurements taken 36 from sowing in various container types (n = 50).

Container Type	Height (cm)	RCD (mm)	Top weight (g)	Root weight (g)	Top/Root Ratio
PSB313B	32.2	3.5	2.5	1.0	2.5
PSB415B	32.6	4.0	3.9	2.0	1.7
PSB410	34.0	3.8	3.2	1.3	2.6
NatureRoot 415B	32.0	3.9	3.2	1.7	1.9
Plantek 63F	28.6	4.3	3.4	1.8	1.9
Jiffy 96Plus	29.8	4.6	3.7	1.6	2.2

DISCUSSION

First Choice NatureRoot 415B :

Root tips were apparent at each of the steps in many of the seedlings, so the container was successful in this respect. However, in some cases roots spiralled around the steps. This would likely become a serious problem with 2+0 stock. We did not have any trouble with plugs breaking apart at the steps as has been observed elsewhere. We did however have a problem with poor block loading - many of the plugs had large air spaces in the media at the level of the first step, resulting in a large number of culls.

Lannen Plantek 63F.

These containers produced very good seedlings with large caliper and dense roots. The air-pruning through the side-shts in the cavities resulted in many active lateral root tips along the whole length of the plug. Disadvantages were that the containers had to be hand loaded and sown, as block dimensions were different from styroblocks, and seedlings on exposed edges of the containers dried out.

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Elvinco Airbasket ***prototype :***

Douglas fir was not grown in this container. Pine and spruce seedlings grown were shorter than in other containers but most met minimum height specifications. Seedlings had good top:root ratios and the side-slits in the containers resulted in many lateral root tips throughout the plug. These containers are based on styroblock dimensions and thus could be handled with styroblock-based equipment. As this was a prototype the plastic material was rather sharp and brittle; the final product will be made of high density polyethylene. As with the Plantek container, the seedlings along the edges of the outer containers became dessicated.

Jiffy pellet 96PIus

Seedlings had good above ground morphological attributes and particularly large caliper. During the growing season seedling roots grew freely through the mesh walls and into neighbouring plugs. By the time seedlings reached target (B.C. min of forests 1-0 410) specs, about half of each seedlings' root system was actually located in adjacent plugs, which required plugs to be cut apart at lifting. Many of the severed roots were large (1-3 mni) and suberized. Fine roots required for absorption were, to a large degree, located in adjacent plugs and therefore lost. Seedlings grown in Jiffy pellets ended up with a severely truncated root system with few fine roots.

There were some other disadvantages. Plugs required hand sowing because the plug trays do not match conventional styroblock dimensions. Individual pellets tended to fall over and required regular straightening up. Grit did not stay on top of pellets resulting in algae buildup and associated water management problems. Once plugs grow together it is impossible to rogue out diseased seedlings except by cutting. Lifting is extremely labour intensive since individual seedlings have to be cut apart.

It must be noted that alternate container types are part of alternate growing systems for which we do not possess (possibly available) associated materials handling equipment.

Seedlings from each of the container types were planted in field beds at Green Timbers Nursery in Spring, 1994, for further observation.

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Research Update - Mechanisms of Resistance and Susceptibility of Sitka Spruce to the White Pine Weevil

Introduction

The white pine weevil, *Pissodes strobi* (Peck), is the primary factor preventing reforestation with Sitka spruce, *Picea sitchensis* (Bong) Carr., in coastal British Columbia (Wallace & Sullivan 1985). The rapid growth rate of this tree makes it desirable for planting in wet, coastal areas, but repeated colonization of the terminal leader by *P. strobi* results in stunted, deformed and suppressed trees, which rapidly become merchantable and eventually die (Alfaro 1982). Various control techniques such as shading, leader clipping, application of insecticides and biological control agents have been attempted with only partial success (Stiell & Berry 1985; Alfaro & Omule 1990).

The desirability of developing trees that are genetically resistant to terminal weevils has long been recognized (Gerhold 1966; Wood 1987), and there is an urgent need to develop weevil-resistant Sitka spruce. The identification and elucidation of resistance traits would greatly improve the selection process, as well as the understanding of resistance.

A number of putatively resistant Sitka spruce provenances have been identified (Alfaro & Ying 1990; Ying 1991). If the mechanisms by which these trees resist or tolerate attack were known, it would be possible to develop a multicomponent resistance index (Brooks & Borden 1992), which would allow parent trees to be screened for use in weevil resistance breeding programs, and progeny to be screened for retention in or exclusion from such programs. Trees could be assessed for factors that may be invoioved in antixenosis (Kogan & Ortman 1978), such as the presence or absence of volatile host attractants, feeding and oviposition stimulants or deterrents, and morphological characteristics of the leader, as well as factors involved in antibiosis (Painter 1968), such as the ability of the host to resist attack through resinosis. It may also be possible to assess trees for factors that allow them to tolerate attack by weevils without sustaining a serious defect (Painter 1968; Alfaro & Ying 1990). In addition, 'token' traits, such as the presence or absence of certain monoterpenes, that mav not be involved in resistance per se, could be indicators of resistance (Harris et al. 1983; Brooks et al. 1987).

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The objectives of our research are: (i) to determine the mechanisms of resistance and susceptibility of Sitka spruce to the white pine weevil and (ii) to use these traits to develop a multicomponent resistance index for use in selecting parent trees for a Sitka spruce breeding program, and assessing progeny for resistance traits.

Summary of Results to Date

We have examined resistant and susceptible Sitka spruce at five different sites in British Columbia. They included provenance trials at Sayward, Head Bay, Kitimat and Nass River, and a clonal outplanting at Fair Harbour. To date we have found significant differences between resistant and susceptible trees with respect to the resin duct system, foliar and cortical monoterpenes and resin acids, and feeding deterrency. Our results from Fair Harbour are the most complete and we summarize them herein.

The Resin Duct System

Resinosis may be the primary cause of mortality for white pine weevils (Overhulser & Gara 1981). Longitudinal and transverse resin canals are a constant feature in *Pinus, Picea, Larix and Pseudotsuga spp.* (Core et. al. 1976), and it is the distribution, size and density of the resin canals that determine the amount of resin produced.

In our analysis of the longitudinal resin duct system of Sitka spruce, we found significantly more outer resin ducts in resistant than in susceptible trees (P) (Fig. 2a) (Tomlin & Borden 1993). This result suggests that resistant trees might carry more resin providing them with a greater capacity for resinosis, and that weevils feeding on these tees frequently encounter resin ducts and are repe.Ued.

The composition of the resin also varied significantly between resistant and susceptible trees. Analysis of the mmoterpene profile showed that resistant trees have lower amounts of isoamyl and isopentenyl isolvalerate in their foliage than susceptible trees (P 0.05) (Fig. 2b), agreeing with Brooks & Borden (1992). The presence or absence of isovalerates may be a biochemical marker simply associated with resistance, or it could be part of the attractive odour of the trees. Resistant trees also had significantly greater amounts of total resin acid in their cortical tissue than susceptible trees (P) (Fig. 2c). Bark that is high in resin acid content may be toxic or repellant to weevils, or the resin may be viscous and/or slow to crystallize, providing an inhospitable environment for eggs and larvae.

Feeding Deterrency

Feeding preferences of weevils were tested using a paired-twig bioassay developed by 5rooks & Borden (1992). Twigs of 5 cm legths were cut from resistant clones at Fair Harbour. Each resistant twig was pinned end-to-end with a susceptible twig of similar diameter to simulate a single branch. One weevil was allowed to feed on this for four days, after which the number of feeding punctures on each twig was counted, and the amount of ftass under each twig was weighed.

Based on numbers of feeding punctures, our results indicate that weevils, for the most part, preferred to feed on the susceptible twigs (Fig-3). This trend was also reflected by the weight of frass collected under each twig. Females showed greater discrimination than males between resistant and susceptible clones, particularly in the case of Green Timbers trees. Subsequent experiments may disclose oviposition deten-ency by these trees.

Implications and Future Work

Our results to date indicate that there are a number of morphological and chemical differences between resistant and susceptible trees that could potentially be used as criteria in selecting weevil-resistant spruce. This capability would be particularly useful in the case of very young trees which are not yet susceptible to weevil attack. For effective, long-term management of Sitka spruce plantations, it would be desirable to incorporate as many different resistance mechanisms as possible into a breeding program, and for this reason we plan to expand on some of the work we have done, and to investigate other possible mechanisms of resistance.

Our feeding bioassays were performed in the late summer and fall when weevils were **in** reproductive diapause. We intend to repeat these experiments in the spring to test for both feeding and oviposition detemmcy. We also intend to examine the resm duct system of the trees at Fair Harbour by clone, as our feeding bioassav uidicated sipfficant variation between dones within provenance.

We will compare the wourid reaction of resistant and susceptible trees, which we hypothesize might be stimulated by the introduction of microorganisms during weevil feeding or oviposition, and examine trees for other biochemical traits such as amount of tannins. Experiments also must be done to determine how some of the potential resistance traits we have uncovered might affect the behaviour and/or physiology of weevils.

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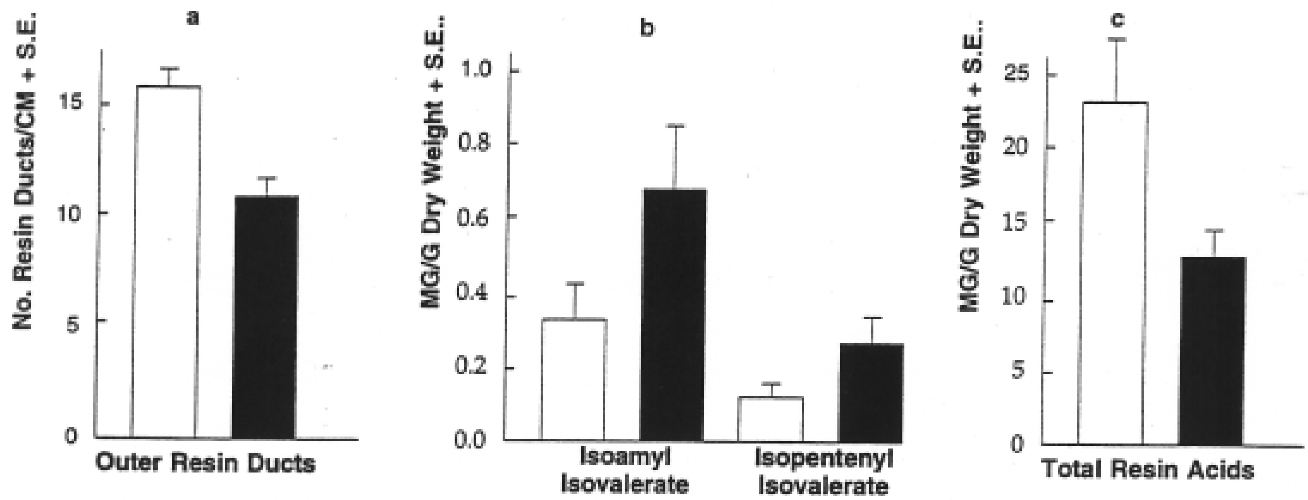

Figure 2. Analysis of resistant and susceptible provenances from Fair Harbour with respect to a) the mean number of outer resin ducts/cm., b) the terpenes isoamyl isovalerate and isopentenyl isovalerate, and c) total resin acids. In each case there are significant differences between paired bars, t-test, $P<0.05$.

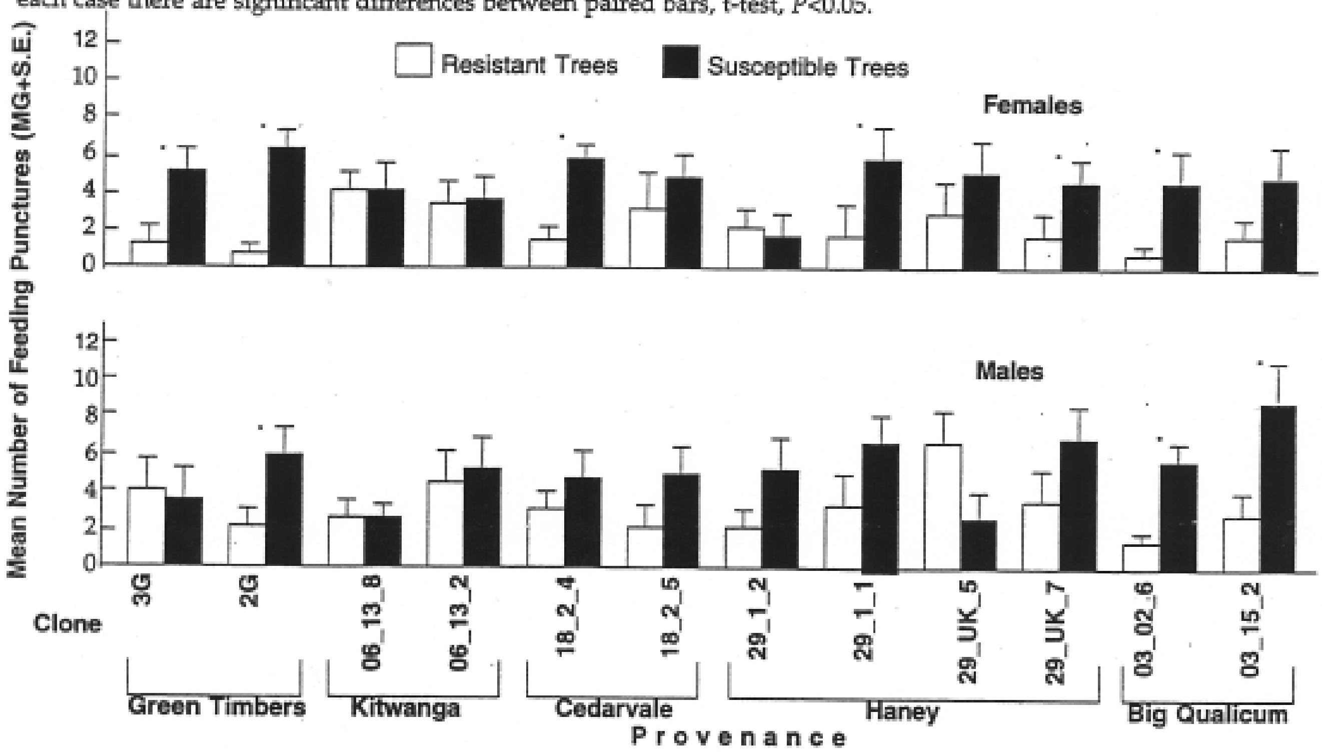

Figure 3. Mean number of feeding punctures made by one male or female weevil given a choice between pairs of resistant and susceptible twigs. An asterisk indicates difference (t-test, $P<0.05$) between feeding on resistant and susceptible twigs.

(continued...)

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PROBLEM SEEDLOTS ... An Outline of Information and Options

Seedlots are unique and need to be treated as such. While species recipes serve as rough guidelines, some extra assessment characterizing seedlots prior to pre-sowing preparation can help reduce problems during early seedling culture. Customizing seed treatments to produce-more consistent germination requires an understanding of problems commonly found in conifer seedlots, the characteristics identifying them and possible solutions. F-mphasis here is on the data available and the logical process by which one can diagnose and solve seed problems.

1. **SOURCES OF RELEVANT SEEDLOT DETAILS:**

*** Nursery Records/Determine Historical Performance:**

- At your facility, or other nurseries?
- From year to year, under different gen-nination envi-rorkments, different stocktypes?
- Nursery vs lab germination vs cutting test data?

*** Cutting Tests/Determine Potential Viability:**

For best results use a 100 seed sample soaked (depending on species) 24-48 hours.

Key points to note:

- % highly damaged	- often fungal sources
- % empty	- easiest to upgrade
- % immature	- indicates low vigour
- % good filled	- viable seed
- water stained during imbibition	- leakage of metabolites (seedcoat damaged or fungi)
- sinking rate during imbibition	- initial moisture content, physical damage, seedcoat permeability?
- hardness of seedcoat permeability	- may reflect seedcoat

(continued...)

* **Laboratory Germination Test Data:**

- How recent are these data, do they match your cutting test results?
- Multiple tests are available, ie. dry seed / after 24 hour soak / after standard stratification.
  - Differences between tests help characterize seedlot condition and allow custom design of stratification treatments.
  - e.g. a seedlot which has greater germination for dry seed than after standard stratification usually has low vigour, ie. is weakened further during/by stratification.
  - No difference between a 24 hour soak and full stratification may indicate a low degree of dormancy and a case for shortening the stratification treatment Period.
  - Other stratification benefits to consider prior to shortening the treatment are;
    - germination uniformity and speed
    - reduced sensitivity (germination) to environmental variation, ie. temperature
    - increased stress resistance (post stratification handling)

*** Incubation Tests/Determine Germination Potential and Readiness to Germinate-**
Incubation Test = leaving a cut seed under germination test conditions.

- A change in embryo colour (greening) and elongation signifies readiness to germinate.
- Cotyledons expand, epicotyl and hypocotyl become more plump as germination nears.
- Periodically perform cutting and incubation tests on a seedlot in stratification to determine required length of stratification, ie. when stratification is complete.
- With White Spruce and Lodgepole Pine, even dry seed will respond after 3 days of incubation, hence one needs to observe the speed and vigour of the response to determine optimum stratification procedures.
- Seeds that rot (quickly) will do the same when sown!

* **Cone/Seed Collection and Processing Notes:**
Clues to possible sources of seedlot problems.

- Level of insect and fungal infestation noted at collection time.
- Collection and storage conditions, temperature and moisture extremes, and sanitation level.
- Problems noted during processing, such as ease of dewinging, seed yield per cone.

II. SOME COMMON ELEMENTS OF A PROBLEM SEEDLOTS ARE:

Biological Disease or Insect:

- Insect infested are easily removed during liquid separation. Frass and/or exit holes identify this type of mechanical seed damage.
- Fungal infections usually stain water during a soak (fungal membranes are more leaky than plant membranes and plant membranes may be broken down somewhat), fermented winery smell.
- Bacterial infections give off an ammonia-hke smell and are hard to control and dispose of.

Mechanical/Environmental Collection/Processing Damage.

- Mechanical damage during processing will be seen as surface abrasion, small fractures in the seed coat.
- Heat damage results in highly resinous and gununy internal contents, a cooked appearance.
- Moisture damage shows up as translucent spots on the megagametophyte and embryo, and is often associated with "mouldy" cone collections. The translucent spots soon become dark due to hyphal growth.

*** Developmental Inadequate Stratification, or Pre/Over-mature Collection.**
What are the barriers to germination?

- Inadequate stratification, Pre/Over-mature collections.
  - Chilling requirements not met, dormancy.
  - Temperature and/or light units inadequate during germination.
  - Physical impermeability of the seedcoat/pericarp to water, oxygen or both.
  - Mechanical resistance to allow embryo growth? e.g. the plug at the micropylar end in
  - Yellow Cedar seed.
  - Low energy reserves.

Without imbibition and gas exchange embryo growth and germination are impossible: Creasey, K.R.: Myland, T.R(1993)

III. OPTIONS AVAILABLE

1 Seed Performance Upgrading

- Sanitation: External
  - Physical: nulling water soak, remove surface born fungi, etc.
  - Chemical: Hydrogen peroxide or bleach.
- Density or Physiological Separation:
  - Liquid (imbibitional/dehydrational).
  - Gravity (use of air separators).

(continued...)

- Removal of poor fraction is also a sanitizing procedure.
- Modified Stratification:
  - Extend to the point where seed shows signs of initiating germination (monitor with cutting and incubation tests).
  - Mix cold-moist treatments with brief drybacks and resoaks to weaken seed coats.
  - Requires performing numerous cutting and incubation tests to monitor progress.
- Pregermination:
  - To reduce crop emergence time.
  - To increase the number of viable gem-tinants obtained from a low vigour seedlot.
  - Pre-gem-dnants with radicles less than 1/2 can often be mechanically sown, if careful. They actively imbibe water, hence respond well to sink-float separations; but be aware that without aeration, they can drown.
- Altering Gern-dnation Environment.
  - Pay attention to the boundary layer climate, temperatu.re-moisture-aeration.
  - Germination environments are also disease growing environments, use them only as long as is necessary.
  - Initiating fertilization (low level) during germination can lead to more vigorous crops.

2 - Disposal: ***Some seedlots are simply not worth growing.***

- Discuss with client!

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Above abstract by E. van Steenis... To receive a copy of the complete article, please send a stamved self-addressed envelope to: Scientificals Consulting, 309-7297 Moffatt Road, Dorchester Circle, Richmond, B.C. Canada V6Y 3E4.

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Interactive Effects of Light and Stratification on Germination Characteristics of Some British Columbia Conifers.

Can. 1. Botany (Submitted)

Pre-germination stratification treatment was generally more important than the effects of light on seed germination by 14 conifer species and varieties native to British Columbia. Nevertheless, there were some strong species differences in the response of germination to light. Final germination % after 21 days (28 days for *Abies* spp.) for both stratified and unstradfied seeds of *Pice,a glauca, P. sitchensis, and Tsuga heterophylla* did not show a response to light. Final germination % *of Abies grandis, Pinus contorta var. contorta and P. c. var. latifolia, P. ponderosa, Pseudotsuga menziesii var. glauca* and P. m. var. menziesii responded positively to light if unstratified but was not significantly affected by light when stratified. For *Thuja plicata* seeds, final germination % responded positively to light regardless of stratification pretreatment. Light appears to reduce final germination % of stratified seeds of *Abies amabilis, A. lasiorarva, Larix occidentalis, and Pinus monticola,* though stratification conditions for these species were suboptimal. The germination rate of stratified seeds of all species and unstratified seeds of most species was enhanced by light. Results showed no significant relationship between response of germination to light, and shade-tolerance ranking or mean seed weight of a species. In six seed lots of *Pinus contorta var. latifolia,* however, we detected a weak negative correlation between mean seed weight and unstratified-hght response measured after one week, but a significant positive correlation when measured after three weeks. Very low light levels in closed-canopy forests or in the forest floor may prolong tree seed germination, but are unlikely to constrain final germination % levels after most seeds have been naturally stratified by moist, cool winter conditions. The importance of differences in rate and timing of tree seed germination under natural conditions remains to be demonstrated.

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The management of Douglas-fir needle midges (Contarinia spp.)

Condensedfrom a technical day presentation to the Southwest B.C. Christmas Tree Association.

Needle midges on Douglas-fir are a concern to Christrnas tree growers, seed orchards and gardeners. In Christmas tree plantations, the loss of current year needles reduces the value of the trees at harvest. When combined with infestations of needle diseases, such as Swiss needle cast or Rhabdocline, the impact of needle midges can be extremely severe. Harvest could be delayed for 3 - 4 years, if it is possible at all. In seed orchards, the immediate impact is not as great, however the weakening and loss of current year needles can reduce the trees' photosynthetic capacity and subsequent vigor. For gardeners, the impact is m vigor and aesthetics of specimen trees.

Damage done by Douglas-fir needle midges is confined to current years needles. As vegetative buds begin to elongate and open in spring, female midges lay their eggs in them. When the eggs hatch, the young insects (larvae) burrow into the new needles. These larvae feed inside the needles in a small gall or chamber which can be observed as a necrotic area on the needle by late summer or early fall. Feeding can also distort needle growth so that it has a crook or kink in it at the gall. Larvae leave the needles late in the season and spend the winter in the duff. They may leave the needles and drop to the ground or may fall with damaged needles and enter the soil later. Exit holes can be seen on the bottom of the needles at that time. Pupatim appears to take place early in spring and adults emerge shortly after to start the cycle again.

Adult midges are small (less than 2 mm) “mosquito like” inserts with a pale orange abdomen and long, fuzzy antenna. They live for only a few days - just long enough to mate and lay eggs. Because emergence from the soil and subsequent flight are greatly affected by temperature, periods of activity can vary somewhat from site to site. However, adult activity seldom lasts more than a couple of weeks in a given field.

Growers can use emergence traps to determine when adult midges are active on their site. This can serve as a guide for when to apply control measures. An opaque container with a jar attached is all that is needed. The jar serves to provide an attractive light source as well as a cmtaininent area for the adults. Traps are placed out at about the time the earliest buds start to elongate and should be checked every couple of days or at least weekly. Most adult activity takes place over about a week or 10 days, so it is imperative that traps be checked often to identify the emergence period.

To-date, the ordy reconunended control measure is to spray elongating buds with a pesticide at the first sign of midge emergence. While this can be effective, there may be some ways to reduce the dependence on chemical controls or at least the frequency of their use. For example, the size of needle midge populations can vary considerably from year to year. One study found the number of infested needles per 18" branch tip dropped from 2773 to 3.5 over a 2 year period. Emergence trap data might be used to detect these midge population fluctuations and predict subsequent damage. In lieu of further research, growers could begin to develop some basic observations for their own fields with a few years worth of data. In years of low midge populations, the amount of damage may be acceptable without treatment

Although little research has been done, trapping over several years may also suggest some correlation between time of Trudge emergence and tree to tree variation in time of bud burst. Ths information could be useful for determining if and when to spray and selecting less susceptible trees or families to plant. In natural stands of Douglas-fir for example, there is some suggestion that earlier flusl-dng trees are attacked more than those that flush later. Treating a small number of early trees in a plantation may control the problem with a minimum of effort and pesticide. Planting only later flushing trees may nunin-dze the problem without the use of sprays. Growers could assess the validity of this suggestion by assessing damage on early and late trees in their plantations over time or by looking at emergence trap catches in relation to the pattern of budburst in their plantation.

Douglas-fir needle midge larvae spend a long period of time in the soil. Although most of this is during the cold winter months when soil fauna is somewhat quiescent, managing the ground cover in a plantation to encourage a variety of predators and fungi might be useful in reducing the survival of midges in the soil. Encouraging a diversity of plants, allowing a bit of a thatch layer and keeping the use of pesticides to a minimum all encourage a diverse soil fauna.

Lots of research could be done on Douglas-fir needle midge. The key for growers is that there are a number of options that can be explored to minimize damage done. Even the most researched management plans have to be adapted somewhat to particular sites and growers themselves are the best source of local knowledge with which to implement that research.

Don Summers
Nursery Extension Services

Genetic-Gain Demonstration Plantations for Orchard Seed

'Tree irnprovementi is carried out to increase the profitability of growing plantation forests.... Unfortunately, most forest planning information and predictive models are based on data from forest stands that are genetically unimproved and these are likely to underpredict the volume and value returns from stands planted with improved stock. The forest industry needs information on the performance of improved seecuots over the full range of sites and management regimes (preferably before they are widely planted), o@hile tree breeders (and orchard managers ed.) need to validate their gain predictions to maintain support for tree improvement programmes..." (Carson, M.J. 1991.)

This has been recognized in British Columbia since December, 19802, when the first proposal was presented to establish demonstration plantations. However, for various reasons, including the lack of 'quality' orchard seed in the Interior, the program was deferred until February, 1992, when the first working plan was approved.

The objective of these plantations will be to demonstrate to Forest Service personnel, representatives of industry and the general public, the benefits of investing in tree improvement.

Specifically, these plantations will be designed to:

A.. visually compare the performance of plantations derived from seed orchard seed with those from wild collected and

B. demonstrate, through height, diameter, volume and quality parameters, the performance of plantations derived from current and potential seed orchard seed and current natural stand seed collections,

C. provide new and/or additional information concerning seed transfer and plantation establishment performance.

To date, plantations have been established in the Hudsons Hope planning zone (Chetwynd, Tumbler Ridge and Pine Pass)-in co-operation with Chetwynd Forest Industries and in the Shuswap Adams zone (near Adams Lake) in co-operation with Adams Lake Lumber. Seed for a third set of plantations has been sown for the East Kootenay planning zone in co-operation with the Cranbrook Forest District.

Each plantation consists of two distinct designs - one to provide quantitative data to calculate actual genetic gains; the other to visually compare the performance of various natural stand and orchard seedlots. Both plantations are established simultaneously on the same site.

The quantitative plantations consist of at least four - 100 to 144 tree plots planted at normal plantation spacing and include:

1. one seed orchard lot,
2. one n-dx of at least six natural stand seecuots compatible to all sites,

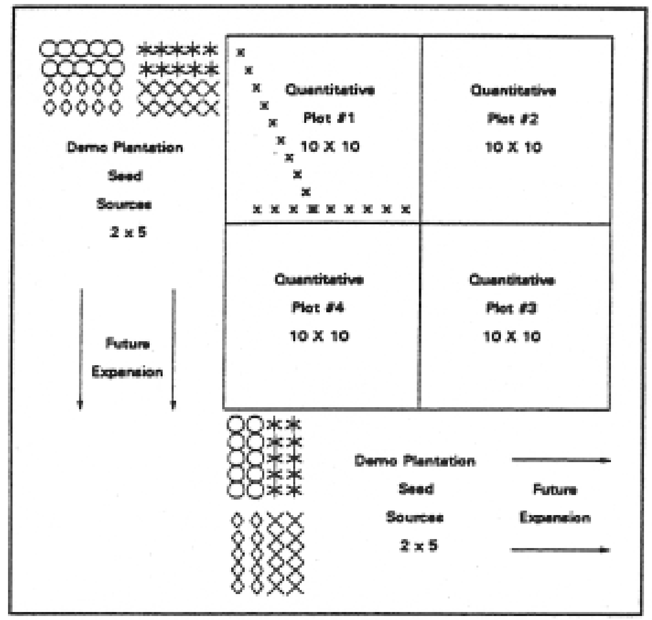

Figure 4. One Suggested Block Design for One Production and Two Demonstration Replicates

3. one mix of seed obtained from at least 5 of the highest ranked clones in the progeny test for that planning zone, and
4. a n-dx of seed from at least 5 of the poorest ranked clones.

The demonstration plantation consists of double row plots (2 x 5), containing ten seedlings from each seed source. The numbers of seedlots represented depend on many factors, but always include the individual natural stand seedlots, the seed orchard, and 'superior' and 'inferior' lots represented in the quantitative plantation. Additional seedlots may include controlled crosses, seed orchard lots from other planning zones, and additional natural stand lots.

Measurements of height and diameter will be made every five years, but may be adjusted to coincide with critical stages of development. Additional measurements such as insect/disease damage, wood

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density, stem form and other parameters may be recorded if deemed necessary.

Data analysis will be based on the objectives of each program and will not be addressed here. However, any analysis under-taken will be compatible to that used by the B.C. Forest Service Research Branch.

[1]Tree improvement includes the selection, breeding and testing of trees, and the production of seed or other porpagules, with the genetic capability of producing highter value timber plantations. It is carried out in conjunction with other forest genetics activities designed to in- crease our understanding of natural genetic-diversity patterns to aid with the development of seed transfer guidelines and gene resource managernent.

[2]Discussion paper entitled 'Some Options to Monitor the Perform- ance of Outplanted Stock from Seed Orchards' prepared by C. Bar- tram, Dec. 9,1980.

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Response of Interior Spruce to Extended Stratification

The germination response of 26 interior spruce (complex *of Picea glauca* (Moench) Voss, *Picea engelmannii* Parry ex Engelm and their hybrids) seedlots to three treatments: soaking, soaking plus three weeks stratification and soaking plus six weeks stratification was investigated. The same seedlots were evaluated for various seedling attributes by Chris Hawkins at Red Rock Research Station. First year nursery results were presented at the 1993 Forest Nursery Association of British Columbia meeting in Courtney, B.C. Canada.

For white spruce many references show that three weeks stratification overcomes embryo dormancy (Caron et al. 1993; Edwards 1980; Leadem 1993; Santm 1970; Wang 1976). Investigations by Santon (1970) showed that 4 weeks of stratification was preferable to 3 weeks. Leadem showed optimal germination at between 3 and 6 weeks stratification, depending on the temperature regime used for testing. 12 weeks stratification resulted in lower germination compared to three and six weeks stratification at all three temperature regimes (Leadem 1993).

Materials and Methods

The 26 seedlots were comprised of 20 wild stand collections and six seed orchard collections. A total of 600 seeds were available for each seedlot. Selected treatments were a 24 hour soak; a 24 hour soak plus three weeks stratification (moist chilling of seed - moisture content approximately 30% and temperature 2C); and a 24 hour soak plus six weeks stratification. For each treatment 200 seeds were available per seedlot and these were allocated to four replications of 50 seeds. Each replication consisted of a germination dish with Kimpack, blotting paper and 50 ml of water added.

Treatments were scheduled to allow all germination dishes to be placed into the testing environment simultaneously. Testing was conducted in a Conviron germinator set at 8/16 hours day/night and $3O^{C}/20^{C}$ day/night. Seeds were evaluated for 21 days and considered germinated when the radicle reached a length 4X that of the seed coat. Abnormal germinants were not included as germinated seeds. The level of dormancy was quantified as the genilination percent of the three week stratification treatment, divided by the germination percent of the 24 hr soak treatment. This parameter indicates the relative degree of dormancy for use in comparing seedlots.

Results and Discussion

Total germination [gern-dnation capacity] of seedlots did not, on average, increase with an increase in stratification from three to six weeks (Figure 5). Both treatments resulted in total germination of 88%. Embryo dormancy present in these seedl -ots was apparently overcome with the standard three weeks stratification. Differences in germination % were greatest at day seven when the soak treatment had attained a level of only 51%, while the three and six weeks stratification attained levels of 73% and 77% respectively.

Response to extended stratification varied among seedlots sampled. Some seedlots such as 25578 showed large gains by extending stratification, but five seedlots performed more poorly with extended stratification (Table 5). The soak only treatment generally showed good results indicating that dormancy was not 'deep' in this sample of interior spruce seedlots. Dormancy as presented was relatively uniform between seedlots,

(continued...)

ranging from 1 to 15%. It is unclear why some seedlots perform better with only a soak treatment, but possible explanations could be the presence of fungal pathogens or mechanical damage. A standing water soak was used I in this trial to avoid cross contamination among the 26 seedlots. Use of a running water soak might reduce any impact pathogens could have during extended stratification.

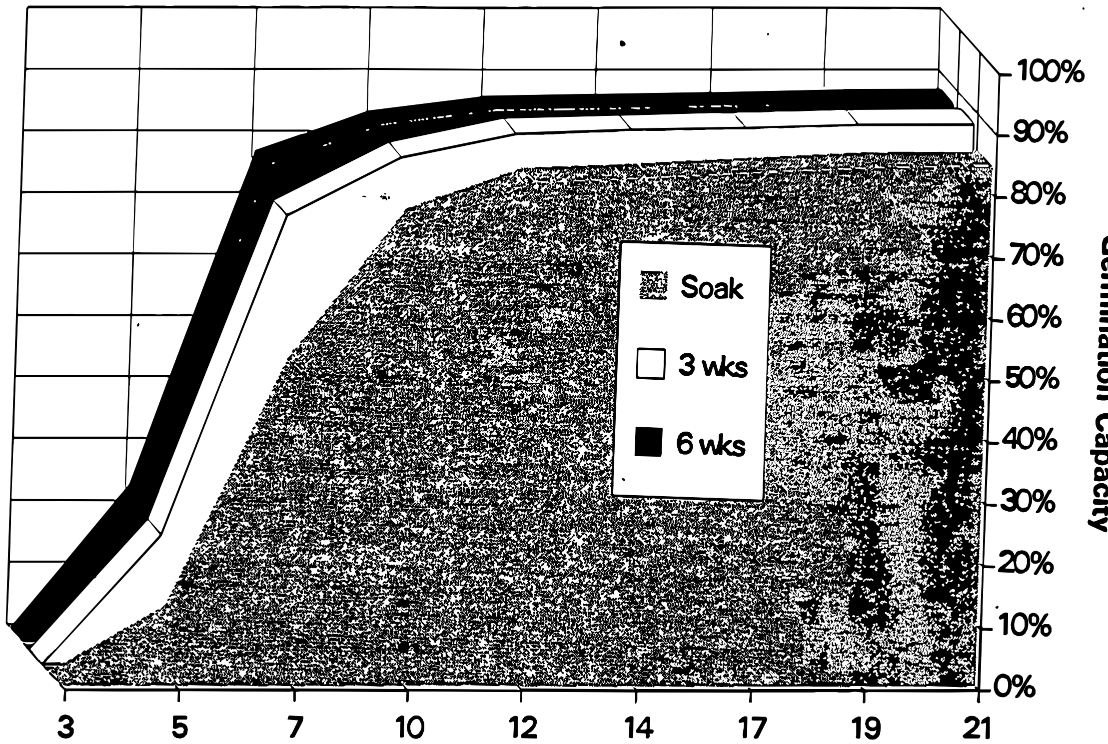

Figure 5. Response of 26 interior spruce seedlots to a 24 hour soak [soak], a 24 hour soak plus 3 weeks stratification [3 wks], and a 24 hour soak plus 6 weeks stratification (6 wks].

There were no differences found between responses of seed orchard and wild stand seedlots to increased stratification. Since orchard seed is collected closer to natural seed dispersal, some concern was expressed that the seeds may exhibit deeper dormancy and require longer stratification. This was not supported by the results, however much fewer seed orchard seedlots (9?%) than wild stand seedlots were included in the sample.

Although gains in germination capacity were not exceptional, extending stratification to six weeks increased the rate of germination in 23 of the 27 seedlots tested. The differences are not large (Figure 5), but crop uniformity will increase and the time available for fungi to establish themselves as pathogens on succulent tissues will decrease. Increased stratification time has been shown to widen the range of temperatures over which germination will occur (Gosling & Rigg, 1990). If maintenance of high germination temperatures is problematic, extended stratification will allow seeds to germinate at lower temperatures! Stratification will also reduce the need for light during germination (Edwards & Olsen 1973; Wang 1987) and reduce performance differences between seedlots which have received different collection, handling and storage techniques *[within reasomble limits]* (Wang 1987).

The standard Tree Seed Centre (TSC) treaf3nent is to stratify interior spruce seedlots for 21 days following a 24 hour soak. After the three weeks stratification seed

(continued..)

remains in stratification until the shipping date. The shipping date is determined to efficiently ship sowing requests to nurseries and may result in up to me additional week of stratification. After arrival at the nursery seed is kept in cool conditions, further extending the stratification period. Actual stratification duration that a sowing request obtains is a combination of the standard three week pretreatment plus the time until shipping from the TSC plus the time spent at the nursery until sowing.

Table 5. Germination Capacity (GC) of 26 seedlots with a 24 hour soak [soak]; 24 hour soak plus 3 weeks stratification [3 weeks]; and 24 hour soak plus 6 weeks stratification [6 weeks) and a quantification of dormancy based on the results of 3 weeks stratification divided by the soak treatment..

Seedlot	GC% - soak	GC% - 3 weeks	GC% - 6 weeks	Dormancy
2666	69	70	74	1.01
4073	68	75	76	1.10
4932	84	89	85	1.06
6675*	93	96	95	1.03
6863*	86	92	96	1.07
6866*	95	90	96	0.95
6913*	93	99	94	1.06
6914*	95	94	94	0.99
6915*	92	94	94	1.02
8139	89	87	95	0.98
8565	68	78	71	1.15
8582	87	92	81	1.06
8779	84	82	82	0.98
8782	90	92	90	1.02
8791	69	71	65	1.03
8976	81	86	77	1.06
14501	85	89	90	1.05
25578	54	62	73	1.15
29164	77	85	88	1.10
29170	87	88	90	1.01
30543	95	90	97	0.95
30664	94	96	96	1.02
31117	86	96	92	1.12
31308	94	96	96	1.02
31460	90	95	93	1.06
35075	94	97	96	1.03

Total stratification period for a request can approach six weeks. The extension of stratification at the TSC does not seem necessary for interior spruce due to the dbnirtishing gains obtained and the normal extension of stratification occurring at the TSC and the nurseries. If anyone is interested in extending stratification in interior spruce one can simply move the sowing date forward (allowing seed to sit in stratification at the nursery longer). If you are interested in extending stratification for other species please contact myself for available information on your species of interest.

[1] seed orchard produced seedlot

(continued...)

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David Kolotelo
Tree Seed Centre, Surrey

IMAGINE!

A 350 year old vertical column of fixed carbon (old growth Douglas-fir) situated somewhere on the west coast of Vancouver Island, B.C. Canada.

Near the top of the crown is a cone. In the cone are many seeds, but two in particular, one on the south side, and one on the north side. Southy and Northy, as they are called, are maturing happily during the summer months, although Northy is a bit slower due to the lower temperatures on her side of the cone. In the fall, just prior to natural seed drop, all the cones are harvested and transported to 'the seed centre'. Here the two siblings are subjected to a barrage of physical treatments during which Southy picks up a few scratches. They ultimately become separated (on the basis of density) and spend several lonely years in a bag at -180C.

After release the two are in-unersed in water for 24 hours where Southy's scratches pick up some fungal spores and Northy ahnost drowns. They find each other and spend 3 happy weeks in stratification where Northy recovers somewhat from her watery adventure but Southy spends a lot of her energy fighting off the impending fungal infection. Seed coats swollen and embryos raring to go they are transported to a local nursery and dumped into a seeder hopper just prior to lunch time. Southy is sown right away but Northy is left in the hopper over lunch and partially dries back, much to her dismay.

Once in the greenhouse, Southy finds herself buried a bit deep but germinates quickly anyway. She tries to outgrow the fungus but finds herself in the shade of a structural member. Then, to add insult to injury, she is accidentally ffdimed out because she was growing on the edge of the cavity, even though she was a little larger than the well centered seedling. Northy ends up in a sunny spot in the greenhouse and (luckily) is accidentally single sown. She gern-dnates slowly but manages to catch up to her surrounding peers because of the excellent climate and the fact that her cavity contained an extra portion of slow release ferfflizer, and is situated in an area of increased sprinkler overlap.

Northy is finally part of the crowd when a broken vent spills some cold air on her, causing her apical meristem to initiate a terminal bud. She feels herself gammg in gaining while loosing in height, and unable to change the hormonal balance created. A stroke of luck blows in a green caterpillar which chews off the newly forming bud, thereby releasing the hormonal hold on the closest lateral bud, which immediately flushes, resuming Northy's height growth. By the end of the crop cycle, Northy has made exactly target specifications, while most of her peers are struggling in the overheight category.

Later, during a course on "stocktype selection", an instructor chooses her as an example of genetic superiority...

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B. C. Ministry of Forests

EVENTS

Southern Forest Nursery Association Meeting

July 11-14,1994

For more information contact:
Ronald S. Jenkins
Virginia Dept. of Forestry
PO Box 3758
Charlottesville, VA, USA 22903
Phone: 804-966-7201

Ist International Symposium on Plant Dormancy

(Patterned after the NATO Advanced Research Workshop Series.)

August 4-6, 1994

For more information contact.
Gregory A. Lang
137 Juliean C. Miller Hall
Lousiana State University
Baton Rouge, LA, USA 70803-2120
Phone: 504-388-1043
Fax: 504-388-1068

Joint Meeting of the Western Forest Nursery

Association and the Forest Nursery Association of British Colurnbia

August 15-19,1994

For more information contact.
Kas Dun-Lroese
Forest Research Nursery
University of Idaho
Moscow, ID, USA 83843
Phone: 208-885-7017
Fax: 208-885-6226

Making the Grade - An International Symposium on Planting Stock Performance and Quality Assessment

September 11-15, 1994
Sault Ste. Marie, ON, CAN

For more information contact.-
Tom Noland or Peter Menes
"Making the Grade"
Ontario Forest Research Institute
PO Box 969
1235 Queen Street E.
Sault Ste Marie, ON, CAN P6A 5N5

The Ecology of Agricultural Pests: Biochemical Approaches

September 21-23, 1994

University of Wales College of Cardiff., Wales, LTK.

For more information contact. .
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