

Seed and Seedling Extension Topics

David Trotter — Editor

Welcome to the tenth anniversary edition of the Seed and Seedlings Extension Topics newsletter. Ten years...whew...what changes have we all seen in ten years in the reforestation industry! In 1987-88, it all started with the sweeping changes to forestry legislation shifting almost all silviculture responsibilities to the private sector and the privatization of most of the Ministry nurseries. These changes have continued with major private and public reorganizations and downsizing, the Forest Practices Code, Forest Renewal BC and aboriginal land claims. In the reforestation nursery industry, there has been the move to larger and new container stocktypes (i.e. PSB 410), the almost complete disappearance of bareroot stock, the move to gutter-connect greenhouses, the enhancement of greenhouse computer control systems, better growing regimes for all reforestation species and stocktypes, the move to precision seeding, reductions in sowing and oversow factors, smaller request keys, the shift to A-class or improved seed, better seed upgrading and handling, the almost universal use of blackout systems, automated seedling extraction, the advent of vision grading, better stock-handling, copper pruning as an industry standard for root form in lodgepole pine, increased production for the summer planting program, somatic embryos, native plants and the list goes on.

The first newsletter appeared in August 1988 with Glenn Mathews, the provincial nursery culturist, as its first editor. In his editorial, Glenn identified this new initiative as an informal means of keeping the industry up to date with technical information. He envisioned that “The newsletter will be a vehicle of Extension Services to enhance

communication among nurseries, seed orchards, research agencies, administrators and field staff. It is organized in sections designed to accommodate different levels of interest and available time. The purpose of the newsletter is to disseminate technical information from anyone who would like to contribute.” Over the years, there have been a number of different editors each with their own themes or emphasis. In all, I think we have been successful in trying to reach an ever expanding audience with current and relevant information while continuing to meet the original objectives.

As with all things these days, change is now an integral part of everyone’s life and the same is true for Extension Services. With the decision to create a Tree Improvement Branch in the Ministry of Forests, the Extension Services, the Tree Seed Center and SPAR have been moved from Nursery and Seed Operations Branch to Tree Improvement. This initiative is to better align and provide a coordinated approach to the delivery of enhanced genetic material to all sectors of the forest industry. This has not been an easy transition but we all look forward to expanding our roles in extension to a wider client base while maintaining and enhancing our close ties to the nursery industry. The next ten years are definitely going to see even more surprises so enjoy the ride.

Dave Trotter
Extension Services
Tree Improvement Branch

...The contents of this publication are the sole and exclusive property of the respective authors.
No reproduction in any manner or form is permitted without express written permission. ...

GROWER'S NOTES

Summary of Samples sent to the Forest Seedling Health Clinic May 1, 1997 to March 31, 1998

Overview:

The Forest Seedling Health Clinic (FSHC) received 268 requests from the forest industry. Of these, 54 were from the British Columbia Ministry of Forests (MOF). There were 23 requests from company foresters dealing with plantations. A request may have contained many seedlots, pieces of containers or seedlings treatments, so the actual number of assays performed in the lab is very much higher. Over 53% of the samples dealt with container seedlings and only 6% with bareroot grown stock. Over 13% of the requests were preventative samples dealing with peat, styroblocks, seeds or water. These samples were assayed for potential pathogenic fungi and recommendations were made to nursery personnel on how to eliminate or minimize losses before they had a chance to occur. Over 7% of the samples were from Christmas tree growers who had sent damaged plant tissues to the Christmas Tree Specialist at Green Timbers Reforestation Center for recommendations. These samples were forwarded to the FSHC to rule out the presence of diseases. Just under 5% of the samples came from seed orchards. Spruce and Douglas-fir were the most common tree species sent to the Clinic (20% and 19% respectively). *Abies* species accounted for 17% of the samples reflecting the increase in sowing of these species and the inexperience of nursery personnel in growing it. Lodgepole pine and western redcedar followed with 11% and 10% respectively. Slightly over 5% of the samples were hardwoods (aspen, alder, cottonwood and maple).

As far as age class is concerned 45% of the samples were 1+0 stock, 22% were over 3 years old and 17% were germinants. Over 23% of the seedling samples had unspecified damage to the whole plant. Over 29% of the samples had specifically foliage damage, 28% had general shoot/bud damage and 11% had root damage. Seed accounted for 7% of the tissue type damaged.

Fusarium disease, either seed infection, damping-off, shoot blight or root rot accounted for 24% of all the samples sent. Grey Mould (*Botrytis*) occurred on 12% and *Sirococcus* Blight on 3% of the samples. The root infecting

fungus, *Pythium*, was found in 10% of the samples and *Cylindrocarpon*, was isolated 8% of the time.

Two workshops on disease recognition and identification of the causal pathogenic fungi were presented at the "Tree Seedling Health Management Course". Response from nursery personnel attending the course was very positive. Four presentations were also given at meetings. One was a lecture given to the Canadian Food Inspection Agency (CFIA - formerly Agriculture Canada) inspectors on recognition of diseases in forest nurseries. This was to aid in the export and import to B. C. of healthy stock and determine the need for quarantines or restriction of plant movements. Another presentation was made at the meeting of the Pacific Northwest forest nursery pathologist's meeting in Oregon. The talk presented a summary of pest problems encountered in 1997 and promoted an exchange of ideas on disease control methods. The third presentation delivered results of a joint MOF/CFS seed experiment to the MOF Tree Seed Center and encouraged discussions on developing techniques for improving the quality of seed delivered to nurseries. The fourth presentation was given to the Horticulture/Forestry class from Kwantlen University College. This lecture was on the forest industry and what role the FSHC plays in supporting forest sustainability. Examples of some of the disease identification techniques was also demonstrated at the Pacific Forestry Centre laboratory.

Visits to most of the nurseries were made during the months of September, October and November before crops were harvested and inclement weather made it impossible to travel. This period is also a time when late season diseases such as root rots and foliage blights affect what seedlings are put into storage and have the ultimate effect on the ability of nurseries to meet seedling requests. There were also special visits to nursery sites where specific problems needed to be sampled, assessed and disease control recommendations made.

(Continued)

Unique occurrences

There were several unique findings during the 1997-8 time period. Diplodia Blight (*Sphaeropsis sapinea*) occurred on bareroot lodgepole pine. Records kept since 1984 indicate that this is the first time this has occurred on B. C. grown nursery stock. Expression of the disease usually occurs after heat or drought stress which happened this year when weather changed rapidly from cool and overcast to hot and sunny. It remains to be seen whether this will be a single year disease event or whether the disease will become chronic. Careful monitoring of future crops should continue.

One nursery site sent western larch seedlings to be checked for *Meria laricis* (larch needle cast). None was found and the problem appeared to be *Fusarium* hypocotyl rot with *Sclerophoma* coming in afterwards. However, *Sirococcus conigenus* was found on several germinants. Although *Sirococcus* was isolated from seed by the FSHC in two seedlots of western larch in 1994, this is the first time this fungus has been recorded on western larch seedlings. Since then, Applied Forest Science has isolated *Sirococcus* from several other western larch seeds during routine assays.

Rhizoctonia damping-off occurred at two nurseries this year. It was found at one nursery for the first time and affected lodgepole pine grown in containers previously used for growing yew cuttings. The yew had exhibited crown rot which may have been the source of the *Rhizoctonia*. Uneven sanitation of the containers with sodium metabisulfite may have allowed the disease to survive between crops. *Rhizoctonia* was also identified for the second time on Douglas-fir. The previous occurrences were on interior Douglas-fir and lodgepole pine on the same site. Initially, the source of inoculum was determined to be a poinsettia crop infected with *Rhizoctonia* crown rot. Poor sanitation due to harsh winter conditions allowed the fungus to remain viable and attack a subsequent pine crop. This pathogen appears to be present on this site and causes damping off in the germination growth phase. It does not appear to persist into the later phase of growth. It may be necessary to monitor early losses in order to determine *Rhizoctonia*'s disease potential and importance.

Damping-off

Damping-off appeared to be significant this spring. *Sirococcus* on spruce and *Fusarium* on both spruce and *Abies* were the dominant causal fungi. Both of these fungi can be seed-borne and many of the incidents were related

to contaminated seeds. The MOF Tree Seed Center contracts to Applied Forest Science to assay seeds in storage for these pathogens and this has helped identify problem seedlots. Nurseries can then modify seed handling techniques to reduce expression of these disease.

Several nurseries sent samples of germinants that appeared to have radicals became desiccated from growing laterally or upwards rather than into the media. No pathogenic cause was found in these samples and one nursery determined that the problem was excessive styroblock manipulation after sowing. This caused the seed to migrate into the covering grit layer and produced aerial pruning of the radicals before it could find its way to the moist media.

Root Rot

There were several instances of *Pythium* root rot with lodgepole pine, spruce, Douglas-fir and yellow cedar being affected. The lodgepole pine were both container and bareroot with the bareroot problem being significant enough for one nursery to cease growing this stock type. One bareroot nursery had problems with *Pythium* as well as *Fusarium* after using Busan rather than methyl bromide for soil fumigation. In a 2+0 lodgepole pine crop, root disease was patchy, as if fumigation was not applied uniformly. This was also the case when pathogen assays were done on recently Busan treated beds which will be sown in spring of 1998. Additional samples on a grid were taken of these beds to see if any pattern related to chemical application of Busan could be found and a warning to the nursery that there is a potential for losses to the crop sown in this field.

Spruce *Pythium* problems at one site were related to excess irrigation on part of the crop to maintain an adequate level of cavity moisture in containers which were drying out rapidly. This upset the wet/dry cycle on the rest of the crop and led to root disease. The *Pythium* was unusual in its growth pattern on laboratory media making it difficult to identify it compared to many other fungi. It also showed up in styroblock container pathogen assays before and after sanitizing treatments. This indicated cleaning methods were not adequate and led to an assessment of chemical (sodium metabisulfite) and steam cleaning equipment and techniques. It was found that the chemical concentrations became extremely low after dipping wet styroblocks into solution for less than 1 hour. Steam treatments reduced levels of

(Continued)

pathogens, but did not totally eliminate them. After having chronic problems with root rots, the nursery was keen on testing various methods to eliminate potential carry-over of the pathogens. The Seedling Health Clinic was instrumental in choosing the most efficient methods for cleaning styroblocks.

Late season root rot syndrome was identified in crops this year. Classic symptoms of small buds, thick lower stem and dark roots were noted in two coastal Douglas-fir crops, two interior Douglas-fir crops and one lodgepole pine crop. Root and growing media isolations produced *Fusarium* and *Cylindrocarpon*. Heat stress early in the season predisposed the crops to these fungi. This is unusual in lodgepole pine, so pot studies were initiated to see if the seedling roots would commence root activity. More relevant may be that several samples were received which, during adjudication, were considered to have this root problem. Poor summer weather made severe drought stress methods necessary for shutting down shoot growth. This caused darkened roots and the superficial appearance of the disease. Fortunately for the nurseries involved, laboratory results helped prevent these crops from being rejected.

Two container seedling trials conducted at Green Timbers Reforestation Center were assayed for root pathogens. One trial was using Nutrifor (sewage sludge) as a container amendment. Clinic results indicated that concentrations above 25% increased *Fusarium* and *Cylindrocarpon* in the plugs. The second trial was a container design test on the new plastic air pruning blocks done at the Green Timbers Reforestation Center. Root assessments for pathogens were done by the FSHC to determine negative effects by these new containers. *Botrytis*, normally shoot inhabiting fungus, and *Phoma* were found in roots of several treatments. It is not considered a pathogen. However, it predominates in situations where there are drought or heat stress conditions. It may be worth noting that some of these container treatments may be undergoing these stresses.

Shoot Blights

Botrytis continued to plague nursery growers this fall. Poor spring and summer weather caused late sowing of certain crops, specifically western hemlock and western redcedar. This promoted the use of high fertilization and delayed dormancy induction in the fall and winter, allowing the *Botrytis* to infect succulent tissues. Western redcedar

is susceptible to grey mould and several crops exhibited losses. *Botrytis* problems also occurred on high genetic value potted spruce at Mesachie lake. Several laboratory assays on *Botrytis* isolates from nurseries were done to determine fungicide resistance and to assist MOF personnel in making recommendations on which fungicide to apply. Isolates were shown to be resistant to the fungicide benomyl. Unfortunately this has caused greater use of the fungicide ipridione as an alternative to the benomyl. Frequent use is likely to produce resistance to ipridione similar to what has happened on other crops in Europe. Fungicide resistance laboratory assays also were requested for *Rosellinia* on spruce and *Phomopsis* on yellow cedar. No resistance in the fungi were found.

At one nursery site fir seedlings became infected with *Botrytis* when put in the same greenhouse as a *Botrytis* diseased western hemlock. This was also the case with *Rosellinia* which infected western hemlock for the first time. The hemlock had been in the same greenhouse as a *Rosellinia* infected spruce crop. Recommendations for preventing disease transfer and spread were given to these nurseries.

There was only one incident of stem girdling of lodgepole pine by *Sirococcus* this last fall. It appears that work done on this problem is preventing the problem which occurs on pine with artificially induced secondary or primary needles.

There was also only one incident of western redcedar with *Keithia* blight (*Didymascella thujina*). However, it may have been a very important sample because the nursery was receiving trees infected with the disease from another nursery. This can be a poor practice and provided evidence that the stock should not be accepted on the site which current did not have this disease.

Several hardwood samples were sent to the FSHC for disease assessment. Aspen shoots were found to have very long splits in the stems. No definite diagnosis could be made on the cause of these splits, but *Lygus* bug damage or some environmental conditions produce symptoms such as these. The leaf rust fungus *Melampsorium hiratusukanum* was found on alder leaves at one nursery. This is a rare occurrence and produced great interest from mycologists and pathologist at the Pacific Forestry Centre. Follow up studies to examine this disease are being considered.

(Continued)

Following is a tabulated summary of all samples received at the Forest Seedling Health Clinic from May 1, 1997 to March 20, 1998.

**Tabular Summary of Forest Seedling Health Clinic Reports
For the period May 1, 1997 to March 31, 1998.**

Total samples 268 samples

BCMF samples 54 samples

Number of samples by type: Preventative assays:

container -	143	container mix/peat -	5
bareroot -	16	bareroot soil -	3
plantation -	23	styroblocks -	7
Christmas tree -	20	water -	4
Seed Orchard -	12		
stool bed -	2		

Number of samples by tree species:

spruce -	38	black spruce -	3
Sitka spruce -	1	lodgepole pine -	24
jack pine -	4	yellow pine -	3
coastal Douglas-fir -	23	interior Douglas-fir -	17
western hemlock -	9	mountain hemlock -	1
western redcedar -	20	yellow cedar -	8
<i>Abies</i> species -	35	western larch -	11
yew -	2	aspen -	5
alder -	4	maple -	1
Cottonwood	1		

Insects

Total: 19 samples

aphids	5	weevils	2
fungus gnats	3	cutworms	1
budworms	1	orange	
willow sawfly	1	tortrix	1
bark beetles	4	<i>Lygus</i>	1

Samples sent in by Month:

May	24	
June	38	
July	26	
August	22	
September	41	
October	32	
November	14	
December	19	
January		10
February	19	
March		23 (as of March 20 th)

Number of samples by age:

0.5+0.5	- 3	2+1	- 1
1+0	-84	2+2	- 1
1+1	- 4	3	- 3
1p+1	- 1	3+	-42
2+0	-16	germ	-32

Number of samples by damage:

whole plant	-53	cone	- 1
foliage	-66	hypocotyl	- 2
roots	-24	seed	-16
shoots	-59	bud	- 5

Number of Samples with the following diseases:

<i>Acremonium</i>	1	<i>Phomopsis</i>	4
<i>Botrytis</i>	31	<i>Pythium</i>	28
<i>Cyclaneusma</i>	1	<i>Rhabdocline</i>	4
<i>Cytospora</i>	2	<i>Rhizoctonia</i>	2
<i>Cylindrocarpon</i>	22	<i>Rhizosphaera</i>	1
<i>Fusarium</i>	65	<i>Rosellinia</i>	2
<i>Hormonema</i>	2	<i>Sclerophoma</i>	5
<i>Kabatina</i>	1	<i>Sirococcus</i>	7
<i>Lophodermella</i>	1	<i>Sphaeropsis (Diplodia)</i>	2
<i>Meria</i>	2	<i>Verticillium</i>	5
<i>Phaeocryptopus</i>	1	felt blights snow moulds	0
<i>Phoma</i>	34	<i>Pestalotiopsis</i>	1
<i>Keithia</i>	1		

John Dennis

Canadian Forest Service
Pacific Forestry Centre

Extended Nursery Growing Impacts on Field Performance of Container Reared Conifer Seedlings

Various studies at the Atlantic Forestry Centre of the Canadian Forest Service in Fredericton, New Brunswick have shown that there is very little relationship between seedling root weight at outplanting and first season field root growth. A fairly tight inverse relationship was found between root density (mg root/ cm³ soil) at shipping and field root growth; plugs that are most densely packed with roots produce less root growth after outplanting. Root regeneration capacity testing of seedling lots is generally accepted as a major indicator of stock quality and subsequent field performance. First season root growth (seedlings excavated and destructively sampled) can be thought of as a very extended root regeneration capacity test. Our experience with field tests, regarding the relative importance of various nursery seedling characteristics relative to stock quality, supports that of Bernier *et al.* (1995).

Recently there has been a general trend among seedling purchasers to demand larger container stock. There are two main avenues for producing larger stock: 1) the use of containers with larger plug volumes which accommodate longer rearing regimes without exceeding cavity capacity or 2) the use of existing containers with longer rearing regimes. Containers with larger cavities support lower numbers of seedlings per square metre of rearing area and both regimes incur more expense because of extended nursery residence time. The experiments described here were designed to test the efficacy of these two approaches for producing larger stock.

Hardwall

White spruce winter greenhouse crops were started in STYROBLOCK/ 415 D (large cavity), IPL/ 45-90 (medium cavity) and Can Am/ 67 (small cavity) containers in January, February, and March of 1994, respectively. For comparison, a summer crop in IPL/ 45-90 was started in May. Winter crops were hardened off outside and half of the seedlings ("short keep") were planted in July; the remaining half ("long keep") were allowed to continue growing in the nursery until October when they were frozen stored. Summer crop white spruce were hardened off in the greenhouse and then frozen stored in December. Frozen seedlings were thawed and field planted the following May.

Larger cavity sizes allowed longer nursery rearing without overgrowing the container capacity and produced larger seedlings for outplanting (Fig. 1). At the conclusion of several field seasons (four for "short keep" seedlings and three for "long keep" seedlings), the original size advantage of seedlings from the larger cavities at planting was still obvious within both "short keep" and "long keep" seedling groups. However, the larger "long keep" seedlings from each container type, which had somewhat lower height:diameter ratios and considerably lower shoot:root ratios than their "short keep" counterparts at planting, had consistently lost their planted size advantage in the field (Fig. 1). Four expensive months of extended nursery rearing, designed to achieve larger, sturdier seedlings, had produced a field growth disadvantage.

Summer-reared seedlings (frozen 12/94), which had intermediate size and moderately high shoot:root ratios at outplanting, outperformed their "overgrown", root-bound May-planted counterparts. Similar results, to these with white spruce, were obtained with red spruce and white pine reared in the three sizes of hardwall containers.

(Continued)

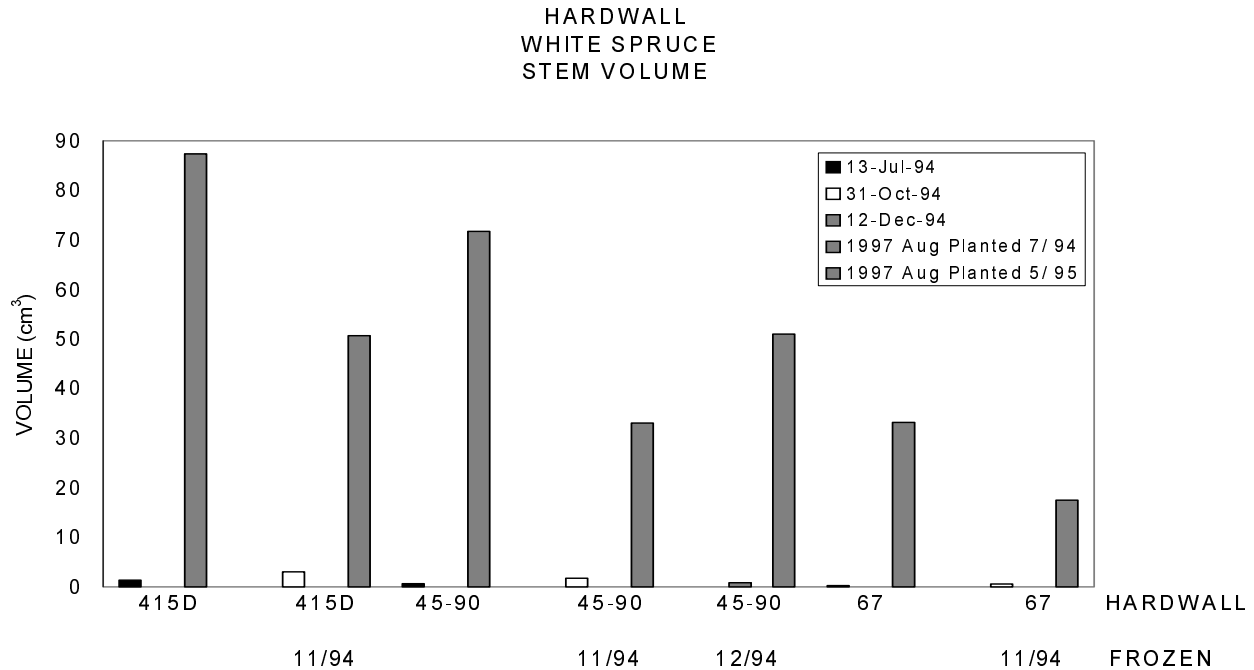


Figure 1. Seedling volumes of hardwall container-reared white spruce at planting and after several field seasons

Jiffy

The same experimental design as that for hardwall containers was carried out with white spruce grown in mesh-covered JIFFY systems. Large (70), medium (96) and small plugs (140) were started in January, February, and March of 1994, respectively. “Short keep” seedlings, reared as winter crops and submitted to a short hardening period before outplanting, were very sparsely interrooted and did not require cutting to separate individual plugs from each other. “Long keep” seedlings, that had spent several months growing in the nursery after setting bud in late summer, had firmly interrooted soil plugs that had to be cut in two directions in order to separate individual seedlings from each other. There are two sets of “long keep” seedlings for each of the JIFFY plug sizes (Fig. 2), comparing root cutting in early fall (1/9/94) and in late fall, just before freezer storage (26/10/94). This comparison was done to determine whether root wound healing, after early cutting and well in advance of freezer storage, would be beneficial; there did not appear to be any advantage to early root cutting for white spruce.

Results with JIFFY were similar to those with hardwall containers. The larger “long keep” seedlings, with much lower shoot:root ratios than their “short keep” counterparts, had consistently lost their planted size advantage in the field (Fig. 2).

Figure 2. Seedling volumes of JIFFY-reared white spruce at planting and after several field seasons.

Summer reared-seedlings (frozen 12/94), which also required root cutting after a prolonged growing period following bud formation, did not display a field growth advantage compared to their “overgrown” May-planted “long keep” counterparts. Similar results, to these with white spruce, were obtained with red spruce and white pine reared in the three sizes of JIFFY plugs.

Recommendations:

There is a field growth advantage to using larger seedlings for outplanting when these larger seedlings are produced in larger non root-bound soil plugs. However, producing large seedlings by prolonged nursery rearing regimes is counterproductive, despite achieving sizes specified by seedling purchasers.

(Continued)

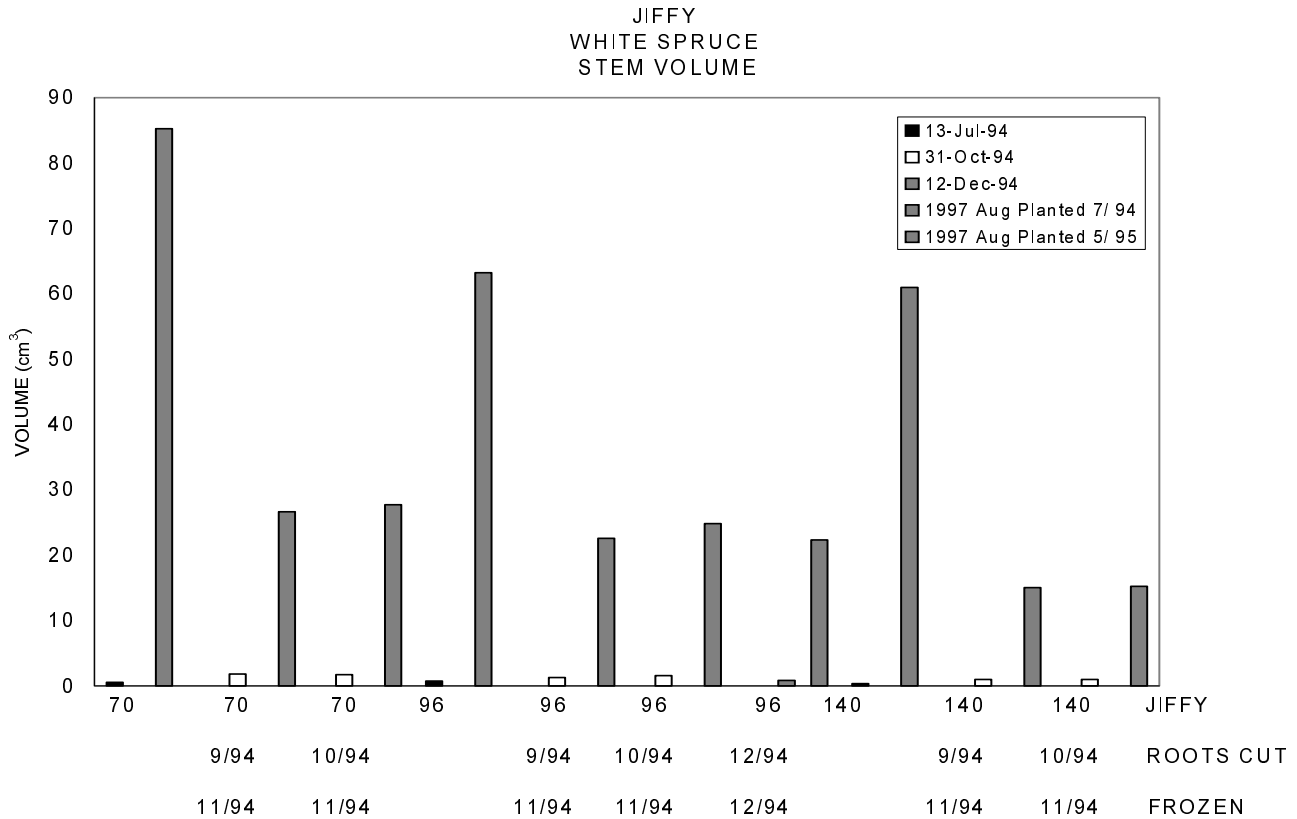


Figure 2. Seedling volumes of JIFFY reared white spruce at planting and after several field seasons.

Hardwall container rearing regimes should be designed to produce seedlings for shipping when root growth is just sufficient to hold the soil plug together for extraction after the hardening period.

JIFFY rearing schedules should be designed so that minimal interrooting between plugs has occurred and seedlings can be shipped without cutting after hardening off. Seedling stature and sturdiness are better achieved by the growth of vigorous “non overgrown” seedlings in the field rather than by extended growth in the confines of the container root plug.

Reference:

Bernier, P.Y., M.S. Lamhamedi, and D.G. Simpson. 1995. Shoot:root ratio is of limited use in evaluating the quality of container conifer stock. *Tree Planters' Notes* 46(3): 102-106.

*Peter Salonijs
Ron Hallet
Calvin French*

*Kathy Beaton
Blair Roze
Joe Lewis*

*Canadian Forest Service
Atlantic Forestry Centre*

1997 Cone Crop Summary

The following is a summary of the 1997 seed orchard production results from all producers for both the coast and the interior. Seed yields are based on actual extraction results from the Tree Seed Centre. Further seedlot details are available on SPAR. Overall, it was a light crop year generally due to cool moist weather during bud initiation. Also, there was a large interior spruce crop in 1996, so it was not surprising that there was not a spruce crop in 1997. All of the seed orchards in the province produced enough seed to provide 11.6 million plantables. The 1998 crop is also expected to be light due to weather conditions with an expected crop for all agencies of around 16 million plantables.

However, the weather conditions in 1998 have been good for bud initiation and so a bumper crop is expected in 1999. So agencies are being advised to exercise caution when planning a natural stand cone collection if they operate within a seed zone that has seed orchard seed being produced. If there are any questions on this or other seed related issues, please contact David Reid or Ron Planden at (250) 652-5600.

*Dave Reid
Ron Planden
BC Ministry of Forests*

1997 Interior Seed Orchard Cone Crop Summary

Agency Owner	Orch. #	Location	Species	SPZ	Seedlot	Cones Collected (H)	Est. Yield (kg)	Actual Yield (kg)	Potential Seedlings
MoF	609	Skimikin	PW*	SA / VK / Mc / EK	42133	34.0		17.225	291.9
MoF	607	Skimikin	PW*	SA / VK / Mc / EK	42132	9.2		7.339	132.0
MoF	230	Kalamalka	Pli	NST	60282	29.4		11.348	1,247.1
MoF	307	Kalamalka	Pli	SA	60283	21.2		3.015	342.0
MoF	203	PGTIS	Pli	MGRMRB, Q, C T, NCH	60211	5.2		1.816	222.1
MoF	203	PGTIS	Pli	MGRMRB, Q, C T, NCH	60213	2.8	0.7		61.8
MoF	228	PGTIS	Pli	BLK	60214	2.8		0.994	104.8
MoF	201	PGTIS	Pli	CP, FIN	60212	33.5		16.847	1,888.8
Sub-Total Ministry Orchards						138.1	0.7	58.6	4,290.5
Private Orchards									
Weyerhaeuser	308	Grandview	Pli	TOA	60403	30.9		11.053	1,229.4
Riverside	310	Eagle Rock	Pli	TOA / TCD	60137	15.0		1.969	240.0
Sub-Total Private Orchards						45.9		13.022	1,469.4
Total All Interior Orchards						184.0	0.7	71.6	5,759.9
Total All Lodgepole Pine Orchards						140.8	0.7	47.0	5,336.0

* currently categorized as "B" seed

Tree Seed Centre estimates are in bold, other data are averaged estimates

1997 Coastal Seed Orchards Cone Crop Summary By Agency

Agency	Orch.	Location	Species	SPZ	Seedlot	Cones Collected (HI)	Actual Yield (kg)	Est. Yield (kg)	Potential Seedlings (000's)*
Ministry of Forests	120	Saanich	Fdc	Sm	60386	28.8	5.91		167.7
Ministry of Forests	120	Saanich	Fdc	Sm	60387	51.0	9.78		263.8
Ministry of Forests	146	Surrey	Fdc	Sm	60385	16.8	4.16		106.6
Ministry of Forests	149	Bowser	Fdc	M	60373	54.6	8.13		329.1
Sub-total Ministry Orchards						151.2	27.98	0.00	867.2
Private Orchards:									
MacMillian Bloedel	137	Yellow Point	Cy	SM M	60340	2.9		0.87	25.4
	132	Yellow Point	Hw	M	60338	7.4	4.30		528.3
	139	Yellow Point	Cw	M	60339	1.3	0.31		29.1
Canadian Forest Products	133	Sechelt	Hw	M	60624	0.7	0.54		71.2
	133	Sechelt	Hw	M	60625	0.8	0.35		45.3
Western Forest Products	128	Lost Lake	Cw	M	60381	9.1	0.41		83.4
	128	Lost Lake	Cw	M	60382	0.7	0.02		2.0
	126	Lost Lake	Hw	M	60383	0.1		0.07	10.8
	127	Lost Lake	Hw	M	60608	1.1	0.38		33.1
	127	Lost Lake	Hw	M	60609	0.3	0.15		14.1
	156	Lost Lake	Hw	M	60610	0.4	0.20		23.4
	142	Lost Lake	Ss	M	60611	1.3	0.76		92.1
	155	Lost Lake	Cw	M	60384	4.6	0.13		25.6
Western Forest Products	171	Saanichton	Cw	M	60346	8.4	2.85		366.8
	165	Saanichton	Hw	M	60345	5.0	4.85		747.9
	121	Sannichton	Fdc	M	60344	93.3	29.07		1,060.4
	166	Saanichton	Fdc	M	60343	37.9	10.74		330.7
	169	Saanichton	Fdc	M	60316	6.6	1.12		34.0
Timberwest Forest Ltd.	134	Mt. Newton	Fdc	M	60630	62.0	10.65		309.5
	134	Mt. Newton	Fdc	M	60631	16.3	2.46		66.2
	154	Mt. Newton	Fdc	M	60632	29.7	6.15		129.7
	154	Mt. Newton	Fdc	M	60633	67.0	15.70		450.9
	152	Mt. Newton	Cw	M	60634	18.2	2.62		405.8
	138	Mt. Newton	Yc	M	60635	4.80		0.03	0.8
Sub-total Private orchards:						379.90	93.75	0.97	4,886.4
Total all Coastal orchards:						531.10	121.72	0.97	5,753.6

*= seed centre estimates are in bold, other data are averaged estimates

TECH TALK

Leptoglossus and Low Seedset in Southern Pli Seed Orchards

Seedset in southern interior lodgepole pine (Pli) seed orchards has historically been lower than in natural stands or northern Pli orchards. The latter two categories usually average between 18 and 26 filled seeds per cone (FSPC), while in the southern Pli orchards FSPC has ranged from 1.7 to 13.2, with an average of 6.5. In spite of much work, this problem has remained unresolved. In a 1996 pollination experiment (M. Stoehr, C. Hollefreund, D. Harrison, and R. Painter; BC Forest Service) mesh insect bags were placed over some cones in each treatment, while other cones were left unprotected. The bagged cones averaged 15.9 FSPC as opposed to 6.7 in the unprotected cones, suggesting that an insect, possibly *Leptoglossus occidentalis* (the western conifer seedbug), was responsible for the poor seedset.

L. occidentalis is known to deplete seed in Douglas-fir, ponderosa pine, and white pine seed orchards. A related species, *L. corculus*, reduces seedset in Loblolly pine in the southeastern United States. However, seedset in southern Pli orchards in BC has been consistently low despite varying densities of *L. occidentalis*. Also, *L. occidentalis* are found in natural stands of lodgepole pine. Furthermore, the bags in the 1996 experiment might have changed the microclimate around the cones in such a way that seed development was favoured (e.g., changing the humidity or cone temperature).

In 1997 Stoehr et al. repeated their experiment. In conjunction with this, we conducted a bagging study to determine if *L. occidentalis* exclusion or a "bag effect" was responsible for the increased seedset in bagged cones.

Leptoglossus experiment methods:

On each of 10 trees in Orchard 307 (SA Pli), 6 south-facing branches with 3-5 cones each were selected. On each branch, one of the following treatments was applied in late May:

1. **Control** — no bag. The cones were left exposed as per normal orchard management.
2. **Insect exclusion bag.** A 30 x 60 cm bag of insect mesh (similar to the bags used in 1996) was tied off

tightly over the branch, enclosing cones to exclude insects.

3. **Seedbug inclusion bag.** An insect bag was placed as above but with a single mated female *L. occidentalis* enclosed. She and her offspring were kept alive or replaced as necessary through the summer. Up to 14 nymphs were produced in each bag. This treatment was designed to indicate whether high densities of *L. occidentalis* (one family per 3-5 cones) would reduce seedset.
4. **Open bag.** An insect bag was installed as in the exclusion treatment, but not tied off tightly, and several slits and right-angle tears were made in the bag. This treatment was designed to distinguish between the bag effect and an insect effect. Changes in microclimate presumably would be similar in open and exclusion bags, but insects could enter the open bag.
5. **Sun bag.** An insect bag with a 20 x 40 cm panel of netting on one side replaced with a panel of clear flexible plastic was placed as in the exclusion treatment. This allowed full sunlight to shine on the cones, but excluded insects. This was designed to test if seedset is reduced by direct sunlight and consequent cone heating.
6. **Parasol.** A 25 x 50 cm brown paper bag with one side removed was tied open side down over the branch, forming a sort of hood. This was meant to keep direct sunlight out (without changing the microclimate in other ways) but allow free access to the cones by insects. This was also designed to test the effect of direct sunlight.

Temperature probes were installed in one cone in each treatment of one tree. Cone temperatures, bag condition, and *L. occidentalis* survival in inclusion bags were checked once or twice weekly until cone harvest.

Cones were harvested in mid August 1997 and air dried in mesh bags. Seeds were extracted by dunking in boiling water, oven drying for 10 hours at 45 °C, shaking,
(Continued)

soaking in cold water, oven drying again, and shaking again. They were then X-rayed to determine the numbers of filled versus empty seeds. Results were analyzed by ANOVA with the following transformations: untransformed (total seed per cone); $\log(x+1)$ (filled seed per cone), or $\arcsine(x^{-2})$ (percent filled seed). Means were separated with Fisher's LSD at $P = 0.05$.

Results

There were several surprises during the course of the experiment. The parasols were prone to wind disturbance and rain, and were replaced with waterproof bags tied in a windproof way. Yellow-jacket wasps then discovered them and chewed off layers of paper to build their nests. The chewing could be heard from a distance of several meters and soon thin areas and holes appeared in the bags, necessitating their replacement. The plastic pane in the sun bag was frequently fogged with condensation, making it less transparent and indicating an increase in humidity. Mortality of *L. occidentalis* in the inclusion bags was considerable and much time was spent scouring the orchards to conscript live replacements of the correct growth stage. Finally, spittlebugs (*Aphrophora* species) showed up in nearly every bag and needed to be removed.

Nonetheless, the final results were conclusive. Total seeds per cone (filled + empty) were lower when *L. occidentalis* were enclosed with cones, while the other treatments (including controls) had about the same numbers of total seeds per cone (Fig 1a). This indicated that while *L. occidentalis* are capable of affecting the total number of seeds, they don't at the early-season population densities found in 1997.

Both FSPC and percent filled seed were very low in the *L. occidentalis* inclusion treatment (Figs 1b, c). Most seeds in these cones were empty. The insect exclusion and sun bags had the highest FSPC counts, at 28-31 FSPC and up to 71% filled seed. This reflected the results of the 1996 experiment. The similarity between these two 1997 treatments indicated that microclimate differences (due to the clear pane) were unimportant, but rather that insect exclusion was important. These treatments suggest a possible upper limit for seed production at this site.

Between these high and low seedset extremes were the control, open bag and parasol treatments, which all had similar FSPC counts (8 - 11) and percent filled seed (25 -

29%). The FSPC in the controls was the highest ever observed at Kalamalka Seed Orchards, but still substantially below natural stand or insect-exclusion treatment averages. Under the parasols the airflow seemed restricted and the air felt warmer than ambient, suggesting that they changed the microclimate somewhat, but FSPC was still similar to the controls. Open bags, which presumably would have a microclimate similar to exclusion bags, had almost the same FSPC counts as the controls. Results from the two treatments which affected microclimate, but allowed insect access, support the notion that insects are the reason for the low seedset, rather than microclimate change.

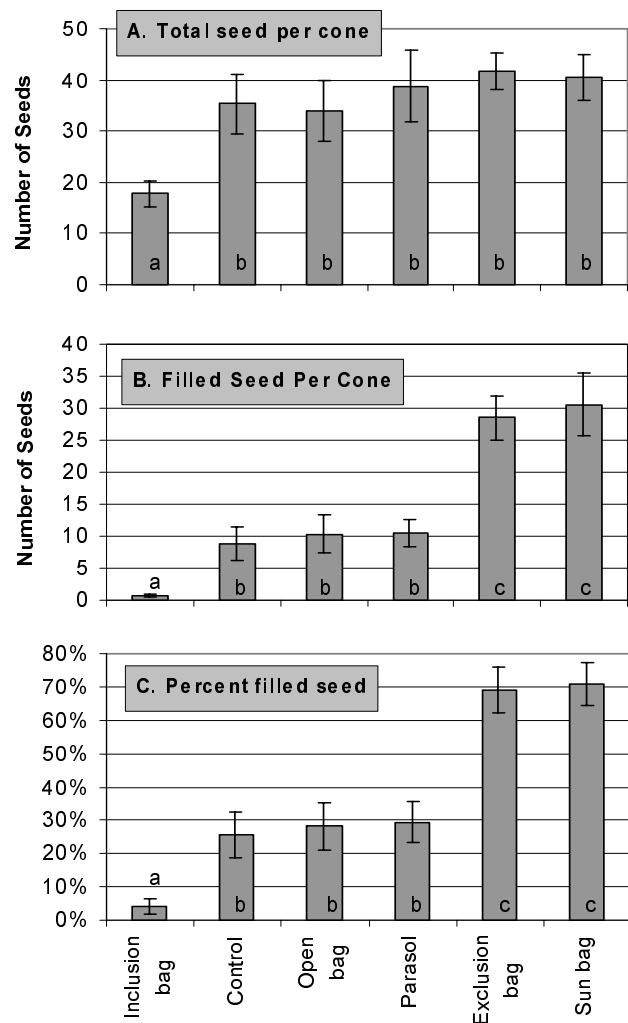


Figure 1. Mean seed counts with standard error bars from each treatment. Columns with the same letter are not significantly different (Fisher's LSD, $P=0.05$).

(Continued)

However, we never observed *L. occidentalis* feeding on cones in the open bags, while they were occasionally found on the control cones. The bag openings were not large, and it seems unlikely that a seedbug landing on a bag would remain long enough to find the opening, and even more unlikely that it would then find its way back out before we checked the bag. We can't think of another insect which might have caused the seedset reduction, and observed none except spittlebugs, but it is possible that *L. occidentalis* is not acting alone. Since spittlebugs were observed in almost all 60 bags, they are not likely to be the cause, although other evidence suggests that they may reduce seedset and filled seed viability.

Other circumstantial evidence indicated that *L. occidentalis* are likely the cause of low seedset. Deflated seeds, which are concave like rugby balls with all the air sucked out, were observed by Stoehr et al. in seed from unbagged treatments, but rarely in insect-exclusion bags. We found that deflated seeds were frequent in the inclusion treatment, common in the control, open bag, and parasol treatments, and rare in the exclusion treatments. This damage may result from feeding by late-instar nymphs in late June and early July, when the seed coat is fully formed but not yet hard, as has been observed in *L. occidentalis* feeding on Douglas-fir seeds by S. Bates (Simon Fraser University).

Probably the rate of feeding by *L. occidentalis* is low in the early season, increases as the nymphs hatch and begin to grow, and declines before harvest as the nymphs mature and fly away. Early season feeding may result in aborted seeds, lowering total seed count. This could explain the similar total seed between all treatments but the inclusion bags, which did have high early season feeding rates. Increased feeding later in the season would affect FSPC, but not total seed (feeding after the seed coat hardens would result in normal appearing seed with shriveled contents).

When X-rayed, the empty undeflated seed from different treatments showed different characteristics. Empty seeds from insect exclusion treatments contained only the shriveled, membranous remnants of the megagametophyte. In treatments which allowed insect access, similar damage was noted but also some empty seeds contained milky residues, or portions of the otherwise intact megagametophyte tissue were dissolved. This

indicated partial feeding on seed contents by seedbugs. More of these partially-filled seeds were found in the inclusion bags than in the control, open bag, and parasol treatments.

One of us (WS) microscopically examined about 1,400 mature, empty seeds from unbagged cones which were not part of this study. Tiny holes (approx. 50 μm diameter, about the same diameter as the feeding stylet of *L. occidentalis*) were found on seven seeds. Perhaps these seeds are examples of late season feeding by *Leptoglossus*.

Derek Harrison (BC Forest Service) managed to decapitate several feeding adult *L. occidentalis* with their stylets (mouthparts) still inserted into the pine cones. He then sliced the cones along the length of the stylet to find where the stylets ended. In all cases, they ended near or next to a developing seed. Since the *L. occidentalis* were observed to pull out a little before the final blow, the stylet may have been inserted directly into the seed before decapitation.

Conclusions

It seems clear that *L. occidentalis* is responsible for causing the low seedset in BC's southern Pli seed orchards. This agrees with American studies on other conifers, including loblolly, Ponderosa, and white pines as well as Douglas-fir. This is the first critical examination made of the circumstantial evidence linking *L. occidentalis* with Pli seed damage.

What remains now is to determine how to a) monitor *L. occidentalis* population levels, b) relate population levels to damage potential, and c) control them. In many seed orchards in the US, broad-spectrum pesticides are applied to control *L. occidentalis* when a cone crop is being managed. For many reasons, such broadcast applications are undesirable. We are currently planning a trial of soil applications of systemic insecticides for *Leptoglossus* control. If successful, insecticides could eventually be applied in relatively small quantities through the drip irrigation system (reducing the hazard to workers and the environment) and only target insects will be killed (beneficial insects and other organisms will not be harmed).

Ward Strong
Robb Bennett
Gerald Hales

BC Ministry of Forests

CO₂ Enrichment for One Month Applied Three Months after an Early Winter Germination in a Greenhouse can Result in Faster Growth of Some Conifer Species

INTRODUCTION

Carbon dioxide enrichment has become a standard procedure in the B.C. greenhouse vegetable industry, with increases in yield from 35% to 50% with CO₂ levels at 1000ppm^{1,2}. While not used extensively with B.C. greenhouse forest seedlings, studies on pine and spruce species have shown that the time from seeding to transplanting can be reduced by 20%, and plant weight can be increased by as much as 50%^{3,4,5} when these trees are enriched with CO₂. Work done by EcoTech Research and Development with Nursery Extension Services tested four conifer species (Lodgepole pine, Douglas-fir, Interior spruce, and Western Red cedar) planted in late March by growing the seedlings under 0%, 25%, 50% and 75% shade, and testing monthly for photosynthetic rate, shoot and root dry mass, caliper thickness, and branching on a monthly basis⁶. Trees of all species showed higher photosynthetic rates in the third month after germination, as compared to photosynthetic rates during the rest of the growing season⁶. A similar increase over the first 60 days of a 120 day period was observed in Engelmann spruce (*Picea engelmannii*) grown under 1000ppm CO₂^{4,5}. Another study observed the same pattern in Black spruce, White spruce (*Picea glauca*), and Jack pine (*Pinus banksiana*) when the trees were supplemented with 700ppm for 16 weeks⁷. These results published in the scientific literature and the results of last year's work at Nursery Extension Services indicate that conifer seedlings have an "enrichment window" in their development starting three months and ending four months after germination during which they are super-responsive to any addition of CO₂ in their environment.

Another interesting result of last year's project was that the 25% shaded trees of all species showed 100-200% higher rates of photosynthesis per ppm CO₂ enrichment in the third month after germination, as compared to the unshaded trees of the same species. Even though the trees were grown at ambient CO₂ levels, the shaded trees that had exhibited higher rates of photosynthesis showed larger leaf areas, thicker root collars, and more branching in the third and early fourth month, as compared to the unshaded trees. An early-season photosynthesis rate increase followed by increases in physical measurements in shaded trees is

consistent with a previously observed pattern in Black spruce (*Picea mariana*) where it was observed that seedlings which had germinated in early February (i.e. in a natural low light condition) responded to an environment enriched with 1000ppm CO₂ during 3 weeks in late April-early May (approximately 3 months after germination), with 30% more dry mass (measured at the end of the growing season) than trees enriched in March or August⁸. Some trees may be more responsive than others during the enrichment window when shaded or receiving lower levels of natural light, perhaps because of an interaction between the shade tolerance of the tree and its ability to utilize extra CO₂ during the enrichment window.

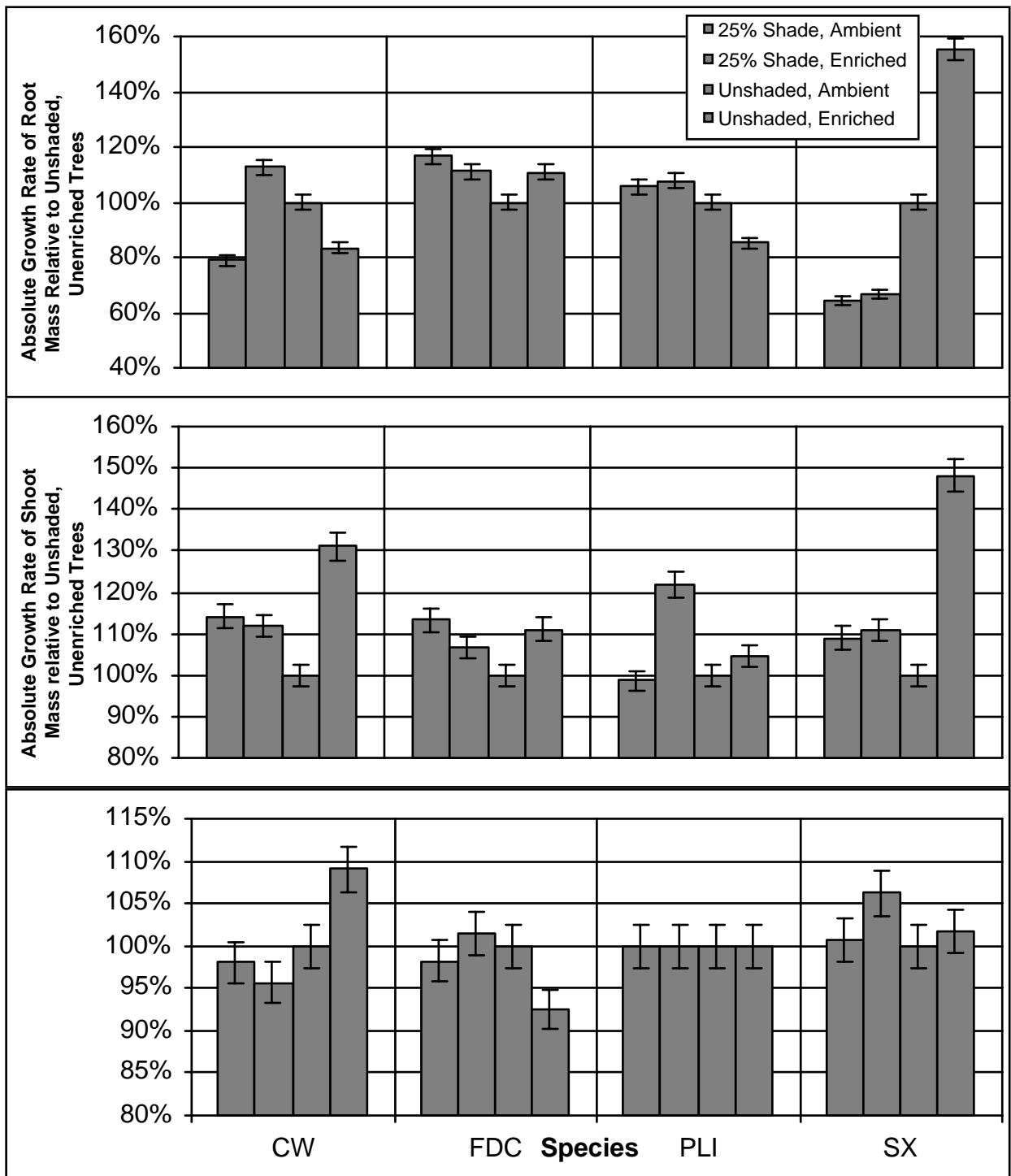
This year's continuation was to discover whether CO₂ enrichment during the third-month CO₂-responsive enrichment window resulted in increased growth of trees overall, and to determine whether the increases in growth observed when shading trees of particular species could increase the CO₂ enrichment effect.

RESULTS AND DISCUSSION:

Considering the Lodgepole pine, the 25% shade treated-trees showed higher growth rates for root mass (Figure 2a) and root collar (Figure 2b) as compared to unshaded trees, regardless of whether or not CO₂ was supplied to the environment; this is in agreement with last year's observations. However, CO₂ enrichment-treated pine trees showed increases as compared to unenriched trees when shoot mass (Figure 2a) and height (Figure 2b) were considered. The Western Red cedar, when treated with 25% shade, showed increases in the growth rate of shoot mass (Figure 2a) as compared to unshaded, unenriched trees; however, the unshaded enriched trees showed growth rates for shoot mass that were significantly higher than shaded trees. Additional CO₂ also seemed to be responsible for increases in root mass and branching (Figure 2a) and both root collar and height (Figure 2b). Even though growth in both species matched observations made last year with regard to shading, CO₂ enrichment during the enrichment window increased growth parameters for both species.

(Continued)

Figure 2b. Absolute growth rate for root collar diameter and total tree height as a function of number of months after germination. Bars with error bars greater of less than other bars are significantly different, alpha=0.05, n=40.

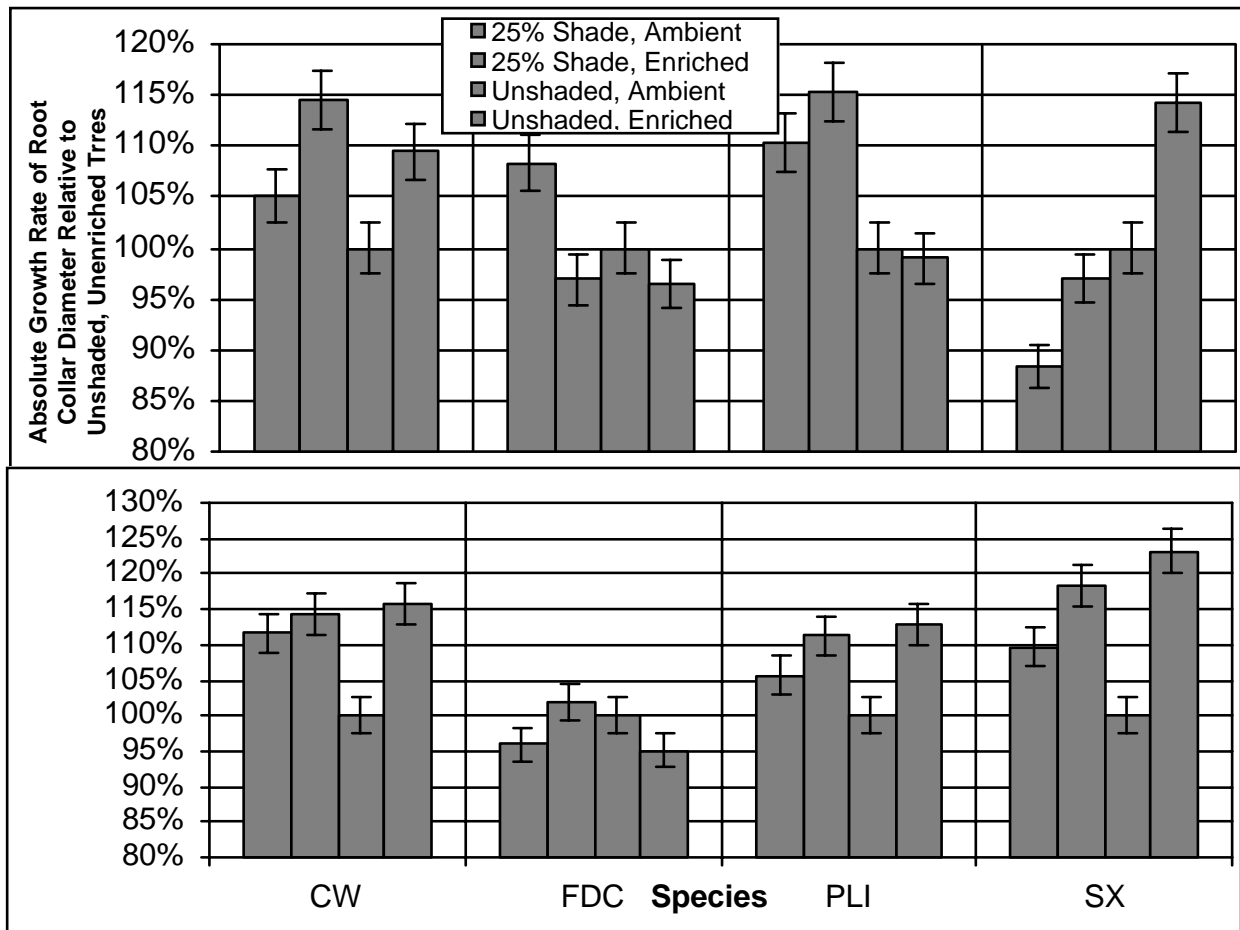


(Continued)

The propensity of CO₂ enrichment during the enrichment window to increase the growth of the trees was also observed for the Interior Spruce, the most responsive of all species tested to CO₂ enrichment. Root and shoot mass (Figure 2a), root collar, and height (Figure 2b) growth rate measurements were all higher for the CO₂ enriched trees, as compared to unenriched trees. However, CO₂ enrichment during the enrichment window did not seem to increase the

growth of the Douglas fir significantly. Shade alone seemed to result in higher growth rates of the fir, for shoot and root mass (Figure 2a) and root collar diameter (Figure 2b). It will be important to note that the efficacy of CO₂ enrichment and/or shade is species specific, and that before CO₂ enrichment/shade is used on species not tested here, testing of those species will be required to determine whether the treatments will be cost-effective.

Figure 2b. Absolute growth rate for root collar diameter and total tree height as a function of number of months after germination. Bars with error bars greater of less than other bars are significantly different, alpha=0.05, n=40.



There are economic benefits to a program of early germination and the provision of additional CO₂ during the enrichment window. Table 1, showing the effect of time needed to grow trees to target levels relative to unshaded, unenriched trees, shows the impact of CO₂ enrichment and shade during the enrichment window. Growers following the above recommendations when growing Western Red

cedar, Lodgepole pine, Interior spruce, and to a lesser extent, Douglas fir, should note reduced time to grow to target levels, with a resulting reduction in estimated growing costs and increases in gross margin. Interior spruce in particular should receive CO₂ enrichment, as the reduction in growing time can result in increases in gross margin by up to 32%.

(Continued)

Table 1. Amount of time needed to grow trees to target root collar diameter and height as compared to trees grown in an unshaded, ambient CO₂ environment (actual time shown), and estimated cost to grow 1000m² trees to target levels using time to grow to target root caliper diameter (which takes longer than growing to target height). n=40

Species	Treatment	% of Time to Target for Unshaded, Ambient Tree		Gross Profit ¹	Gross Margin Change
		Root Collar Diameter	Tree Height		
CW	25% Shade, Ambient	1.19%	-5.48%	\$21,905	-4%
	25% Shade, Enriched	-5.50%	-7.97%	\$27,326	19%
	Unshaded, Ambient	4.53	3.66	\$22,867	0%
	Unshaded, Enriched	-3.59%	-4.12%	\$25,779	13%
FDC	25% Shade, Ambient	-3.34%	9.31%	\$29,706	9%
	25% Shade, Enriched	-1.32%	-3.85%	\$28,118	4%
	Unshaded, Ambient	4.30	3.38	\$27,137	0%
	Unshaded, Enriched	-1.02%	4.66%	\$27,919	3%
PLI	25% Shade, Ambient	1.87%	-8.31%	\$26,670	-5%
	25% Shade, Enriched	-6.63%	-12.64%	\$33,124	18%
	Unshaded, Ambient	4.24	2.38	\$28,093	0%
	Unshaded, Enriched	-3.46%	-4.55%	\$30,719	9%
SX	25% Shade, Ambient	5.86%	-11.87%	\$18,563	-20%
	25% Shade, Enriched	-2.65%	-17.03%	\$25,437	9%
	Unshaded, Ambient	4.51	3.52	\$23,296	0%
	Unshaded, Enriched	-9.70%	-11.94%	\$31,126	34%

1. Income based on \$104,000 per 1000m² crop. Cost of \$17,883.00 per 1000m² per month based on estimated figures for direct expenses for potted chrysanthemums published by the B.C.

Ministry of Agriculture, Fisheries and Food (Agdex 280 - 810, Spring 1990). The cost does not include the cost of CO₂ delivery - if CO₂ delivery needs to be added, Air Liquide estimates additional cost for one month for 1000m² to be \$1,250.

LITERATURE CITED

- ¹ Dugal, A., Yelle, S., and Gosselin, A. 1990. Influence of CO₂ enrichment and its method of distribution on the evolution of gas exchanges in greenhouse tomatoes. *Can. J. Pl. Sci.* **70**: 345-356
- ² Neherhoff, E.M., and Schapendonk, A.H. 1985. Effects of environmental conditions on growth and production of cucumber; comparison between empirical and simulation data. *Acta Hort.* **174**:251-258
- ³ Grilke, N.E., Horn, J.L., and Roberts, S.W. 1993. Physiological adjustment of two full-sib families of ponderosa pine to elevated CO₂. *Tree Physiol.* **12**(4): 391-401
- ⁴ Guy, R.D., Chomba, B. and Holowachuk, D. 1993. Influence of CO₂ enrichment on growth, non-structural carbohydrates, and post storage root capacity of Engelmann spruce. Canadian Botanical Association Conference Proceedings
- ⁵ Chomba, B.M., Guy, R.D., and Weger, H.G. 1993. Carbohydrate reserve accumulation and depletion in Engelmann spruce (*Picea engelmannii* Parry): effects of cold storage and pre-storage enrichment. *Tree Physiol* **13**: 351-364
- ⁶ Young, R.J. 1997. Measurement of relationship between CO₂, light, and optimum growth of conifer seedlings under greenhouse conditions. Report prepared for Nursery Extension Services, BCMF, under Major Service contract 1070-20/EcoTech
- ⁷ Yakimchuk, R. and Hoddinott, J. 1994. The influence of ultraviolet-B light and carbon dioxide enrichment on the growth and physiology of seedlings of three conifer seedlings. *Can. J. For. Res.* **24**: 1-8
- ⁸ Campagna, M.A. and Margolis, H.A. 1989. Influence of short-term atmospheric CO₂ enrichment on growth, allocation patterns, and biochemistry patterns of black spruce at different stages of development. *Can. J. For. Res.* **19**: 773:782

Roderick Young

EcoTech Research and Development

Does Embryo Immaturity Play a Role in Dormancy Inception and Maintenance in Yellow-Cedar (*Chamaecyparis nootkatensis*) Seeds?

Development of yellow-cedar seeds is completed by about 17 to 21 months after pollination (Owens and Molder, 1984). Following dispersal from the parent plant, the seeds exhibit a low capacity for germination and typically require an additional year to meet their stratification requirements and break dormancy (Pawuk, 1993). The causes of dormancy can be various, but most dormancy mechanisms can be classified as being either embryo dormancy or coat-imposed dormancy (Bewley, 1997). In the latter category, the seed is dormant only because the tissues enclosing the embryo exert a constraint that the embryo cannot overcome; in the case of yellow-cedar embryos, these tissues include the megagametophyte, megaspore membrane, nucellus and seed coat. Mature embryos of yellow-cedar seeds which have been excised from their surrounding seed tissues are able to germinate, suggesting that the mechanism of dormancy is, at least in part, coat-imposed. Kurz et al. (1994) suggest that a further factor underlying dormancy maintenance is embryo immaturity at the metabolic and physiological levels. This suggestion was based in part on events following germination of isolated embryos of yellow-cedar, in which it was observed that post-germinative breakdown of stored reserves proceeds slowly, a property attributed to embryo immaturity. Further, the moisture content of the embryo is still relatively high (33%) at the time of seed dispersal and dry weight of embryos is still on the increase (Kurz et al. 1994). Thus, the seed may require a prolonged stratification period in order to accumulate sufficient protein and lipid reserves to permit successful germination and subsequent seedling establishment.

Synthesis and accumulation of storage proteins in the embryo and megagametophyte during yellow-cedar seed development

Biochemical analyses were undertaken in order to address whether seed dormancy is imposed and maintained because the embryo or megagametophyte is immature at the time of seed shedding and hence requires time to complete developmental events before dormancy can be terminated. These basic studies are important because they have an impact on research to enhance the germinability and seedling growth of yellow cedar. We examined the fate of several "markers" of mid- to late-development at different

stages during yellow-cedar development and in embryos and megagametophytes at the time of seed dispersal or shedding. The most abundant protein reserves of the embryo and megagametophyte are the buffer-insoluble crystalline storage proteins. These proteins will be degraded after germination to support growth of the young seedling. Quantitative protein analyses, SDS-PAGE (sodium dodecyl sulfate-polyacrylamide gel electrophoresis) and various other biochemical analyses show that the greatest increase in protein reserve synthesis and accumulation occurs between the first and second years of yellow-cedar seed development; deposition of insoluble storage protein is largely completed in seeds of second-year cones by August, 2-3 months prior to seed dispersal. This is illustrated in Figure 1 A which shows no further increase in the insoluble protein fraction in the embryos or megagametophytes of second year seeds harvested in August versus those harvested near the time of seed shed in November (compare "2nd year" with "shed" in Fig. 1 A). The insoluble crystalline storage proteins are hexamers; each of the six subunits which assemble to form the holoprotein is composed of several polypeptides in the 30- and 20-kDa ranges (Fig. 1B). These crystalline subunit polypeptides are present at the earliest stage of development studied (i.e. in embryos and megagametophytes of 1st year seeds) and there is little further accumulation of the proteins during the later stages of the second year of development.

These biochemical analyses and others (Xia and Kermode, 1998) strongly suggest that the shed seed has largely completed synthesis of the major insoluble storage protein reserves and can be considered to be "biochemically mature" with respect to the developmental process of protein reserve deposition.

Synthesis and accumulation of proteins implicated in desiccation-tolerance

For most species, another essential process that must be completed during seed maturation is the acquisition of desiccation tolerance, a process linked to the synthesis and accumulation of so-called 'late embryogenesis abundant' (LEA) proteins and other molecules important for withstanding desiccation (reviewed in Kermode, 1995, 1997). Shed

(Continued)

seeds may also require additional time to complete these late developmental events. We used Western blot analyses to examine the accumulation of proteins implicated in the acquisition of desiccation-tolerance including (i) the cytosolic dehydrins (a subset of the LEA proteins) and (ii) an integral protein of the vacuolar membrane: tonoplast intrinsic protein or a-TIP. As shown in Figs. 1C and 1D, the major accumulation of these proteins (i.e. the 26-kDa (X-TIP) polypeptide and the authentic dehydrin polypeptides of 10 and 27 kDa) occurred primarily between the first and second years of development, with little further accumulation occurring during the later stages of second-year development (Compare "2" vs. "shed").

Mature seeds of yellow-cedar continue to synthesize heat-stable proteins after stratification

Dehydrin proteins are heat-stable proteins and, as noted above, their accumulation during seed development may contribute to the acquisition of desiccation tolerance — i.e., the ability of seed tissues to survive drying or desiccation during late development. We undertook analyses to examine whether dehydrin proteins were still synthesized by the embryo following cold stratification of mature (shed) seeds. These analyses involved *in vivo* labelling of heat-stable proteins using "S-methionine, SDS-PAGE and fluorography (Fig. 1E), as well as immunoprecipitation of *in vivo*-labelled heat-stable protein extracts. Several heat-stable proteins and some of the proteins associated with late development continued to be synthesized after seed shedding (data not shown) and in 13-d stratified mature seeds (Fig. 1E). However, this did not include the major (10-kDa) dehydrin-like protein of yellow-cedar seeds (data not shown). We do not yet know the significance of this continued pattern of protein synthesis nor the role that these heat-stable proteins may play (if any), in dormancy maintenance. Prolonged synthesis of LEA/dehydrin-like proteins following imbibition of dormant cereal grain has been reported (Van Beckum et al. 1993). However, even in non-dormant seeds such as those of castor bean, proteins associated with late developmental programmes (e.g. dehydrin-like proteins) persist for up to 96 hours following seed imbibition (Han et al. 1997). Most pertinent to this study is the question of whether the embryos of yellow-cedar seeds are maintained in a dormant state following dispersal from the parent plant because they require additional time to complete developmental protein syntheses. We maintain that embryo imma-

turity is not a factor in dormancy maintenance in yellow-cedar (see below).

The mechanism of dormancy in yellow-cedar is primarily coat-imposed, but the embryo also plays a role

The continued synthesis of heat-stable proteins in mature seeds after their shedding and after a short period of stratification (13 d) does not appear to be a factor preventing the germination of yellow cedar seeds. When isolated embryos of mature seeds are placed on water, germination is elicited after a considerable lag of 9 d and 100% germination is not achieved until 12 d. Further, as noted earlier, events associated with post-germinative growth (i.e. storage protein breakdown and utilization) do not proceed rapidly, a property which has been attributed to embryo immaturity (Kurz et al. 1994). However, we have found that when mature embryos are subjected to a 5-d pre-treatment (e.g. agitation in water, mannitol, liquid nutrient medium or 10% PEG), the pre-treated isolated embryos commence germination faster as compared to their untreated counterparts (Fig. 1F), despite some of these treatments having little effect on the accumulation of dehydrin-like proteins (Fig. 1D, H₂O and MSG nutrient medium).

We conclude that embryo immaturity is not a factor in dormancy maintenance in yellow-cedar and that the mechanism underlying dormancy is primarily coat-imposed or coat-enhanced. However, despite the mechanism being predominantly coat-imposed and despite the lack of a role for embryo immaturity in dormancy maintenance, intrinsic factors within the embryo may nonetheless play an important role. For example, the increased rate of germination of mature isolated embryos following their agitation in water (Fig. 1F, H₂O) is consistent with the leaching of germination inhibitors such as abscisic acid (ABA), a process that may be important for the release from dormancy-

Future and ongoing research: Treatments effective in terminating dormancy of yellow-cedar seed

This general information on the underlying mechanism of dormancy inception and maintenance in yellow-cedar seeds has been useful for our ongoing studies to effectively terminate dormancy of the mature whole seed. Some of the treatments effective in dormancy breakage (including use of an ABA biosynthesis inhibitor) indicate that the plant hormone ABA plays a key role in dormancy maintenance in this species. In addition to optimizing protocols for

(Continued)

dormancy termination of different seed lots of yellow cedar, we are investigating critical events at the cellular level that accompany dormancy termination. For yellow-cedar seeds, these may include a decline in ABA levels within the embryo or surrounding seed structures (i.e. the megagametophyte and seed coat), as well as a decline in embryo sensitivity to ABA (N. Schmitz and A. Kermode, unpublished).

We thank Tim Crowder, Stan Wheat, Mike Gerhard and Dave Kolotelo for their help in obtaining developing and mature seed of yellow-cedar. Antisera for the Western blot analyses were kindly provided by Tim Close, University of California, Riverside and Maarten Chrispeels, University of California, San Diego. This research was supported by a Forest Renewal B.C. grant HQ96232-RE to A.R.K.

References

- Bewley, J.D. 1997. Seed germination and dormancy. *Plant Cell* 9: 1055-1066.
- Han, B., D.W. Hughes, G.A. Galau, J.D. Bewley and A.R. Kermode. 1997. Changes in late embryogenesis abundant (Lea) messenger RNAs and dehydrins during maturation and premature drying of *Ricinus communis* L. seeds. *Planta* 201: 27-35.
- Kermode, A.R. 1995. Regulatory mechanisms in the transition from seed development to germination: interactions between the embryo and the seed environment. In: *Seed Development and Germination*, G. Galili and J. Kigel (eds.), New York: Marcel Dekker, Inc., pp 273-332.
- Kermode, A.R. 1997. Approaches to elucidate the basis of desiccation-tolerance in seeds. *Seed Science Research* 7: 75-95.
- Kurz, M., D.R. Roberts, B.S. Flinn and W.E. Vidaver. 1994. A morphological and biochemical analysis of embryo maturation during yellow-cypress seed development. *Canadian Journal of Forest Research* 24: 431-441.
- Owens, J.N. and M. Molder. 1984. The reproductive cycles of western red cypress and yellow cypress. Province of British Columbia, Ministry of Forests, Victoria.
- Pawuk, 1993. Germination of Alaska-cedar seed. *Tree Planters' Notes* Winter: 21-24.
- Van Beckum, J.M.M., K.R. Libbenga and M. Wang. 1993. Abscisic acid and gibberellic acid-regulated responses of embryos and aleurone layers isolated from dormant and nondormant barley grains. *Physiologia Plantarum* 89: 483-489.
- Xia, J.-H. and A.R. Kermode. 1998. Analyses to determine the role of embryo immaturity in dormancy maintenance of yellow-cedar (*Chamaecyparis nootkatensis*) seeds: Synthesis and accumulation of storage proteins and proteins implicated in desiccation tolerance. *Journal of Experimental Botany*, in press.

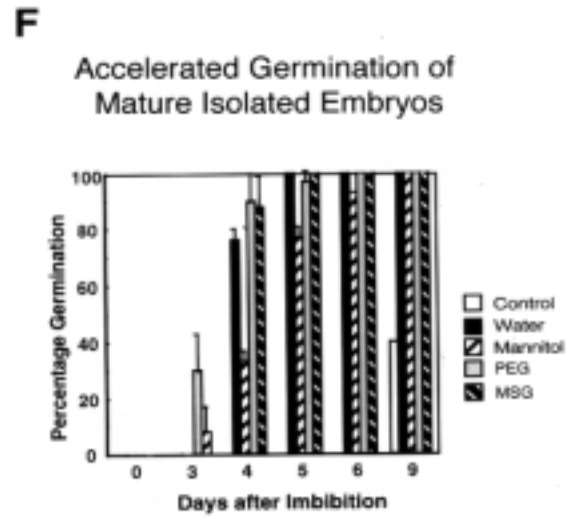
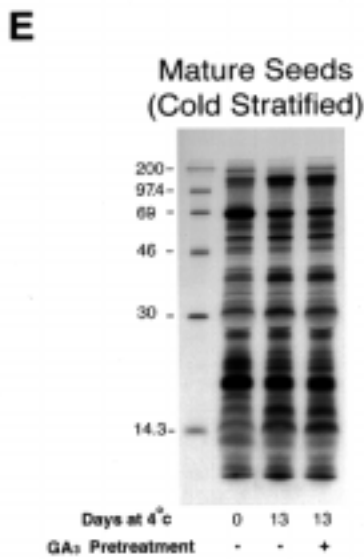
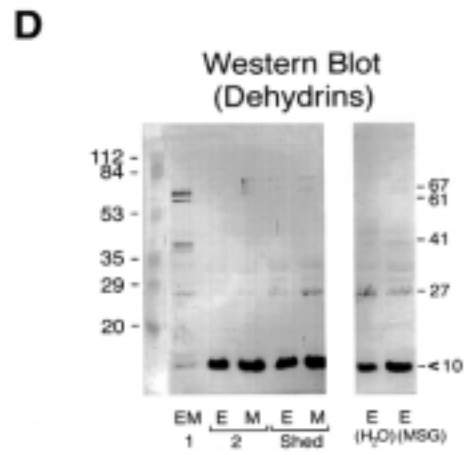
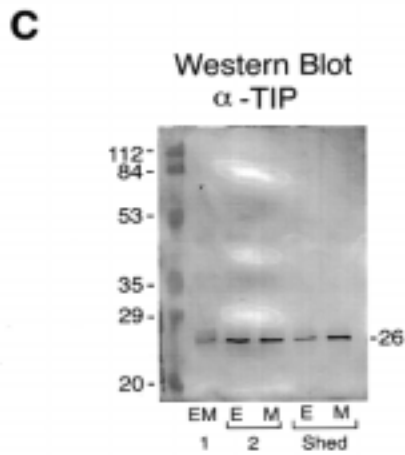
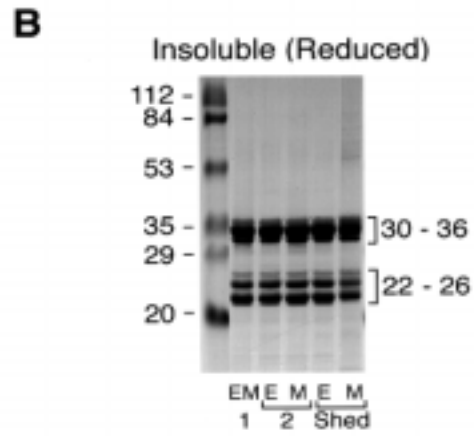
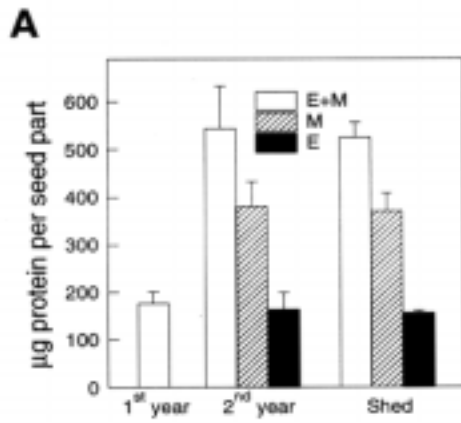
*Jian-Hua Xia Nancy Schmitz
Mirian Kim Kelly Adames
Allison R. Kermode
Department of Biological Sciences
Simon Fraser University*

*John Russell
Tree Genetics
B.C. Forest Service*

Figure Legend: Figure 1 (A-F).

A. Quantitative changes in the insoluble protein fraction during seed development in the embryo (E), megagametophyte (M) or the embryo and megagametophyte combined (EM). **B.** SDS-PAGE profiles of the insoluble crystalloid protein fraction of the embryo and megagametophyte at different stages of seed development. **C.** and **D.** Western blot analysis to examine accumulation of α -TIP and dehydrins. Also shown in **D.** is the effect of two pre-treatments (effective in accelerating the rate of germination of isolated embryos) on dehydrin accumulation (agitation in water or in nutrient medium, MSG).

E. Fluorograph showing changes in the profile of heat-stable soluble proteins synthesized *in vivo* within the embryo of mature seeds subjected to a 3-d soak only (0, -), a 3-d soak and 13 d of cold stratification (13, -), or a 3-d soak and a 2-d GA3 treatment at 25°C, followed by 13 d of cold stratification (13, +). **F.** Effect of various treatments (in which embryos were pre-treated by agitation in various media, including water, mannitol, PEG, or nutrient medium [MSGI], as indicated, on the percentage germination of isolated mature yellow cedar embryos. Control=untreated embryos; these exhibit 100% germination at 12 days after imbibition.

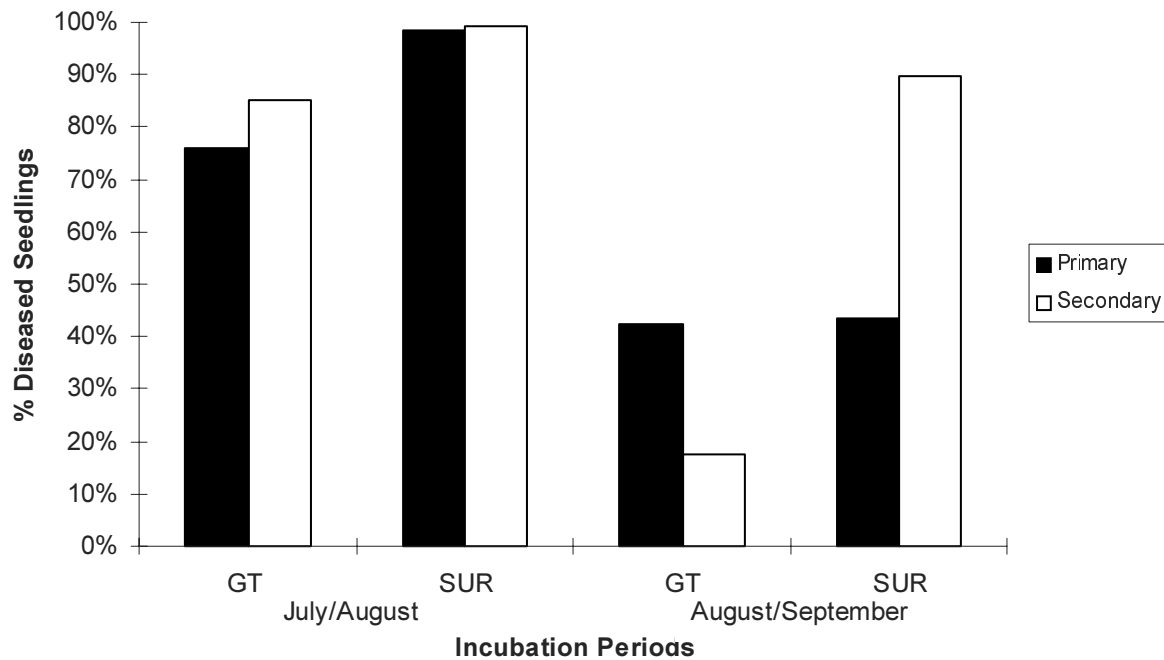


Correction (Seed and Seedling Extension Topics Volume 10, Numbers 1 & 2, page 12)

Influence of Lodgepole Pine Stock Type and Seedling Phenology of *Sirococcus* Disease Development by Paige Axelrod and David Trotter

The months at the bottom of the figure were inadvertently missing from that issue. The corrected figure is shown below.

Figure 2:
Sirococcus disease on primary and secondary needle stock type seedlings inoculated in July and August, 1995 and incubated in growth chambers.



GT = Seedlings originated from B.C. Ministry of Forests Green Timbers Reforestation Centre; SUR = Seedlings originated from B.C. Ministry of Forests Surrey Nursery. Significant differences between primary and secondary needle stock types: July/August, GT, $p = 0.05$; August/September, GT, $p = 0.0001$ and SUR, $p = 0.0001$.

EVENTS

Forest Nursery Association of B.C. & Western Forest and Conservation Nursery Association Combined Annual Meeting, Victoria, B.C. Canada August 10 - 13, 1998

Location: **Victoria**, a **great** tourist destination with many attractions - bring family and guests.

Venue:	Dunsmuir Lodge Pacific Research and Conference Centre 1515 McTavish Road North Saanich, B.C. Tel: (250) 656-3166; Fax: (250) 656-1999	<u>Mailing Address:</u> Box 2369 Victoria, B.C. V8L 3Y3 Canada
---------------	--	---

Dunsmuir Lodge is a wonderful conference facility, situated on a hill overlooking North Saanich, Sidney, and Salt Spring Island.

A limited number of rooms are available to delegates on a first come-first serve basis. Suites (4) @ \$119.00/night and bedrooms (40) @ \$99.00/night Canadian funds. These are excellent summer rates for Victoria, and include free shuttle service to and from the local airport and ferry terminals! Overflow accommodations at a local hotel available on request.

Committee: President - Ev van Eerden	Tel: (250) 381-1404; Fax: (250) 381-0252 em: evaneerden@prtgroup.com
Program Chairman - Drew Brazier	Tel: (250) 387-8955; Fax: (250) 356-0472 em: Drew.Brazier@gems1.gov.bc.ca
Registration - Susan Zedel	Tel: (250) 356-1598; Fax: (250) 356-0472 em: Susan.Zedel@gems8.gov.bc.ca
Commercial Exhibits - Hans Stoffelsma	Tel: (250) 656-4162; Fax: (250) 656-0818
Posters - Patti Kagawa	Tel: (250) 387-8949; Fax: (250) 356-0472 em: Patti.Kagawa@gems4.gov.bc.ca
Finance & Field Trips - Al MacDonald	Tel: (250) 387-8945; Fax: (250) 356-0472 em: Allan.McDonald@gems4.gov.bc.ca
Proceedings - Tom D. Landis	Tel: (503) 808-2344; Fax: (503) 808-2339 em: nurseries@aol.com

(Continued)

Can-West '98 Hort Trade Show

September 22- 23, 1998.

Tours: September 24, 1998

Vancouver Trade and Convention Centre,

Vancouver, B.C. Canada.

For More Information Contact:

BCNTA Office @ 604-574-7772/Fax: 604-574-7773

Making Connections

International Conference of the Society for Ecological Restoration

September 28 - 30, 1998

Austin, Texas

For more information contact:

Society for Ecological Restoration

1207 Seminole Highway, Suite B

Madison, WI 53711 USA

Ph. (608) 262-9547 Fax: (608) 265-8557

E-mail: ser@vms2.macc.wisc.edu

Canadian Greenhouse Conference

October 17-18, 1998. Guelph, Ontario, Canada.

For more information contact:

Donna Cobbleidick @ Ph: 905-945-9057

Western Region of the International Plant Propagators' Society

October 28 -31, 1998. Ontario, California, USA.

For more information contact:

Eugene K. Blythe @ Ph: 818-334-1264

Fax: 818-334-3126

E-mail: g_blythe@lightside.com

Helping the Land Heal

Ecological Restoration in British Columbia

November 5 - 7, 1998

Victoria, BC

For more information contact:

Helping the Land Heal Conference

PO Box 50043 15 - 1594 Fairfield Road

Victoria BC V8S 1G0

Ph. (250) 598-9056 Fax (250) 598-9076

E-mail: restore@islandnet.com

Website <http://www.islandnet.com/~restore>

Native Plants: Propagation and Planting Conference

December 09-10, 1998.

Oregon State University, College of Forestry

202 Peavy Hall

Corvallis, Oregon, 97331-5707 USA

For more information contact:

Forestry Conference Assistant

Tel (541) 737-232 Fax (541) 737-4966

E-mail: duncanp@ccmail.orst.edu

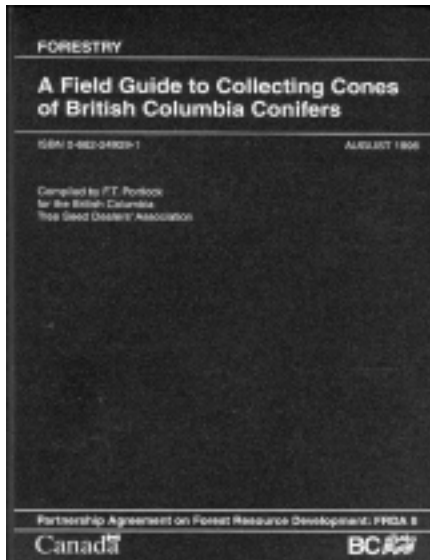
Questions regarding the conference content, contact

Diane Haase @ Ph: 541-737-6576

Fax: 541-737-5814

E-mail: haased@fsl.orst.edu

NEW PUBLICATIONS

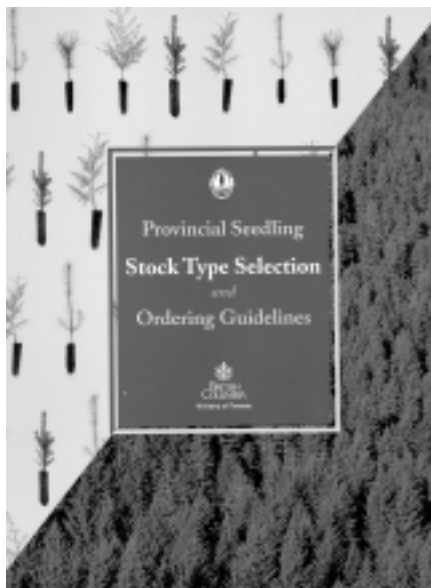


Field Guide To Collecting Cones of British Columbia Conifers

The BC Tree Seed Dealers Association (BCTSDA) is pleased to present "A Field Guide to Collecting Cones of British Columbia Conifers". The publication is intended as a reference for forest practitioners who are directly involved in cone collection, and provides practical information to assist them in obtaining their seed requirements while maintaining quality.

Copies can be obtained free of charge **except for \$3.50 to cover postage and handling** from:

Peter Hellenius Tel: 250-963-8617
 Treasurer BCTSDA Fax: 250-963-3490
 c/o Silva Enterprises
 Box 2888, Station B
 Prince George, BC
 V2N 4T7

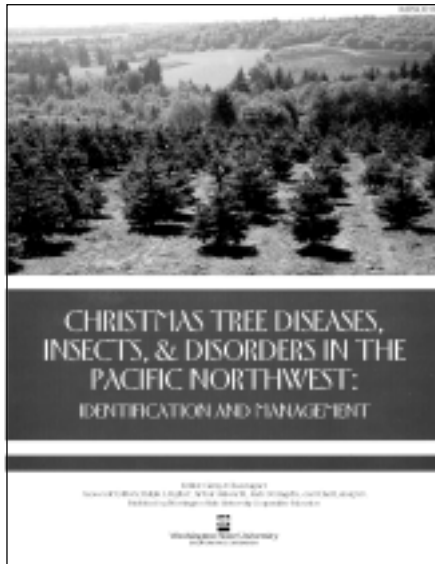


Provincial Seedling Stock Type Selection and Ordering Guidelines.

This guide has been produced to assist silviculturists in making stock type selection decisions. The terminology and definitions used in describing stock types are explained for both field- and container-grown stock. Site and nursery factors that could influence your decision are presented for consideration in the selection process. Information on ordering seedlings and tracking your order is provided. A section on handling has been included to increase your ability to assess and manage seedlings upon receipt. Finally, common stock types are illustrated and described by species.

The information and recommendations contained in these guidelines are based on field and nursery experience, as well as that of district, regional and licensee specialists. The results of Ministry of Forests SX, EP, unpublished operational trials, and FRDA research trials have also been incorporated.

Available free of charge while quantities last from:
 Extension Services, BC Ministry of Forests,
 14275 - 96th Ave. Surrey, BC Canada V3V 7Z2
 Ph: 604-930-3303 Fax: 604-775-1288
 Em: Eric.vanSteenis@gems5.gov.bc.ca



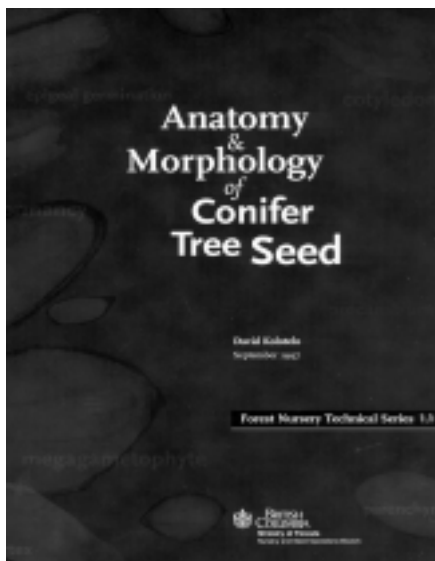
Christmas Tree Diseases, Insects, & Disorders in the Pacific Northwest: Identification and Management (MISC 186)

Editor : Gary Chastagner

Authors have compiled descriptions, life cycle, and management information on pests and disorders common to Christmas trees in the Pacific Northwest. They also have included less common pests for purposes of identification. Disease and insect sections provide a list of hosts, damage potential rating, and calendars that pinpoint when to watch for pest activity on conifers. Indexed for host, pathogen, and insect. Sections of note are Integrated Pest Management Principles and seasonal Monitoring Activities for Disease and Insect Pests. This publication should also be of interest to pest managers in seed orchards and those responsible for young forest plantations.

\$25.00 US funds plus \$4.00 shipping & handling

Available from: Bulletin Office
 WSU Cooperative Extension
 PO Box 645912
 Pullman, WA 99164-5912
 Ph. 509-335-2857 Fax 509-335-3006
 1-800-723-1763
<http://caheinfo.wsu.edu>



Anatomy & Morphology of Conifer Tree Seed

By David Kolotelo.

An excellent compilation of anatomy and morphology of conifer tree seed. It is the first in a series which takes the reader beyond the traditional parameters of height, caliper, and germination used to describe forest seed and seedlings.

Available free of charge while quantities last from:

Tree Seed Centre, BC Ministry of Forests, 18793 - 32nd Ave. Surrey, BC Canada V4P 1M5 Ph: 604-541-1683
 Fax: 604-541-1685

Extension Services, BC Ministry of Forests,
 14275 - 96th Ave. Surrey, BC Canada V3V 7Z2
 Ph: 604-930-3303 Fax: 604-775-1288
 Em: Eric.vanSteenis@gems5.gov.bc.ca

CONTRIBUTORS TO THIS ISSUE

Robb B. Bennett
Gerald Wales

B.C. Forest Service
7380 Puckle Rd. R.R.#3
Saanichton, BC V0S 1M0
Canada
Tel: 250-652-5600
Fax: 250-652-4204

Peter Saloniuss
Kathy Beaton
Ron Hallett
Blair Roze
Calvin French
Joe Lewis

Canadian Forest Service
Atlantic Forestry Centre
PO Box 4000
Fredericton, NB E3B 5P7
Tel: 506-452-3500
Fax: 506-452-3525

John Dennis

Canadian Forest Service
Pacific Forestry Centre
506 Burnside Road
Victoria BC V8Z 1M5
Canada
Tel: 604-363-0600
Fax: 604-363-6005

Ward Strong

Kalamalka Seed Orchards
3401 Reservoir Rd.
Vernon, BC V1B 2C7
Canada
Tel: 250-549-5696
Fax: 250-387-0046

David Reid
Ron Planden

Coastal Seed Orchards
7380 Puckle Road
Saanichton, BC V8M 1W4
Canada
Tel: 604-652-5600
Fax: 604-652-4204

Roderick Young

Ecotech Research
and Development
3737 W27th Avenue
Vancouver BC V6S 1R2
Tel: 604-221-9363

John Russell

Research Scientist
BC Ministry of Forests
Cowichan Lake Research Stn.
Box 335
Mesachie Lake, BC V0R 2N0
Tel: 250-749-6811
Fax: 250-749-6020

DEADLINE FOR CONTRIBUTIONS TO NEXT ISSUE

(Volume 11, Number 2) November 15, 1998

ORDER FORM

To receive **Seed and Seedling Extension Topics**,
or to correct your mailing address, please complete
the following form and mail it to:

- Address change - Please include copy of old label
- New

David Trotter
Seed & Seedling Extension Topics
B. C. Ministry of Forests, Extension Services
14275 - 96th Ave., Surrey, B.C.
CANADA, V3V 7Z2
Dave.Trotter@gems4.gov.bc.ca

NAME _____
ORGANIZATION _____
ADDRESS _____

CITY _____ PROV/STATE _____
COUNTRY _____ POSTAL CODE _____ TELEPHONE _____