NURSERY AND SEED

Volume 10 Numbers 1&2 1997 1

Seed and Seedling Extension Topics

Eric van Steenis — Editor

Hello everyone! We're back with another issue of SSET. This one contains everything submitted for the 1997 year. For 1998 we'll split it up into two issues again. Some of you actually called... worried that your name had fallen off the mailing list! This is not the case but it was nice to know our publication is still in demand!?

BC reforestation efforts for 1997 have held steady at approximately 230 million seedlings planted. The forest seedling industry is still expanding due to the trend toward larger stock-types and increased export of product to other Canadian provinces and US states. Three BC companies now operate nurseries in Alberta, one of those also establishing a presence in Saskatchewan. I wonder who will be the first to set up an operation south of the 49th, or maybe south of the 32nd?

Well, I hope you all had an excellent 1997 and will prosper (some more) in 1998.

Eric van Steenis
Nursery Extension Services

GROWER'S NOTES

Removal of Poor Quality Seedlots From TSC Storage

Currently, there are approximately 5,300 seedlots totalling 74,000 kg in long-term storage at the Ministry of Forests, Tree Seed Centre (TSC). A review of poor quality and low balance seedlots has recently been completed and the TSC has recommended that 343 low balance seedlots and 360 low germination seedlotsbe removed from inventory, based on the criteria shown in Table 1. Seedlot information including quality, quantity and usage over time has been forwarded to owners to review and confirm whether or not seedlots may be removed from inventory; also included, are individual seedlot and species deterioration rates (see David Kolotelo's, "Germination Retest Frequencies".)

Table 1. Germination and potential trees criteria for recommending seedlot removal from inventory.

Species	Criteria for Removal from Inventory
Amabilis & Subalpine Fir	• Germination <40% • Balance <5k potential trees
Grand Fir	• Germination <40% • Balance <5k potential trees & germination >41 and <65%
Western Redcedar Western & Mountain Hernlock Western Larch	• Germination <45% • Balance <1 k potential trees & germination >46 and <65%
Coastal Douglas-fir Spruce species Sitka Spruce and Sitka crosses Ponderosa Pine	• Germination <65% • Balance <5k potential trees
Interior & Coastal Lodgepole Pine Interior Douglas-fir	• Germination <45% • Balance <5k potential trees & germination >46 and <65%
White Pine	• Germination <25% • Balance <5k potential trees & germination >26 and <45%

The TSC is recommending these changes to our inventory, to help us better manage and quality-assure seedlots, most likely to be actively used for crown land reforestation purposes. Elimination of poor quality seedlots will also benefit efficient nursery production. Questions, comments or feedback on seedlots that perform poorly are welcomed.

Heather Rooke
Surrey Tree Seed Centre

Germination Retest Frequencies

Germination tests are initially performed on all seedlots prior to long-term storage. For registration seedlots must be between 4.0 and 9.9% moisture content and 97% + purity. Seeds are stored at -I 8'C to minimize deterioration. Quality seedlots with good vigour, germination capacity and rate can retain these characteristics for up to 30 years (and counting) in long-term storage. Seed deterioration occurs with aging and theories range from the i) accumulation of deleterious products of metabolism ii) wear and tear of organelles, cells and organs making them inefficient over time and iii) increased mutation rates with aging, causing metabolic malfunctions[1]. Seed deterioration may also be caused by fungi, bacteria, or insects, but the impact of these organisms is considered minimal for dry seed in long-term storage as most require elevated temperatures and/or moisture levels for active feeding or growth. The final outcome of seed deterioration is the inability of a seed to germinate under any conditions. Prior to seed mortality seeds will decrease in vigour and this trait will be variable for different seeds within a seedlot. Decreased seed vigour can be recognized by a reduction in germination speed, an increase in proportion of abnormal gerrninants, and increased sensitivity to sub-optimal conditions (e.g. temperature).

Seedlots are retested after a period of storage to ensure the germination capacity and seedling potential of a seedlot is current. Retest frequencies are directly related to the estimated deterioration rate of a species. Species and seedlots both show variability in the rate of deterioration. The objective of this note is to present a simple means of calculating deterioration rate and present the average deterioration rates of BC conifer species.

Deterioration Rate = (Current Germination% - Initial Germination%) / (Time in storage)

The units of the deterioration rate are % change in germination per year (year is the unit of time[2]). For each species a deterioration rate was calculated as the average of all seedlots having a storage duration of greater than 500 days (Table 1). This restriction was used as small changes in germination, due to sampling variability, over a short time period can result in an erroneous deterioration rate being calculated (e.g. a four percent difference in germination for tests performed 6 months apart estimates a 8% rate of deterioration per year). For several species (Ba, Bg, BI, Py) the germination test type has changed over time and various estimates of species deterioration were performed and averaged to produce the species deterioration rate. Deterioration rates ranged from a 1.44% decrease in germination per year for western redcedar to a gain of 0.67% per year for subalpine fir. Several species showed positive deterioration values and although these appear 'unrealistic' they are probably explained by sampling variation, erratic historical retest frequencies, improvements in seed testing procedures over time, and possibly by changes in seed dormancy during storage. The deterioration rates are being used as guides to prioritize our retesting of seedlots in storage. Using the deterioration rate, sample sizes, previous retest frequencies, feedback from clients and Quality Assurance monitoring the new retest frequencies were recommended and implemented for each species (Table 1). Retest frequencies range from 18 months (Cw) to 42 months (Ple and SS). For all *Abies* sp. the available data reflects only a short period of storage for any particular germination test and recommended retest frequencies are more conservative than the deterioration rates would suggest (especially with BI).

These retest frequencies automatically assign a pending retest for all seedlots with a minimum balance of 5000 potential trees. Approximately 1000 seedlots will be retested this year. Seedlots are being prioritized based on seedlot size, seed quality and seedlot usage. If you would like information on a seedlot's retest status, performance or to request a germination test please contact the Tree Seed Centre (604) 541-1683.

(Continued)

Table 1. Deterioration rates, sample sizes and retest frequencies for conifer tree seed.

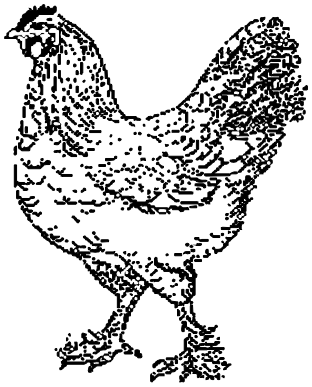
Species	Sample Size	Deterioration Rate (GC/yr)	Retest Frequency (months)
Ba - Amabilis fir	85	-0.78	24
Bg - grand fir	*40*	-0.24	24
BI - subalpine fir	*50*	+0.67	24
Cw - western redeedar	248	-1.44	18
Fdc - coastal Douglas-fir	264	+0.03	39
Fdi - interior Douglas-fir	402	-0.07	39
Hm - mountain hemlock	33	-0.36	24
Hw - western hemlock	272	-1.22	20
Lw - western larch	95	-1.06	22
Plc - coastal lodgepole pine	34	+0.08	42
Pli - interior lodgepole pine	756	-0.01	36
Pw - western white pine	77	-1.03	30
Py - Ponderosa pine	62	-0.28	30
SS - Sitka spruce	97	+0.10	42
Sx - interior spruce	820	-0.07	36
SxS - Sitka X interior spruce	62	-0.25	30
Yc - yellow-cedar	15	+0.46	36

[1]McGee, D.C. 1983. Introduction. Phytopathology: 73: 314- 315. From Symposium: Deterioration Mechanisms in Seeds. 73rd Ann. Meet. Amer. Phytopathological Soc. New Orleans, LA. Aug. 3, 198 1.

[2]actual # days used between tests, divided by 365 to convert to a yearly basis

Dave Kolotelo
Surrey Tree Seed Centre

Styroblock Recycling Machine!?



It was sometime-back in 1988 that a nursery grower observed the clandestine consumption of a number of Styro-8 blocks holding up his 1961 Desoto. Some years went by before the word reached Paul O'Neill at Beaver Plastics. What ensued was a full "fledged" research study at the University of Alberta by members of the faculty of agriculture.

The study investigated the effects of the non-nutritive, non-traditional feed diluent, expanded polystyrene (EPS), on the performance of broiler breeders. It was mixed with feed in ratios of 20:1, 1O:1, and 5:1 grams feed to EPS.

Growth rate of broiler breeders relates in large part to their voracious appetite. The birds normally consume food in excess of metabolic requirements which leads to waste and increased variability in growth rate between the more aggressive vs more passive specimens. Consequently feed restriction is considered beneficial to broiler chicken production. Feed restriction can be practiced by limiting day-length, food availability, or diluting with a non-nutritive "filler". The latter is termed qualitative feed restriction, and is deemed to be less compromising to the well-being of the birds from an animal welfare perspective.

In general, feed restriction has been shown to improve feed efficiency, control body weight, decrease fatty content, increase egg production and laying sequences, with fewer eggs laid outside the normal period of oviposition, fewer defective eggs, and fewer multiple ovulations daily. Diluents such as ground oat hulls, sand, and cellulose have been used in the past.

This study utilized EPS and found no negative effects on digestibility of other feed ingredients or the composting cycle of waste produced by the birds. Positive results were obtained with respect to weight distribution. Total weights were not.significantly different for treated vs control feeds and treated feed birds had less variability in body weight. The latter being due to the fact that volume of feed was not restricted quantitatively such that aggressive and passive birds both could eat their fill and attain similar total nutritional intake (i.e. less competition led to better nutrient distribution). it was also determined that particle size of dituent had to match feed particle size to prevent the birds from preferentially consuming the larger feed pellets.

The complete paper, "Ground Expanded Polystyrene as a Nutrient Diluent for Broiler breeders" by I.E. Edeogu, J.J. Feddes, F.E. Robinson, and M.J. Zuidhof can be obtained from the Canadian Society of Agricultural Engineering, Box 3 8 1, RPO University, Saskatoon, SK, Canada S7N 4J8.

Eric van Steenis
Nursery Extension Services

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Spruce Gall Adelgid Sample Plan

Introduction

Spruce gall adelgids form galls on spruce vegetative and reproductive shoots, leading to loss of productivity and seedset. Adelgids overwinter as tiny black nymphs (<0.5 mm long) on year-old spruce shoots, on bark near or on buds. In spring they mature and lay eggs. These eggs hatch to "crawlers" which seek out and infest the developing galls. Since controls (e.g., sprays of insecticidal soap) are directed at overwintering nymphs, it is necessary to determine nymph populations early in the spring. However, until now it has been impossible to accurately determine population levels using current sampling methodology.

A study to create a sample plan for accurate assessment of overwintered adelgid densities was initiated in 1996 and completed in 1997. We examined thousands of shoots from seed orchard trees to determine where on a tree adelgids are most likely to be found. We also determined the variation in adelgid numbers between trees within an orchard and timed ourselves with stopwatches to determine the most efficient sampling method. This work was synthesized into a monitoring plan (see below) which will be used by the Seed Pest Management group for estimating spruce adelgid population levels in the future.

Sample unit

We found that a single year-old shoot is the most appropriate sample unit. Adelgids do not overwinter on needles or older bark. Counting a cluster of shoots (e.g., on the tip of one branch) did not improve efficiency. Most adelgids (up to 70%) were found within 3 cm of shoot tips, but we found it took more time to measure that 3 cm than to count the entire shoot. Additionally, there were 1.3 times more adelgids on terminal shoots than on sub-terminals, so it's important to sample I terminal for every 3 or 4 sub-terminals.

Overwintered adelgids tend to cluster near the tip@ of lower branches. Eighty-eight percent of all adelgids were found below 2.5 m, and 64% of these were found within 50 cm of the ends of branches. There were more adelgids on the north and east sides of the tree (57% of all adelgids) than on the south and west sides (43%). However, these numbers are close enough to be ignored during sampling, as long as all samples aren't selected from the same side of the trees (i.e., mix it up). Therefore, the sample unit is here defined as a single one-year-old shoot selected randomly from the ends of branches below 2.5 in. All adelgids on the shoot should be counted.

Sampling plan

We found that the variation in adelgid numbers per sample unit was slightly greater between trees than it was within trees. We also determined that it took very little longer to move to a new tree and take a sample than it did to stay and take another sample within the same tree. Therefore we decided that a single sample per tree would be most efficient.

We then calculated the number of samples required to estimate the population with a known degree of accuracy (see Table 1). A "Confidence Interval" of 20% about the mean is adequate for field sampling purposes. This means that the average number of adelgids resulting from the sample will be within 20% of the true population mean, 19 times out of 20. Therefore our recommendation is to count about 13 2 sample units (shoots) from throughout the orchard. In most instances (at average adelgid densities) this will take just over an hour for an experienced person. Sampling time will increase with increasing adelgid densities. If more accuracy is desired, the number of samples collected (and thus the time commitment) will need to be increased.

(Continued)

Table 1. Sample numbers and time required to sample with a given degree of accuracy. Taking 132 samples in an orchard will require about 88 minutes, and result in a mean which is within 20% of the true population mean, 19 times out of 20.

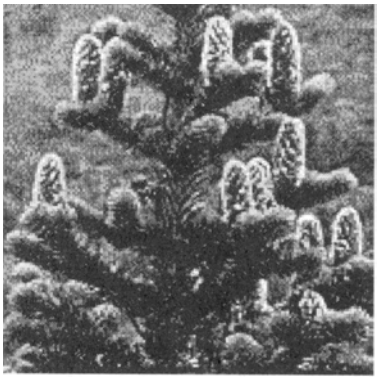
Samples	Time (min)	Confidence Interval (% of mean)
52968	35312	1
13242	8828	2
2119	1412	5
530	353	10
132	88	20
33	22	40

Summary and Conclusions

The sample unit is a single terminal or sub-terminal shoot located at the end of a branch, below 2.5 in in height. One shoot per tree should be sampled, on about 132 trees per orchard. All overwintered nymphs on a shoot should be counted. The resulting average density will be a population estimate for that orchard with a confidence interval of 20% of the mean.

Sampling should be conducted in March, before the overwintered nymphs become physiologically active. Active nymphs swell and secrete a white fuzzy "wool". The orchard should be walked in a transect (crossing rows at an angle - e.g., walking a "W" or "X" pattern through the orchard). A handiens or, preferably, a headband mapifier will facilitate counting these tiny creatures.

If adelgid numbers are high, it may be necessary to spray an insecticide. As active adelgids are very difficult to kill, monitoring must be conducted well before they begin to swell and "wool-up." Some orchardists have had good successwithinsecticidalsoapat I%to 1.5%,appliedthrough an air-blast sprayer at 2000-2400 L/ha of water. Since there is little else active in the orchard at this time (late March- early April), there is little risk of this application destroying any natural enemies. We have seen adelgid kills of 95%, and gall reductions of up to 80%, as a result of sprays under these circumstances. Unfortunately, we have not yet determined an economic threshold for adelgid populations (i.e., the point at which adelgids are abundant enough to warrant a spray). We plan to address this subject in the future. For now, suffice it to say that under some conditions, dramatic damage (>50% seed reduction) can be attributed to adelgid infestations, so they should certainly not be taken lightly.



Ward Strong
Kalamalka Seed Orchards

Robb Bennett
Saanich Seed Orchards

TECH TALK

Fungal Assay Results

Testing seedlots for seed-bome pathogens has been occurring since 1991 with 3667 tests being performed for the three most significant pathogens: *Calescyphafulgens* [seed or cold fungus]; *Fusarium* sp. [that may cause damping-off or root rot] and *Sirococcus conigenus* [Sirococcus blight]. Test results are currently available on SPAR (Seed Planning and Registry System) and electronic or hard copies may be obtained from the Trec Seed Centre. This note provides a summary of the current status of fungal assay testing as presented in Table 1. Use of these figures in planning is encouraged. It is important for seed owners to understand the disease potential of seedlots they own and possibly correct problems related to collection or post-collection handling methods. For nurseries the fungal assays identify seedlots which may incur diseases and/or benefit from seed treatments such as those discussed by Dave Trotter in his article on hydrogen peroxide treatments. Species, are abbreviated, but common names can be found in the article on 'Germination Retest Frequencies' in this volume. Column headings are explained here for simplicity:

- **[#T]** is the total number of tests performed by host/pathogen combination
- **[%T]** is the % of seedlots tested;
- [%1] is the percentage of seedlots tested showing a infection > 0.0%;
- **[Ave]** is the mean infection % of infected seedlots; and
- **[Maxl]** is the maximum infection % of tested seedlots.

Table 1. The current situation of fungal assay testing.

	Caloscypha fulgens					Fusarium sp.					Sirococcus conigenus				
Sp.	#T	%T	%I	Ave	Maxl	#T	%T	%I	Ave	Maxl	#T	%T	%I	Ave	Maxl
Ba	64	28	13	0.9	2.0	180	78	33	0.8	11.6					
Bg						49	84	37	1.3	7.0					
Bl	73	45	42	2.6	9.6	239	87	24	0.9	14.0					
Cw						112	41	71	1.8	20.4					
Fdc	70	21	1	0.4	0.4	284	84	67	2.3	75.4	4	1	0	0.0	0.0
Fdi	98	17	7	1.0	4.4	266	45	85	2.1	19.4	6	1	0	0.0	0.0
Hm						12		17	0.2	0.2					
Hw	49	15	6	0.4	0.4	76	23	43	0.8	4.8	92	27	12	0.5	1.6
Lw						153	94	79	2.8	43.2	2	1	10	0.9	1.4
Plc	4	8	0	0.0	0.0						6	12	0	0.0	0.0
Pli	32	2	0	0.0	0.0	488	33	6	0.3	1.2	10	1	0	0.0	0.0
Pw						42	37	79	1.7	5.8					
Py	3	2	0	0.0	0.0	90	58	71	1.9	9.8					
SS	13	7	31	14.4	37.6	8	4	38	1.7	4.0	28	14	21	0.3	1.1
Sx	180	15	24	2.2	16.0	442	41	35	1.8	39.8	474	39	25	0.7	3.6
SxS	2	4	100	1.1	1.8	1	2	100	3.8	3.8	14	29	29	0.6	1.0
Yc						3	5	33	0.2	0.2					
	588		17	2.5	37.6	2445		44	1.9	75.4	634		23	0.7	3.6

(Continued)

The fungal assay result are intended to identify seedlots which are infected with seed-bome pathogens that may result in disease occurrence in the nursery. The % of seedlots showing an infection [%I] indicates the probability or risk of encountering a seedlot infected with a pathogen (e.g. Fdc - coastal Douglas-fir has a 67% probability of being infected with *Fusarium).* The average infection % indicates the severity of infection as the proportion of seeds harboring the pathogen. This value allows one to assess how infected individual seedlots are in relation to the species average. The maximum infection % indicates the worst- case scenario for each species/pathogen combination

The obvious question is "What infection level is significant?" and the answer is less than satisfying as actual occurrence of disease symptoms will very much depend on the environment in which the crop is grown and the sowing pre-treatment. A seedlot may have a 100% infection, but not produce disease at all in the nursery, while at another nursery a much lower infection rate may result in disease occurrence. The situation is even more complex for *Fusarium* assays as results are only to the genus level, although individual species may or may not be pathogenic to conifer tree seeds. Rather than supplying strict guidelines on importance I am suggesting that if you have had disease problems at the nursery then check the fungal assay results and determine what level is critical at your nursery. If you have had a disease problem and no fungal assay information is available then please contact me and we will have the seedlot tested.

The priorities for fungal assay testing are presented in Table'2. These priorities were prepared by discussions among the following people: Paige Axelrood, BC Research; John Dennis, Forestry Canada; Melody Neumann, ECOS Biological Consultants (currently working on her PhD in Australia); Mike Peterson, Applied Forest Sciences; Dave Trotter, Nursery Extension Services. and myself.

Table 2. The priorities for fungal assay testing by pathogen and tree species.

Species	Caloscypha	Fusarium	Sirococcus
Ba	Medium	Medium	Low
Bg	Low	Low	Low
Bl	High	High	Low
Cw	Low	Low	Low
Fdc	Low	High	Low
Fdi	Low	Low	Low
Hw	Low	Medium	Low
Lw	Low	High	Low
Plc	Low	Low	Low
Pli	Low	Low	Low
Pw	Low	High	Low
Py	Low	High	Low
SS	High	High	High
Sx	High	High	High
SxS	High	High	High
Yc	Low	Low	Low

The fungal assay results are based on dry seed as the results are more reproducible than with stratified seed and stratification regimes may vary by nurseries performing their own seed pretreatment. The results are intended to identify seedlots that are infected with seedbome pathogens. In the future we hope to add the test results to our sowing request labels to allow this information to be available with the seed and avoid having to cross-reference lists.

David Kolotelo, RPF
Cone and Seed Improvement Officer

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Influence of Lodgepole Pine Stock Type and Seedling Phenology on *Sirococcus* Disease Development

In recent years, British Columbia (B.C.) conifer nurseries have been growing the majority of 1-0 lodgepole pine stock under a cultural regime to induce secondary needle formation during the nursery growing season. Nursery managers and the B.C. Ministry of Forests Nursery Extension Service have raised concerns regarding the susceptibility ofprimary and secondary needle lodgepole pine stock types to the foliar fungal pathogen, *Sirococcus conigenus (formerly S. strobilinus)*. In particular, questions have been raised regarding a greater susceptibility to *Sirococcus* in secondary needle type seedlings compared to primary needle type seedlings.

Sirococcus conigenus causes shoot blight on a variety of conifers including lodgepole and ponderosa pine, Sitka, white and Engelmann spruce, and Douglas-fir (Sutherland *et al.* 1989). Inoculum can be seedbome or pycnidiospores can be spread by wind, rain or irrigation water from dead or diseased conifer tissues. Disease development is promoted by cool, moist, low light conditions (Wall and Magasi, 1976). Needle necrosis often begins at the base of needles and progresses upward and needles initially have a red-brown appearance. Black pycnidia may be present on the lower portions of necrotic needles once disease is established. The BC Ministry of Forests, Nursery Extension Services funded studies in 1995 and 1996 to investigate (1) the relationship between lodgepole pine seedling growth stage and susceptibility to infection by *Sirococcus;* and (2) the influence of primary and secondary needle seedling stock types on *Sirococcus* disease susceptibility (Radley *et al.* 1995; Axelrood *et al.* 1996). This article summarizes several key findings from these studies.

Methods

Lodgepole pine seedlings (seedlot 5225) were grown in 313B styroblocks under a standard nursery cultural regime for primary needle formation (primary needle stock type) and a regime of extended day length (23 hr) to induce secondary needle formation (secondary needle stock type). Both stock types were inoculated in mid-July and mid-August, 1995 and at monthly intervals from June through October, 1996 by spraying the seedling shoots with a *Sirococcus* spore suspension (approx. 5 x 10^4 colony forming units per mL) or with sterile distilled water (control treatment). Four and 13 styroblock units were inoculated for each treatment in 1995 and 1996, respectively. There were 40 seedlings per styroblock unit and each unit was comprised of one third of a styroblock excluding seedlings along the cut edges. Styroblock units containing seedlings were initially placed in moist plastic bags for three days within growth chambers to create conditions suitable for *Sirococcus* infection (20^0C + or- 2^0C; relative humidity of 75%; and a 16 hour light/8 hour dark photoperiod of low light intensity, approximately 200 lux). Plastic bags were then removed and half of the seedlings for each treatment remained randomized in the growth chambers whereas the remaining seedling treatments were randomized in the outside nursery environment in 1996. All seedlings were incubated in growth chambers in 1995. Seedlings were evaluated approximately three and one half weeks post-inoculation for the presence or absence of *Sirococcus* disease symptoms. Secondary needles were just beginning to emerge at the beginning of July, 1996 whereas secondary needle emergence was earlier for some seedling treatments in 1995. Logistic regression was used to compare various inoculated treatments since the response was always binary, being the presence or absence of disease symptoms (Montgomery, 1986). Separate analyses were done for each incubation period and for the growth chamber and outside environments.

Results and Discussion

The phenological stage of primary and secondary stock type lodgepole pine seedlings had the greatest influence on susceptibility to *Sirococcus* disease. Younger, actively growing seedlings were most susceptible to disease with disease levels ranging from 64% to 98% in June through August, 1996 for both primary and secondary needle stock types (Figure 1). There were no significant differences in the levels of disease on primary and secondary needle stock type seedlings incubated in growth chambers during June, July and August nor on seedlings incubated outside in June

(Continued)

and August. However, in the outside nursery environment in July, there was significantly greater disease in the secondary needle stock type seedlings (93.3%) compared to the primary needle stock type seedlings (72.3%) (p = 0.000 1). Secondary needles began emerging at the beginning of July, 1996. Occasionally *Sirococcus* disease symptoms were detected at low levels (<5%) on control seedling treatments inoculated with sterile distilled water, but the majority of control seedling treatments did not exhibit disease symptoms.

Disease levels dropped dramatically as the seedlings matured during September and October, 1996 incubation periods for both growth chamber and outside nursery environments. Since the environmental conditions in growth chambers were constant during June through October, these low disease levels were not related to environmental influences on disease development. In September, there were significant differences in the levels of disease on primary and secondary needle stock types, but these differences were not consistent between growth chamber and nursery environments. Significantly greater disease occurred on secondary needle growth chamber seedlings (19.6%) compared to primary needle growth chamber seedlings (2.1%) *(p* = 0.0001) whereas disease was significantly greater on primary needle outside seedlings (I 1.0%) compared to secondary needle outside seedlings (4.2%) *(p=0.005)*. Disease levels were less than 2.0% for all seedling treatments in October. Assessments of healthy and diseased needles from June through October incubation periods indicated *Sirococcus* was not present on healthy needles *and Sirococcus* pycnidia were microscopically observed on the majority of the examined diseased needles.

Sirococcus disease results from the 1995 study showed similar trends as the 1996 study. Disease levels were higher in the July/August, 1995 incubation period compared to the August/September, 1995 incubation period and there were also not consistent significant differences in *Sirococcus* disease on primary and secondary stock types (Figure 2). Secondary needle stock type seedlings were classified as having only primary needles; primary and immature secondary needles; and mature primary and secondary needles and *Sirococcus* disease was observed on all three seedling types in 1995 and 1996.

Figure 1: *Sirococcus* disease on primary and secondary needle stock type seedlings inoculated at monthly intervals (June - October, 1996) and incubated in growth chambers and outside nursery environments.

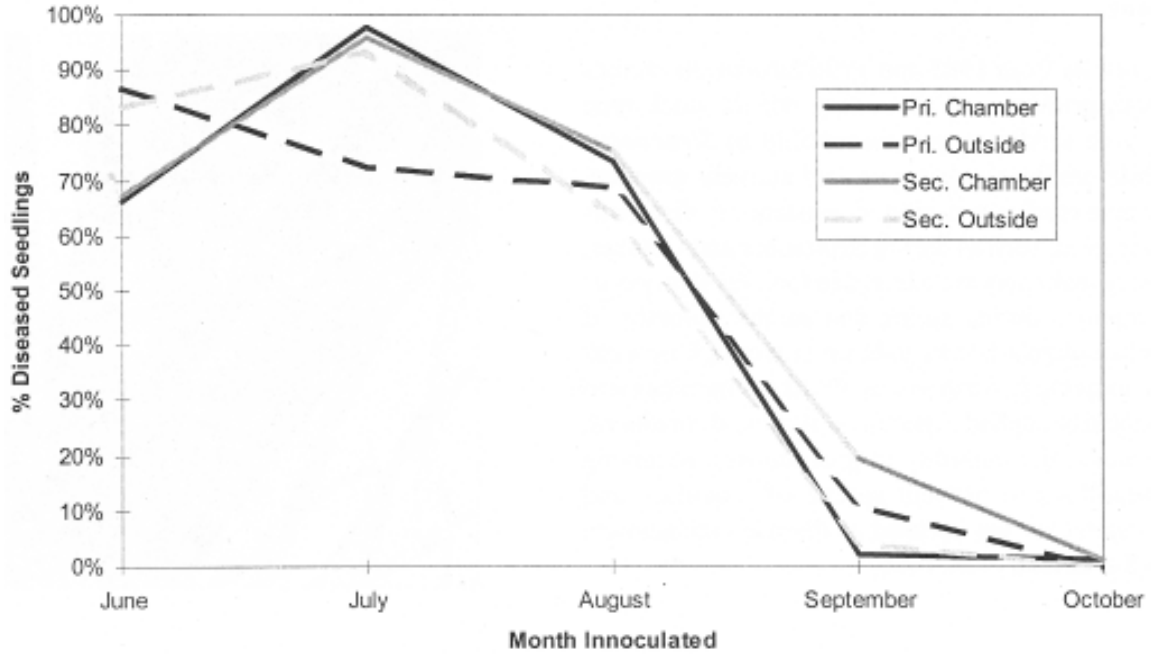
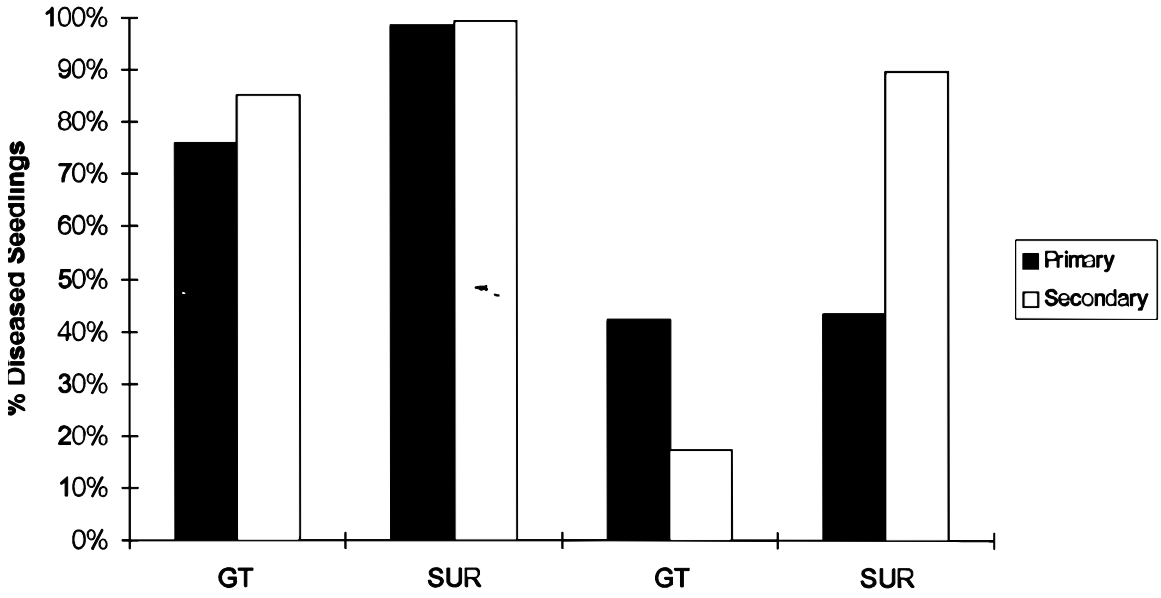


Figure 2: *Sirococcus* disease on primary and secondary needle stock type seedlings inoculated in July and August, 1995 and incubated in growth chambers.



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 = 0.000 I and SUR, p = 0.000 1.

Conclusions

The results from 1995 and 1996 *Sirococcus* studies indicate both primary and secondary needle stock type lodgepole pine seedlings are susceptible to *Sirococcus* disease while seedlings are young and actively growing. Lodgepole pine seedlings exhibited resistance to disease as seedlings matured, such as during September and October, 1996. Nursery managers are advised to look for *Sirococcus* disease symptoms during spring and summer months. If *Sirococcus* inoculum is known to be present or if *5irococcus* disease is expected, *Sirococcus* disease management strategies should be applied. Alterations of cultural conditions, such as reducing the humidity in greenhouses, removing diseased seedlings to prevent spread of inoculum and fungicide treatments can be used as disease management strategies (Sutherland *et al.* 1989).

(Continued)

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Paige Axeirood,
Reed Radley, Monica Chow
B.C. Research Inc.

Dave Trotter
Nursery Extension Services

Assessment of Fungicides for *Sirococcus* Disease Management

Introduction

Sirococcus conigenus (formerly S. strobilinus) is a fungal pathogen that causes shoot blight on lodgepole pine seedlings and is of concern to British Columbia (BC) conifer nurseries. Inoculum can be seedbome or pycnidiospores can be spread by wind, rain or irrigation water from dead or diseased conifer tissues. Disease development is promoted by cool, moist, low light conditions (Wall and Magasi, 1976) and these environmental conditions can occur in BC. Alteration of cultural conditions, such as reducing the humidity in greenhouses, removing diseased seedlings to prevent spread of inoculum and fungicide treatments can be used as disease management strategies (Sutherland *et al* 1989). Chlorothalonil is the only fungicide registered and currently used for *Sirococcus* disease control on conifer seedlings in BC. Additional fungicides are used for other fungal diseases on nursery-grown conifer seedlings such as propiconazole and mancozeb for *Keithia* on western red cedar and chlorothalonil, captan, benomyl and iprodine (Rovral) for *Botgtis* on a variety of conifer species. The BC Ministry of Forests, Nursery Extension Services funded a study to determine the effectiveness of three of these ftmgicides, mancozeb (Dithane M-45), chlorothalonil (Bravo) and propiconazole (Topas) for *Sirococcus* disease control (Axelrood *et al.* 1997). These fungicides were tested on lodgepole pine secondary needle stock type seedlings in two growth chamber trials (July and August, 1996) at three fungicide concentrations.

Methods

Lodgepole pine seedlings (seedlot 5225) were grown in 313B styroblocks under a standard nursery culture regime with extended day length to induce secondary needle formation. Seedling shoots were sprayed with fungicides at rates similar to minimum and maximum recommended rates on the product labels (Table 1). Seedling shoots were inoculated with an aerosol application of a *Sirococcus spore* suspension (approx. 5 x 10^4 colony forming units per ml) one hour after fungicides were applied. Control treatments included seedlings inoculated with *Sirococcus* (positive control) or sterile distilled water (negative control) without prior fungicide treatment. Three styroblock units were inoculated per treatment and each unit was comprised of one third of a styroblock excluding seedlings along the cut edges (40 seedlings/unit). Styroblock units containing seedlings were placed inside moist plastic bags and units were randomly placed within growth chambers (I unit/ treatment/chamber). Growth chambers provided conditions suitable for *Sirococcus* infection (200C +or -2^0C; relative humidity of 75%; and a 16 hour light/8 hour dark photoperiod of low light intensity, approximately 200 lux). Plastic bags were removed three days after inoculation and seedlings were evaluated approximately three and one half weeks post-inoculation for the presence or absence of *Sirococcus* disease symptoms. Secondary needles were just beginning to emerge at the beginning of July, 1996. Logistic regression

(Continued)

with contrasts was used to compare all treatments to the *Sirococcus* inoculated control, since the response was always binary, being the presence or absence of disease symptoms (Montgomerv, 1986).

Fungicide Trial I

All fungicide treatments significantly reduced *Sirococcus* disease development compared to the *Sirococcus* control treatment ($p<0.0001$) (Figure 1). The *Sirococcus* control treatment resulted in 99% of the seedlings with disease symptoms whereas less than 2% of the seedlings in the water control treatment had *Sirococcus* disease symptoms. Mancozeb and chlorothalonil reduced disease by approximately 66% compared to the *Sirococcus* control treatment and yielded very similar results at all application levels. There was no significant difference when comparing the two levels of each fungicide or when comparing the two fungicides to each other. Similarly, propiconazole at the lowest application level (0. 125 units active ingredient) also reduced disease by 67% compared to the *Sirococcus* control. The most effective treatment was propiconazole at the higher application rate which reduced disease by 98% (compared to the *Sirococcus* control treatment) and yielded results identical to the water-inoculated negative control treatment. A significant treatment difference between the two concentrations of propiconazole was observed ($p<0.0001$). These results indicate all three fungicides were effective in reducing *Sirococcus* disease symptoms and superior performance was achieved with propiconazole at the higher application rate.

Fungicide Trial 2

The second fungicide trial included treatments for each of the three fungicides at the higher application rate tested in Trial 1; an increased application rate for each fungicide (not previously tested); a combined chlorothalonil and propiconazole treatment at the lowest application rates included in Trial 2; and the positive and negative control treatments described in Trial 1.

All fungicide treatments significantly reduced *Sirococcus* disease development by 5 9% to I 00% compared to the *Sirococcus* control treatment ($p<0.0001$) (Figure 2). *The Sirococcus* control treatment resulted in 80% of the seedlings with disease symptoms and disease was not present on the control seedlings inoculated with steiile distilled water. Again, the most effective fungicide was propiconazole and *Sirococcus* disease symptoms were not observed on any seedlings treated with the lower application rate. One percent of the seedlings exhibited disease symptoms at the higher application rate of propiconazole. Mancozeb performed significantly better than chlorothalonil ($p<0.0003$). There was no significant difference when comparing the two levels of each of these fungicides. Applying chlorothalonil with propiconazole provided no increase in disease control beyond that seen when propiconazole was used alone. The results of fungicide Trial 2 confirm the results previously seen for Trial I and clearly show the effectiveness of propiconazole *for Sirococcus* disease control. Assessments of healthy and diseased needles from trials 1 and 2 indicated *Sirococcus* was not present on healthy needles and *Sirococcus* pycnidia were microscopically observed on the majority of the examined diseased needles.

Conclusions

Maricozeb, chlorothalonil and propiconazole significantly reduced *Sirococcus* disease development on secondary needle stock type lodgepole pine seedlings in two growth chamber trials. Propiconazole provided the most effective *Sirococcus* disease control and reduced disease levels to less than 2% for two of the three tested concentrations. Future work should include additional trials with propiconazole, chlorothalonil and mancozeb in conifer nursery growing environments for *Sirococcus* disease control and possibly other foliar fungal pathogens. Evaluation of conifer seedling phytotoxicity should also be completed. If mancozeb and propiconazole provide successful disease control ‘an extension of product registration could be pursued to include *Sirococcus* disease control on nursery-grown conifer seedlings. In order to minimize potential acquisition ofresistance to an individual fungicide, two or more ftmgicides with different modes of action could be used in an integrated pest management strategy.

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Figure 1:
Trial 1: Effect of Fungicides on *Sirococcus* Disease Development.

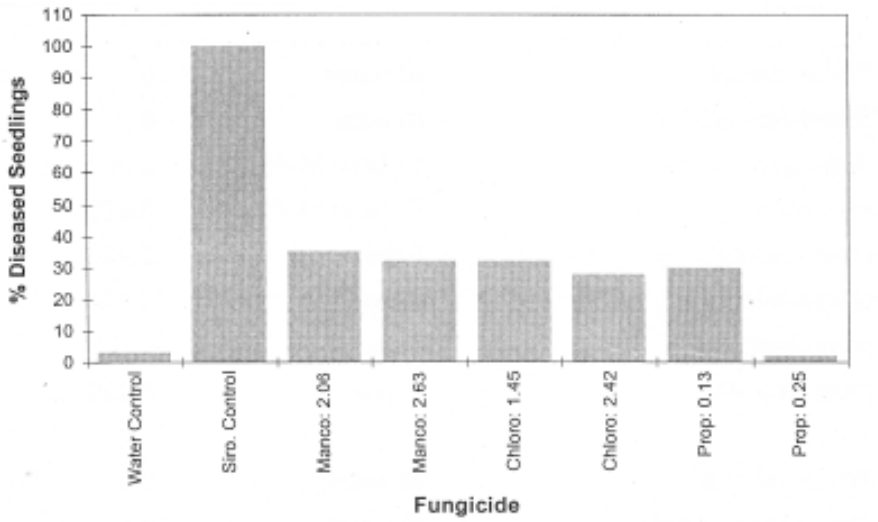
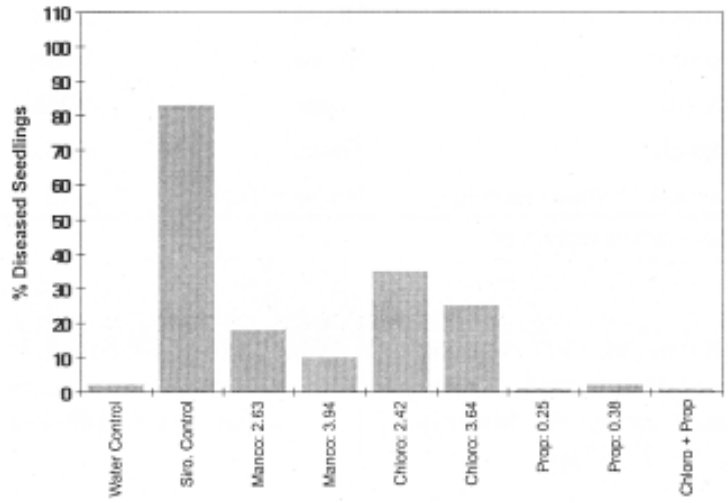


Figure 2:
Trial 2: Effect of Fungicides on *Sirococcus* Disease Development.



Numbers adjacent to fungicides are application rates in kg or L active ingredient ha^{-1}. Siro = *Sirococcus;* Manco = mancozeb; Chloro = chlorothalonil; Prop = propiconazole.
Note: The use of fungicide brand names in this report does not endorse specific recommended use.

(Continued)

Table 1:
Seedling treatments and fungicide rates for growth chamber trials.

Trt	Fungicide	Trade Name	Rate (Kg or L ai ha^{-1})	Product g/L or g
Trial 1				
1	Water control	sd water	0	0
2	*Sirococcus* control	sd water	0	0
3	mancozeb	Dithane M-45	2.063	750
4	mancozeb	Dithane M-45	2.625	750
5	chlorothalonil	Bravo	1.450	404
6	chlorothalonil	Bravo	2.424	404
7	propiconazole	Topas	0.125	250
8	propiconazole	Topas	0.250	250
Trial 2				
1	**Water control**	**sd water**	**0.0**	**0.0**
2	*Sirococcus* control	sd water	0.0	0.0
3	mancozeb	Dithane M-45	2.625	750
4	mancozeb	Dithane M-45	3.938	750
5	chlorothalonil	Bravo	2.424	404
6	chlorothalonil	Bravo	3.636	404
7	propiconazole	Topas	0.250	250
8	propiconazole	Topas	0.375	250
9	chlorothalonil + propiconazole	Bravo + Topas	2.424 + 0.250	404 + 25

sd = sterile distilled; ai = active ingredient

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Wall, R.E. and Magasi, L.P., 1976. Environmental factors affecting *Sirococcus* shoot blight of black spruce. Can. **J.** For. Res. 6: 448-452.

Paige Axeirood, Reed Radley and Monica Chow
BC Research Inc.

Dave Trotter
Nursery Extension Services

SEED SOAKING TANK SANITATION METHOD TO REDUCE RISK OF CONTAMINATION OF SEEDLOTS BY *FUSARIUM*

Conifer seed has been shown to harbour *Fusariuin* inoculum (Axelrood et al, 1995) which may play an important role in damping-off and root rot in seedlings. A previous study has shown that during the running water soak, infested seedlots can contaminate other seedlots (Neumann, 1995). In addition, surveys of seed preparation equipment found *Fusarium* to be present within seed soaking tanks (Neumann, 1996). These studies suggest that sanitation of seed soaking equipment may help to prevent contamination of seed which may lead to reduced losses in the field.

Power-washing tanks with water was not found to be effective. As a result, trials using paint, hydrogen peroxide, bleach, and Ivory™ dishwashing soap were conducted to find an effective tank cleaning regime. The aluminum tanks tested in the study were used for running water soaks and ranged in volume from approximately 60 litres to 600 litres.

The first set of trials involved painting inner tank surfaces with a polyamide epoxy gloss coating to reduce inoculum levels. This treatment substantially reduced *Fusarium* on the sides of tanks, however the fungus was still detected on tank bottoms.

In another set of treatments, tanks were filled with 3% (v/v) hydrogen peroxide and soaked over the weekend. This treatment was very effective and required little labour but was considered to be prohibitively expensive because of the volumes of chemical required. One less expensive option may be to soak just the bottoms of tanks since this was the primary location of *Fusarium* inoculum.

The final set of trials involved scrubbing tanks with one of the following: 3% hydrogen peroxide solution, 0.5% bleach solution buffered to a pH of 7.0 or a 5% solution of Ivory™ dishwashing soap and hot (50 °C) water. All tanks were thoroughly rinsed with tap water following treatment. In most cases, all three chemical scrub treatments reduced *Fusarium* levels by nearly 100%.

Over all, the Ivory™ and hot water scrub treatment was considered to be the best option for tank sanitation. Although labour is required, the low cost of the soap product and worker safety issues detenTnined that this treatment could most easily be incorporated into a tank sanitation regime.

Tank sanitation may play an important role in operations requiring the imbibition of conifer seed. Tanks or seed soaking containers that are not regularly cleaned may contribute to seed contamination. *Fusarium* spores remain viable for several years and the fungus may be able to proliferate on organic materials frequently found on tank bottoms.

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Melody Neumann
Ecos Biological Consultants

David Trotter
Nursery Extension Services

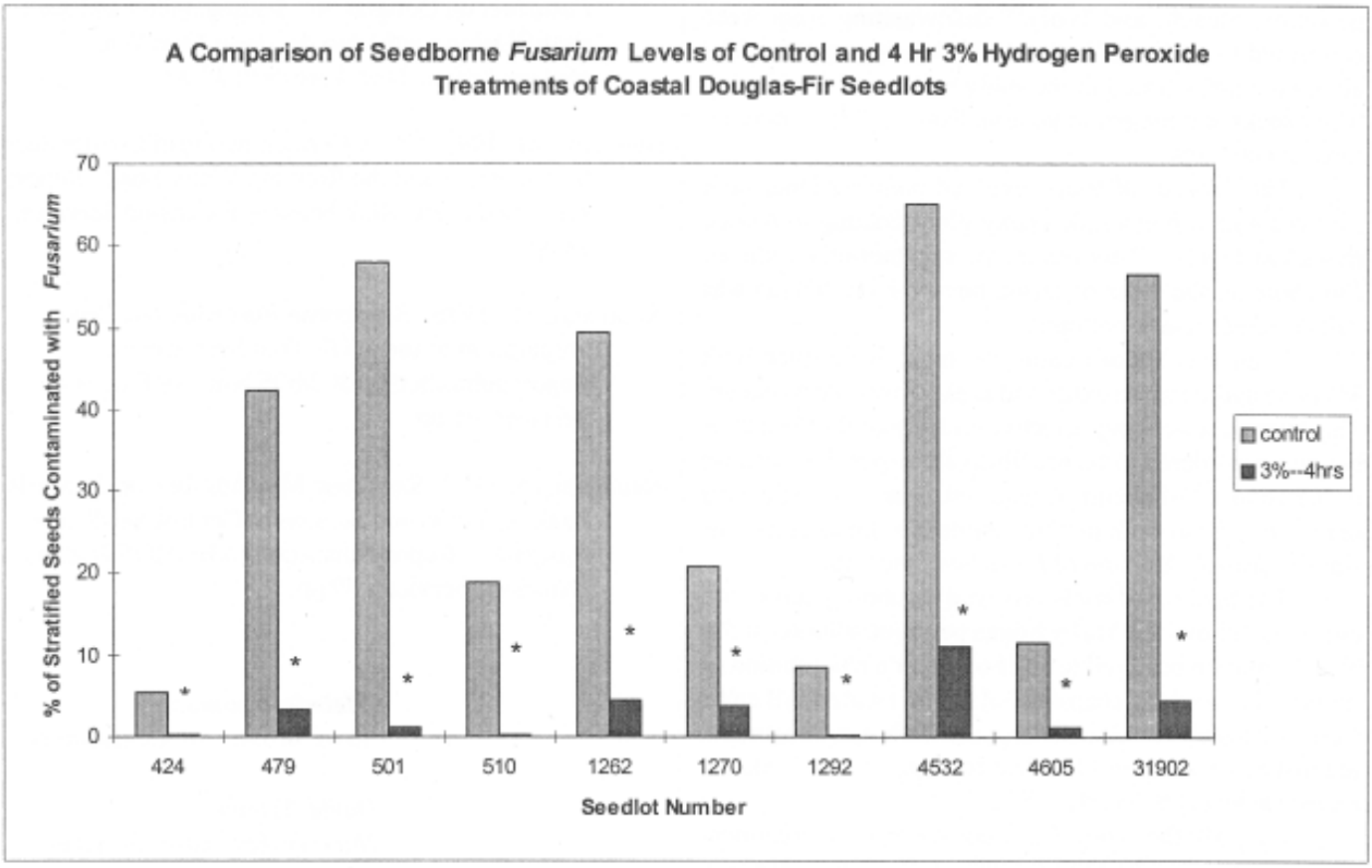
David Kolotelo *Tree Seed Centre*

SEED SANITATION METHOD TO REDUCE SEEDBORNE *FUSARIUM* LEVELS ON CONIFER SEED

INTRODUCTION

The fungus *Fusarium* (Link) has been associated with damping-off and root rot of conifer seedlings in container nurseries. The seed has been shown to be a common source of this fungus. The use of running water to imbibe seed it reduced seedborne *Fusarium* levels without inhibiting prior to stratification can play an important role in the germination. Following on from this work, a trial using reduction of seedborne *Fusarium* levels (Axelrood et al., hydrogen peroxide seed soaking treatments was performed 1995). However, for some seedlots further seed sanitation on stratified coastal Douglas-fir, western larch, *and Abies* is required to reduce the risk of seedling losses at the nursery *lasiocarpa* (Bl) seedlots.

Figure 1



* indicates that the sanitation treatment is significantly different from the control (p=0.01)

METHODS

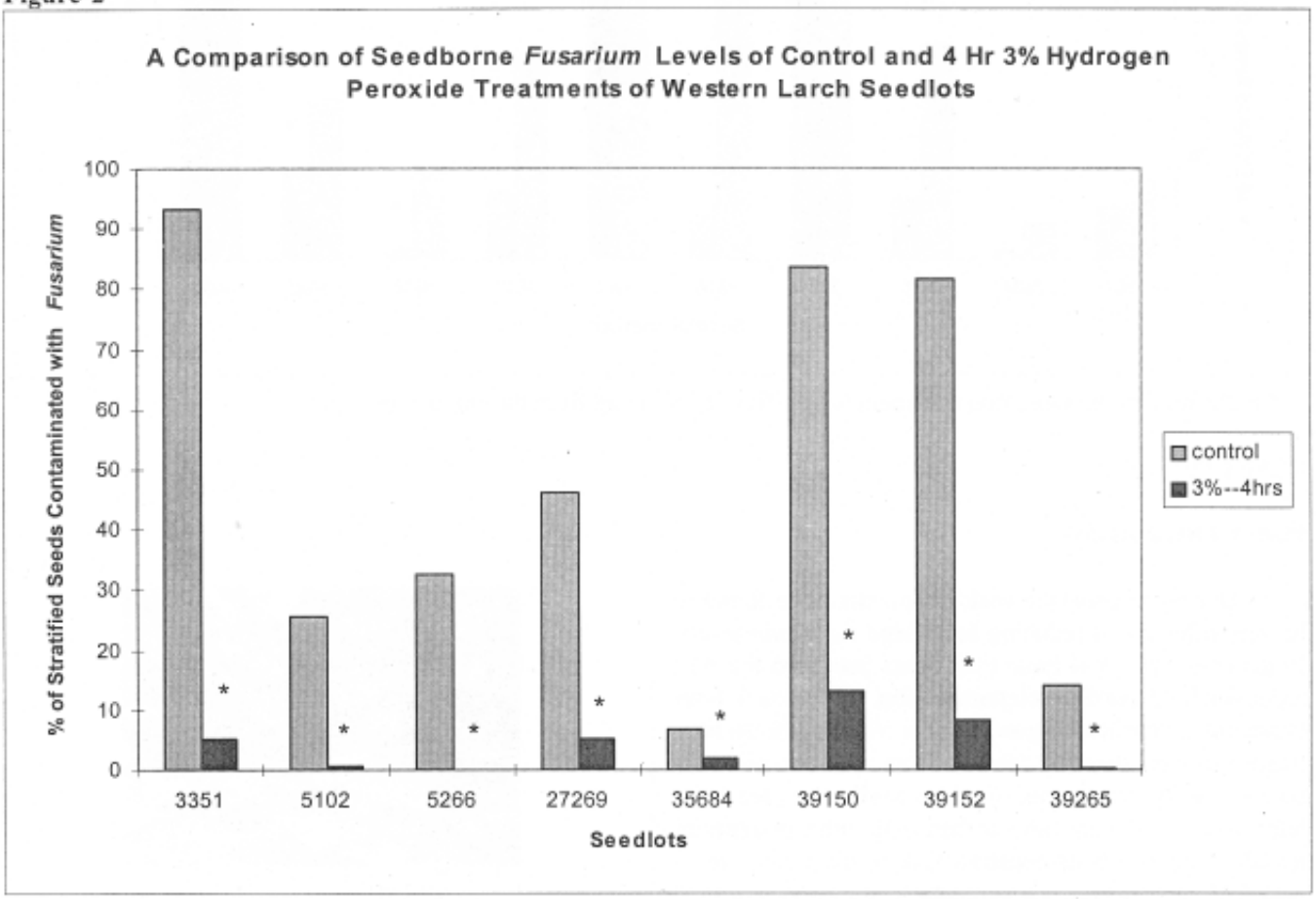
Seed from ten coastal Douglas-fir and *Abies lasiocarpa* and eight western larch seedlots were stratified operationally at the Tree Seed Centre. Seedlots with at least 0.2% *Fusarium* on dry seed (Tree Seed Fungal Assay Results, 1996) were chosen for the study. Following stratification, seed was assigned to one of the following treatments:

i) control (no further treatment)
ii) 1 hour soak in 3% hydrogen peroxide solution
iii) 4 hour soak in 3% hydrogen peroxide solution
iv) 16 hour soak in 3% hydrogen peroxide solution
v) 16 hour soak in 1% hydrogen peroxide solution.

After the hydrogen peroxide soaking, treatments (iiv) were rinsed for 5 minutes under running tap water and surface-dried. Five hundred seeds were placed on Nash and Snyder medium and incubated under continuous fluorescent lighting for 10-14 days. The number of seeds contaminated with *Fusarium* were counted and the effectiveness of the treatment evaluated.

Field and laboratory germination tests of seedlot treatments were performed concurrently (Nursery Extension Services and the Tree Seed Centre).

Figure 2



* indicates that the sanitation treatment is significantly different from the control (p=0.01)

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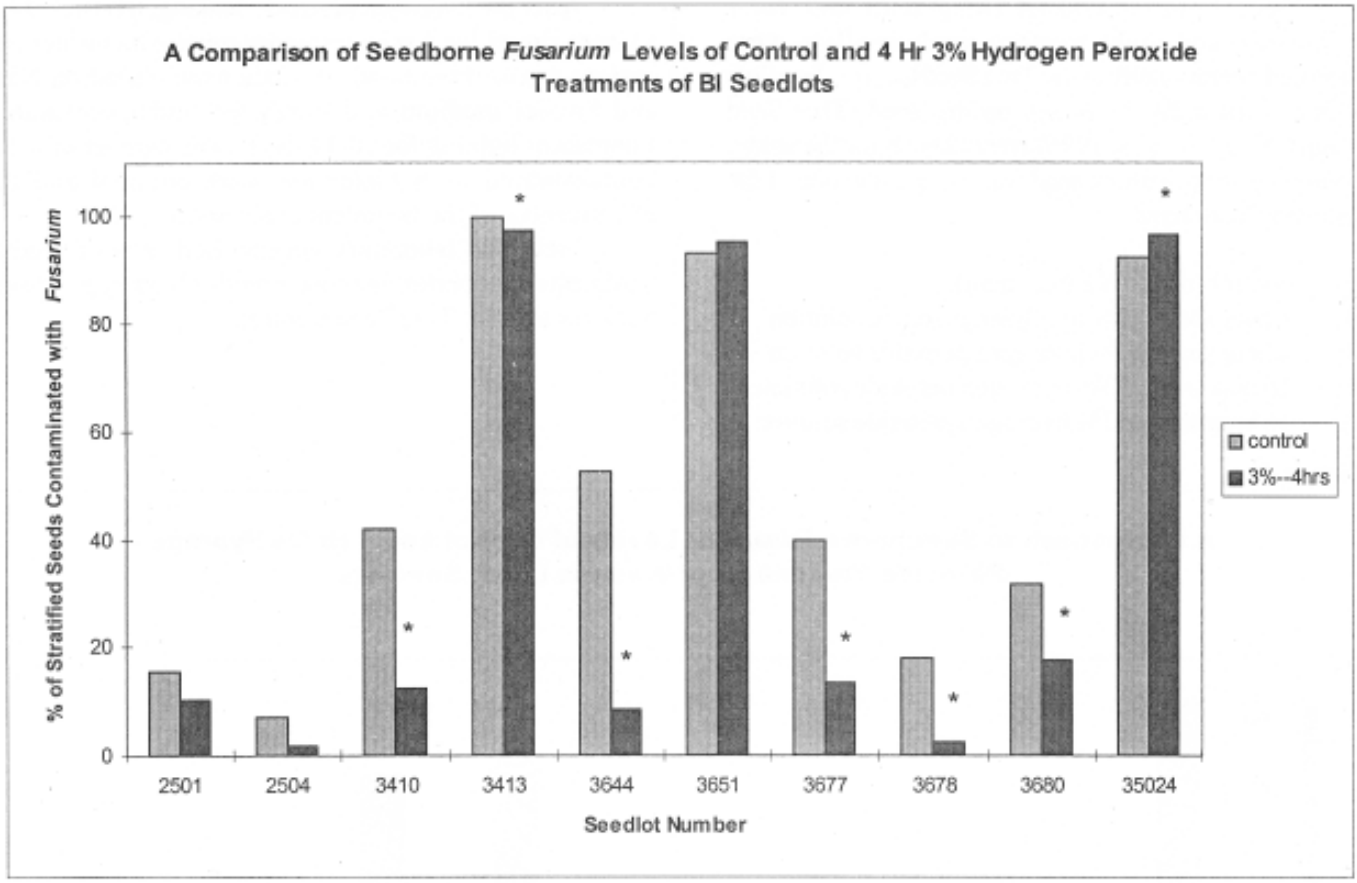
Figure 3 A Comparison of Seedborne *Fusarium* Levels of Control and 4 Hour 3% Hydrogen Peroxide treatment of *Abies lasiocarpa* Seedlots



* indicates that the sanitation treatment is significantly different from the control (p=0.01)

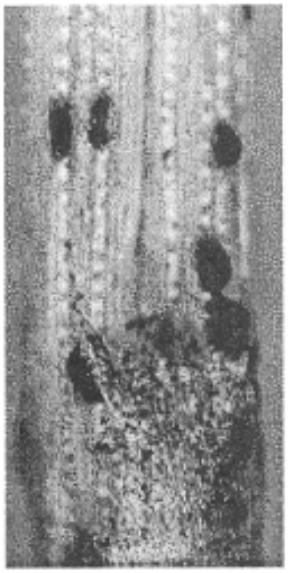
RESULTS

Part A - Seed Assays

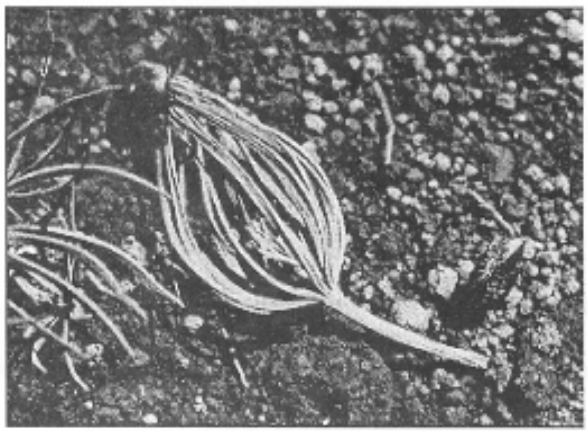
Hydrogen peroxide soak treatments were found to be very effective at reducing seedborne *Fusarium* levels. In general, the 3% 4 hour treatments provided the best reduction in *Fusarium* contamination. The 3% 1 hour treatment also provided good control whereas the 16 hour treatments were the most variable. The hydrogen peroxide seed sanitation treatments of *Abies* seedlots tended to be less effective and more variable than on the other two species tested. Figures 1-3 demonstrate that in most cases the 4 hour 3 % hydrogen peroxide sanitation treatment significantly reduced seedborne *Fusarium* levels compared to the control treatment.

Part B - Laboratory Germination

Results of total germination for all seedlots of the three conifer species are shown in Table 1. The treated seeds were placed in germination boxes in environmentally controlled incubators and germinants were counted 3 times per week for 3 weeks. For Douglas-fir (Fdc)and western larch (Lw), the incubators were maintained at 30^0 C for 8 hours with lights and 20^0 C for 16 hours with no lights. The *Abies lasiocarpa* (Bl) seed treatments were incubated under the same light setpoints but at 25° C and 15° C respectively. In general, the 3% hydrogen peroxide treatments at 1 and 4 hours showed little or no differences in germination compared to the controls in the Douglas-fir and western larch seedlots. In contrast, only the 3% peroxide treatment for 1 hour was comparable to the control results for *Abies lasiocarpa* seedlots. In some of the *Abies* seedlots, germination was reduced with the 3% peroxide for 4 hours treatment. For all three conifer species, the two 16 hour treatments increased the degree of germination variability across all seedlots and resulted in a greater percentage of seed with damaged seed coats.



Sirococcus fruiting bodies on pine needles.



A young pine seedling succumbs to damping-off.

Part C - Field Germination

Results of total germination under greenhouse conditions for all the tested seedlots are shown in Table 2. Stratified seed was single sown into cavities of 313a styrofoam blocks (198 cavities/block) loaded with a 1:3 vermiculite :peat media mix and then covered with a thin layer of forestry sand. The greenhouse environment was set to maintain a 20^0 C soil temperature under an operational misting schedule. Overall, lower germination values were recorded across all seedlots and treatments compared to the laboratory results. For Fdc and Lw, 3% hydrogen peroxide for I or 4 hours resulted in germination values comparable to the controls. Sub-alpine fir germination was least affected by 3% hydrogen peroxide for 1 hour compared to the other treatments. Again, the 16 hour treatments resulted in greater variability coupled with reductions in total germination.

(Continued)

CONCLUSIONS

Hydrogen peroxide seed sanitation treatments can be and consistent for the coastal Douglas-fir and western larch a very effective method of reducing seedborne *Fusarium* seedlots, considerable reductions in pathogen levels may still levels on contaminated seedlots. Consideration of both the be obtained on *Abies lasiocarpa.* For sub-alpine fir, the 1 pathology and field germination results leads to the conclusion hour 3 % treatment is the best alternative to the 4 hour that the 4 hour 3% hydrogen peroxide treatment of stratified treatment so as to reduce any impacts on germination. seed is the best option for reducing *Fusarium* levels in Fdc Neither of the 16 hour treatments are recommended since and Lw. Although seed sanitation was the most effective they resulted in seed coat breakage and poor germination.

Table 1. Mean Total Percent Germination under Laboratory Conditions for Hydrogen Peroxide-treated Seedlots

Species	Seedlot	Control	SD	3% for 1h	SD	3% for 4h	SD	3% for 16h	SD	1% for 16h	SD
Fdc	424	86.0	3.3	85.0	4.5	85.3	2.8	84.8	2.2	84.8	1.5
(n=4)	479	85.0	4.4	85.5	0.6	87.8	2.9	88.5	4.0	86.5	2.4
	501	93.5	5.2	93.5	1.3	92.8	1.9	95.0	2.2	95.5	3.0
	510	95.0	2.4	92.3	3.0	93.3	1.0	95.0	1.8	94.0	2.2
	1262	83.3	3.9	80.5	4.4	81.0	7.3	77.3	4.3	73.0	2.2
	1270	86.5	0.6	81.3	5.7	80.3	2.5	81.5	1.7	82.8	2.8
	1292	78.3	5.3	75.0	9.7	77.3	3.0	75.3	5.0	72.3	3.3
	4532	85.0	4.8	84.8	3.4	87.0	2.3	78.0	3.5	78.3	3.9
	4605	86.0	4.3	77.8	4.1	88.3	1.7	86.0	3.5	88.5	2.5
	31902	95.5	2.4	93.8	1.9	94.5	2.1	94.8	2.9	94.8	3.3
Lw	3351	70.5	3.4	73.3	4.3	71.3	4.8	74.8	4.3	63.5	4.9
(n=4)	5102	83.5	3.3	86.0	4.5	89.3	2.5	91.0	3.4	88.0	1.4
	5266	93.5	2.6	95.5	2.6	93.5	2.4	94.5	3.1	93.8	1.7
	27269	88.0	2.6	84.0	4.2	85.0	0.8	87.5	2.1	87.3	5.6
	35684	80.0	5.0	82.5	5.0	82.5	5.1	82.0	4.1	77.5	5.1
	39150	66.5	2.1	67.0	3.8	70.0	4.7	71.8	6.6	66.5	1.3
	39152	45.0	3.9	46.0	3.7	49.3	4.6	50.5	3.8	41.3	3.3
	39265	84.3	5.5	87.5	2.5	85.8	4.3	87.5	4.8	86.8	3.9
Bl	2501	36.3	3.9	33.3	2.3	25.8	5.2	19.5	4.7	29.8	6.3
(n=4)	2504	53.0	3.7	44.0	2.7	44.3	4.3	54.3	5.1	37.0	7.9
	3410	36.0	2.7	38.0	5.8	34.5	4.1	19.3	8.1	21.3	6.2
	3413	29.5	4.4	26.0	6.3	24.0	6.3	11.0	4.1	23.8	7.0
	3644	45.5	5.9	46.3	3.9	48.8	5.1	35.8	4.7	30.5	2.5
	3651	3.3	0.5	1.8	1.0	2.0	1.4	1.5	1.3	3.0	2.2
	3677	56.3	10.0	56.5	3.9	54.8	4.9	48.5	7.4	35.0	6.4
	3678	22.0	3.2	22.3	3.0	30.0	2.9	30.0	4.4	19.5	4.5
	3680	17.8	5.7	19.0	2.7	17.8	5.0	16.3	5.7	8.3	3.3
	35024	3.5	1.7	3.3	2.1	3.0	3.2	2.0	0.8	2.0	1.4

(Continued)

Table 2. Mean Total Percent Germination under Greenhouse Conditions for Hydrogen Peroxide-treated Seedlots

Species	Seedlot	Control	SD	3% for 1h	SD	3% for 4h	SD	3% for 16h	SD	1% for 16h	SD
Fdc	424	80.0	7.5	68.3	4.9	78.3	4.6	73.3	1.8	77.2	6.6
(n=4)	479	78.3	3.8	84.4	1.8	81.7	4.9	80.0	1.8	74.4	2.9
	501	87.2	8.0	92.2	4.3	96.1	2.1	92.8	4.6	90.6	6.4
	510	90.6	2.1	87.8	6.9	94.4	4.6	91.7	2.1	92.8	4.9
	1262	79.4	6.1	80.6	4.6	78.9	3.8	75.0	5.8	74.4	3.8
	1270	80.0	3.1	81.7	6.4	85.0	1.1	75.6	4.1	75.0	8.4
	1292	70.6	10.6	73.9	11.1	68.9	3.1	66.7	6.3	75.6	7.7
	4532	63.3	8.2	64.4	4.8	58.3	7.6	52.8	11.4	58.3	4.9
	4605	71.7	7.3	70.6	6.9	64.4	8.9	71.7	6.4	77.2	4.6
	31902	96.1	1.1	95.0	3.8	92.8	3.3	93.3	1.8	93.9	3.3
Lw	3351	45.6	6.7	40.6	8.4	45.6	7.8	33.3	6.5	42.8	7.3
(n=4)	5102	70.6	10.6	68.3	7.3	67.2	4.6	76.7	2.9	72.2	4.3
	5266	85.6	12.8	88.3	6.4	96.7	2.9	95.6	2.6	95.0	3.3
	27269	83.3	10.0	70.6	14.6	77.2	4.2	88.3	5.8	81.7	4.9
	35684	71.1	8.3	70.0	5.9	77.8	9.1	80.0	6.5	68.9	4.1
	39150	66.1	7.6	71.7	4.9	72.2	6.7	63.9	2.8	76.7	7.6
	39152	48.9	6.4	51.1	3.1	41.1	10.5	52.8	11.7	36.1	9.0
	39265	87.8	5.9	91.1	4.4	82.8	8.4	87.8	4.3	85.0	7.6
Bl	2501	29.4	5.8	28.3	10.3	18.3	6.1	22.8	3.8	26.1	6.9
(n=4)	2504	43.3	5.3	40.0	4.8	38.9	5.9	42.2	5.4	33.3	5.7
	3410	21.7	5.3	35.0	11.7	25.6	4.3	17.2	4.6	18.9	2.9
	3413	35.6	4.8	25.6	3.8	24.4	7.0	20.6	2.1	21.1	2.9
	3644	33.3	3.9	38.9	12.9	35.6	4.4	45.6	3.8	25.6	5.9
	3651	0.6	1.1	3.9	3.3	2.8	1.1	0.6	1.1	1.1	1.3
	3677	45.6	5.9	41.7	4.6	38.9	3.8	46.1	4.2	37.2	8.6
	3678	18.9	5.3	21.1	6.9	25.0	5.6	22.8	6.6	15.6	1.8
	3680	17.2	5.8	11.1	7.9	10.6	5.8	8.9	4.1	9.4	3.3
	35024	2.2	1.8	3.3	2.9	2.2	1.8	0.6	1.1	0.6	1.1

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Melody Neumann
Ecos Biological Consultants

David Trotter
Nursery Extension Services

David Kolotelo
Tree Seed Centre

New Impact of the Western Conifer Seed Bug, *Leptoglossus occidentalis*, on Developing Douglas-fir Seeds.

The western conifer seed bug, *Leptoglossus occidentalis* Heidemann (Hemiptera: Coreidae), is a pest of conifer seed orchards throughout western North America (Koerber, 1963; Connelly and Schowalter, 1991). Adults and nymphs cause damage by inserting their stylet-like mouthparts into developing seeds within cones and digesting seed contents. Seeds which have been partially fed on can be identified by x-ray radiography, but seeds which have been completely depleted are difficult to distinguish from seeds which have aborted due to unrelated environmental factors (Schowalter and Sexton, 1990). Estimates of seed losses due to *L. occidentalis* are imprecise, but range from <5-50% for coastal Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, and 70-80% for western white pine, *Pinus monticola* Dougl. ex D. Don (Hedlin et al., 1981; Connelly and Schowalter, 1991; Blatt and Borden, 1996; Schowalter, 1998). Krugman and Koerber (1969) have also noted that early season feeding by *L. occidentalis* on developing cones of ponderosa pine, *Pinus ponderosa P.* Laws. ExC. Laws., results in collapsed seeds which adhered tightly to the cone scales. We report for the first time similar seed fusion in Douglas-fir cones as a result of *L. occidentalis* feeding.

Nymphs of *L. occidentalis* were introduced onto bagged Douglas-fir cones to determine the effects of feeding at different times during cone development in TimberWest Ltd.'s Mount Newton Seed Orchard, Saanichton, B.C.. Newly pendant cones were protected with mesh bags (three cones per bag, 28 bags in total) in early May to prevent feeding by resident *L. occidentalis*. *Six* second instar nymphs were placed onto three cones in each bag for a two-week period at one of the following times: early June, early July or early August, 1997, representing early, mid and late stages of cone development. Control bags remained sealed throughout the season. A final set of seven groups of three cones each were tagged in May and left as unbagged controls. Nymphs were removed at the end of each twoweek period and the bags resealed until harvest on 1 September. Bags which were dislodged during the experiment, or which experienced unusually high nymphal mortality, were removed from the experiment, and the corresponding replicates deleted.

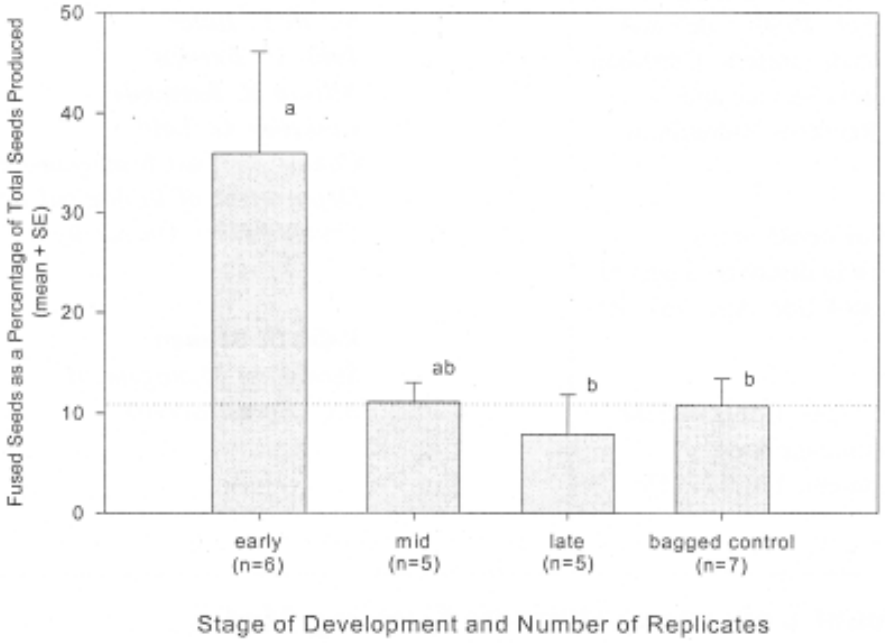
An average of 4.2 nymphs per bag (primarily third and fourth instars at the end of the two-week period) survived. Cones were air dried at room temperature, dissected by hand, and all seeds counted. Seeds which could not be removed without breaking the seed coat, or that had completely fused to the scale were classed as fused. Fused seeds on galled scales characteristic of damage caused by the the Douglas-fir cone gall midge, *Contarinia oregonensis* Foote, were discounted.

Cones which were exposed to *L. occidentalis* feeding for two weeks in June during early cone development had 36.0% of their total seeds classed as fused (Figure 1), compared to only 10.7% in control cones. These results support the findings of Krugman and Koerber (1969), who found a similar impact of early season feeding by *L occidentalis* on developing cones of ponderosa pine. We hypothesize that during early seed development, a bug's stylets rupture the incompletely foiined seed coat, allowing spillage of seed contents and the bug's digestive enzymes, and fusing the seed to its scale. Under normal extraction procedures, fused seeds would most likely go undetected. This little-documented impact of *L. occidentalis,* in addition to the common misdiagnosis of aborted seeds, further suggests that past assessments of damage by the bug may have been considerably underestimated.

We thank Tim Crowder, TimberWest Ltd., for welcoming research at Mount Newton Seed Orchard. This research was supported by Forest Renewal B.C., the Natural Sciences and Engineering Research Council of Canada, and 23 forest industries.

(Continued)

Figure 1. Comparison of fused seeds occurring after feeding by *L. occidentalis* for two weeks on Douglas-fir cones at three different stages of cone development in a coastal B.C. seed orchard. The dotted line represents an unbagged control. Bars with the same letter are not significantly different (Tukey's HSD test performed after arcsine transformation of data, $P<0.05$).



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***Sarah L. Bates*[1]**
***John H. Borden*[1]**
***Allison R. Kermode*[2]**
***Cameron G. Lait*[2]**
Centre for Pest Management[1]
Department of Biological Sciences[2]
Simon Fraser University

Robb G. Bennett
Seed Pest Management
B. C. Forest Service

Coconut Coir as an Alternate Growing Media

Introduction

Containerized conifer seedlings are normaly grown in a mixture of sphagnum peat with a minor component of vermiculite/perlite/sawdust or expanded polystyrene beads.

Coconut coir (mesocarp pith) is an organic byproduct of coconut production and has physical characteristics/ qualities very similar to sphagnum peat moss. Main differences include a higher lignin content and a lower tendency to become hydrophobic upon drying. These result in a slower decomposition rate allowing maintenance of aeration porosity throughout more of the growing season as well as allowing for easier and more uniform rewetting of the media after a drying cycle. Price is about 15 - 20% higher than peat at this time.

Coconut coir is said to be non-toxic and contain no weed seeds. However there may be batches which contain elevated salt levels (high E.C.) hence leaching prior to use is recommended.

The main source at this time is Sri Lanka.

(Continued)

Trial

The 1996 Coconut coir trial attempted to verify the suitability of the material as a substitute for vermiculite, peat or both as a growing media for forest seedlings. Treatments utilized were regular 3:1 peat/vermiculite, 3:1 peat/coir and 100% coir. Stocktypes grown were 1-0 container 410 Lodgepole pine in both copper treated and regular PSB, and coastal Douglas-fir and White spruce in regular PSB. Sow date... March 08, 1996.

Fd c	Height			Root Collar Diameter			Shoot Dry Weight			Root Dry Weight		
% Coir	Mean	SE	DMT	Mean	SE	DMT	Mean	SE	DMT	Mean	SE	DMT
0	341.76	5.37	a	3.62	0.07	a	3.14	0.12	a	1.17	0.05	a
25	344.31	4.79	a	3.77	0.07	a	3.22	0.12	a	1.26	0.06	a
100	299.77	5.97	b	4.45	0.07	b	3.32	0.14	a	1.51	0.07	b

Pli PCT	Height			Root Collar Diameter			Shoot Dry Weight			Root Dry Weight		
% Coir	Mean	SE	DMT	Mean	SE	DMT	Mean	SE	DMT	Mean	SE	DMT
0	187.57	6.01	a	3.81	0.06	a	3.06	0.11	a	1.21	0.06	a
25	194.67	5.38	a	3.96	0.09	a	3.14	0.14	a	1.34	0.08	a,b
100	151.43	3.89	b	3.98	0.06	a	2.17	0.09	b	1.4	0.05	b

Pli	Height			Root Collar Diam.			Shoot Dry Weight			Root Dry Weight		
% Coir	Mean	SE	DMT	Mean	SE	DMT	Mean	SE	DMT	Mean	SE	DMT
0	196.58	6.97	a	3.54	0.07	a	2.77	0.12	a,b	1.22	0.06	a
25	191.24	5.63	a	3.84	0.06	b	3	0.11	a	1.67	0.08	b
100	170.29	5.04	b	3.89	0.07	b	2.64	0.08	b	1.63	0.07	b

Sx	Height			Root Collar Diam.			Shoot Dry Weight			Root Dry Weight		
% Coir	Mean	SE	DMT	Mean	SE	DMT	Mean	SE	DMT	Mean	SE	DMT
0	290.09	9.17	a	3.99	0.06	a	3.1	0.13	a	1.17	0.06	a
25	259.75	9.9	b	3.83	0.08	a	2.8	0.15	a	1.03	0.06	a
100	254.09	6.28	b	4.07	0.06	a	3.06	0.1	a	1.48	0.06	b

Results

Preliminary observations on August 01, 1996 indicated no adverse effects for any of the species trialed or the copper/non-copper treatments. Nursery culture, in particular water management, required a slight amendment to accomodate the increased water holding capacity of the coir media.

Treatments were evaluated during the regular fall/ winter lift. Height, root collar diameter, shoot and root dry weights were measured, and samples of all treatments were sent to John Dennis at Pacific Forestry Centre for pathogen analysis. For Sx a decrease in height was observed for both the 25% and 100% coir treatments, as well an increase in root dry weight for the 100% coir. PSB Pli showed a decrease in height and shoot dry weight for 100% coir only, and an increase in RCD and root dry weight for both the 25% and 100% treatments. With PCT Pli the pattern was similar except that no difference in RCD was observed. The most pronounced differences were observed with Fdc. Here the 100% coir treatment expressed reduced height growth, increased RCD and increased root dry weight, with no difference in shoot dry weight. It is interesting to note that even though morphological differences were not always physically measurable, visually the trend from 0 to 100% coir could be detected in all species. The latter required looking at the root systems, with Fdc being the most pronounced (lighter coloured, thicker root systems as % coir increased).

The pathogen analysis indicated the highest presence of Fusarium sp. in the 100% coir treatments. The lowest numbers of Fusarium sp. were found in the 3:1 peat: coir treatments, with the 3:1 peat: vermiculite showing intermediate numbers. For the copper treated Pli the latter trend was reversed with the 3:1 peat:vermiculite having the lowest levels of Fusarium sp. and the 3:1 peat: coir containing intermediate levels. No disease expression was encountered in the trial and throughout the treatments the presence of Pythium sp. was found to be negligible.

Eric van Steenis
Nursery Extension Services

1996 Interior Orchard Cone Crop Summary

The following is a crop summary of the number of hectoliters (hl) collected from ministry and private interior seed orchards.

Seed yields (kg) and seedling estimates are based on extraction reports from the Tree Seed Centre (estimates bolded). However, there are a number of seedlots for which data is still pending. These were calculated using historical data. A complete list will be circulated once all the results become available.

David Reid
Coastal Seed Orchards

Ron Planden
Interior Seed Orchards

Ministry Orchards

Agency	#	Name	Species	Seedlot	Cones Collected (hl)	Actual Yield (grams)	Estimated Yield (grams)	Potential Seedlings (000's)*
MoF	205	Skimikin	Sx	60244	20.4	26,914		**3,735.6**
MoF	205	Skimikin	Sx	60245	24.6	29,936		**4,375.3**
MoF	206	Skimikin	Sx	60246	7.2	7,813		**1,345.2**
MoF	207	Skimikin	Sx	60247	61.2	65,525		**9,911.0**
MoF	207	Skimikin	Sx	60249	31.4	31,458		**4,550.6**
MoF	208	Skimikin	Sx	60248	19.8	20,527		**3,041.0**
MoF	302	Skimikin	Sx	60242	39.6	41,337		**5,565.6**
MoF	209	Kalamalka	Sx	60431	25.3	27,312		**4,296.3**
MoF	304	Kalamalka	Sx	60432	136.6	182,746		**25,300.7**
MoF	305	Kalamalka	Sx	60433	14.1	13,175		1,005.1
MoF	305	Kalamalka	Sx	60434	58.6	52,347		4,177.1
MoF	306	Kalamalka	Sx	60435	77.8	70,457	5,779.2	5,545.7
MoF	201	PGTIS	Pli	60299	16.8		2,924.0	1,197.5
MoF	203	PGTIS	Pli	60300	8.5		3,784.0	605.9
MoF	203	PGTIS	Pli	60083	11.0	3,927		784.1
MoF	307	Kalamalka	Pli	60437	23.0	6,769		1,639.5
MoF	230	Kalamalka	Pli	60436	17.0		5,192.0	1,211.8
MoF	609	Skimikin	Pw	42131	11.8			841.1
Sub-total ministry orchards					**604.7**	**580,243**	**17,679.2**	**79,128.9**

Private Orchards

RFP	303	Eagle Rock	Sx	60142	9.4	4,374		670.0
RFP	303	Eagle Rock	Sx	60143	26.2	12,536		**1,838.6**
RFP	303	Eagle Rock	Sx	60144	5.2	2,987		370.7
RFP	303	Eagle Rock	Sx	60145	6.0	4,220		**591.5**
RFP	303	Eagle Rock	Sx	60146	5.0	2,621		**267.6**
RFP	303	Eagle Rock	Sx	60147	5.2	1,631		**234.8**
RFP	310	Eagle Rock	Pli	60131	8.8	631		**71.0**
VSOC	214	Vernon	Sx	60117	157.8	185,451		**24,417.7**
VSOC	214	Vernon	Sx	60118	169.4	133,598		**180,812.2**
VSOC	214	Vernon	Sx	60119	161.2	128,231		**22,992.9**
Weyer	308	Grandview	Pli	60402	39.5	9,116		**985.5**
Sub-total private orchards					**593.7**	**485,396**		**233,252.5**

Total all interior orchards	**1,198.4**	**1,065,639**	**17,679.2**	**312,381.5**

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

1996 Coastal Seed Orchards Cone Crop Summary by Agency

updated March 5,1997

Agency Owner	Orchard Number	Location	Species	Seedlot	Cones collected (Hl)	Breeding Value	Actual Yield (kg)	Estimated yield (kg)	Estimated seedlings *
Mof	149	Bowser	Fdc	60371	2.40	12.9	0.433		**18,400**
Mof	146	Surrey	Fdc	60601	9.20	3.0	0.858		**16,900**
Mof	143	Quinsam	Hw	60372	17.00	2.0	13.445		**2,655,900**
Mof	131	Cobble Hill	Se	60124	137.60	3.0	57.925		7,894,772
Mof	180	Cobble Hill	Ba	60362	0.20	2.0		0.40	2,200
Mof	175	Saanich	Pw	60361	1.30		0.339		6,780
Sub-total Ministry orchards					167.70		73.000	0.40	10,594,952
Private Orchards:									
CFP	116	Sechelt	Fdc	60108	11.40	2.2	3.489		**113,500**
	133	Sechelt	Hw	60109	5.80	10.0	4.169		**501,800**
	133	Sechelt	Hw	60376			0.994		**158,200**
	133	Sechelt	Hw	60377			0.260		**36,500**
MB	139	Yellow Point	Cw	60327	1.10	2.0	1.720		**227,300**
	132	Yellow Point	Hw	60328	11.50		8.304		1,275,943
PFP	171	Saanichton	Cw	60342	1.66	2.0	0.780		**138,500**
	111	Nootka	Fdc	60129	12.68	6.4	1.203		37,303
	166	Saanichton	Fdc	60315	7.15	9.7	1.438		44,590
	121	Saanichton	Fdc	60313	28.16	6.9	5.565		172,560
	121	Saanichton	Fdc	60314	39.85	3.4	8.795		272,715
	165	Saanichton	Hw	60130	1.75	2.0	1.770		**289,800**
	160	Saanichton	Ba	60312	2.96	2.0	2.982		13,717
TWest	140	Mt. Newton	Cw	60075	46.25	2.0	23.247		**5,437,100**
	140	Mt. Newton	Cw	60076	8.00	2.0	5.246		**1,218,200**
	134	Mt. Newton	Fdc	60363	17.70		2.992		92,776
	154	Mt. Newton	Fdc	60364	21.10		5.133		**111,300**
	154	Mt. Newton	Fdc	60365	43.33		9.285		**263,400**
	129	Mt. Newton	Ba	60366	7.00			14.00	64,400
	138	Mt. Newton	Cy	60369	2.40			1.00	29,161
	403	Mt. Newton	Pw	60368	3.20			1.20	24,000
WFP	155	Lost Lake	Cw	60239	1.40	2.0	0.609		**98,800**
	155	Lost Lake	Cw	60230	24.80	2.0		23.68	4,850,483
	128	Lost Lake	Cw	60238	7.20	2.0	1.854		**276,900**
	128	Lost Lake	Cw	60228	5.40	2.0	2.734		**418,000**
	128	Lost Lake	Cw	60229	33.80	2.0	19.272		**2,728,000**
	126	Lost Lake	Hw	60231	1.00		0.986		**160,000**
	127	Lost Lake	Hw	60233	3.00		3.046		468,030
	127	Lost Lake	Hw	60234	6.20			6.26	962,181
	156	Lost Lake	Hw	60232	10.40		7.689		1,181,446
	142	Lost Lake	Ss	60235	8.20	1.3	5.763		**537,800**
	142	Lost Lake	Ss	60240	9.60	1.3	6.879		**823,100**
	157	Lost Lake	Ss	60236	5.40	1.3	2.431		**447,700**
Sub-total Private orchards:					389.39		138.635	46.15	23,475,204
Total all Coastal orchards:					**557.09**		**211.64**	**46.55**	**34,070,156**
								Total kg:	**258.181**

* = seed center yield estimates are in bold, other data are averaged estimates.

EVENTS

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em: evaneerden@prtgroup.com

Program Chairman - Drew Brazier — Tel: (250) 387-8955; Fax: (250) 356-0472
em: Drew.Brazier@gems. gov.bc.ca

Please contact Drew directly with program suggestions/presentations.

Registration - Susan Zedel — Tel: (250) 356-1598; Fax: (250) 356-0472
em: Susan.Zedel@gems 8.gov.bc.ca

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Posters - Patti Kagawa — Tel: (250) 387-8949; Fax: (250) 356-0472
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(Continued)

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Dr. Barbara Hawkins Ph: 250-721-7117
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It was produced by volunteer members of the BCTSDA and funded by the BCMOF and FRDA II. Special thanks goes out to Frank Portlock for the compilation, and Dr. George Edwards for his technical edit.

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Eric van Steenis
Nursery Extension Services

CONTRIBUTORS TO THIS ISSUE

Paige Axelrood
Reed Radley
Monica Chow
BC Research Inc.
3650 Wesbrook Mall
Vancouver, BC V6S 2L2
Canada
Ph: 604-224-0540
Fax: 604-224-4331

Sarah L. Bates
John H. Borden
Allison R. Kermode
Cameron G. Lait
Dept. of Biological Sciences
Simon Fraser University
8888 University Drive
Burnaby, BC V5A 1 S6
Canada
Tel: 604-291-4163
Fax: 604-291-3496
slbates@sfu.ca

Robb B. Bennett
B.C. Forest Service
7380 Puckle Rd. R.R.#3
Saanichton, BC VOS IMO
Canada
Tel: 250-652-5600
Fax: 250-652-4204

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

David Kolotelo
Tree Seed Centre
18793 - 32nd Avenue
Surrey BC V4P 1M5
Canada
Phone: (604) 541-1683
Fax: (604) 541-1685

Melodie Neuman
Ecos Biological Consultants
c/o Faculty of Agriculture (AO5)
University of Sydney
Sydney, NSW 2006
Australia

Don Pigott
Yellowpoint Propagation Ltd.
13735 Quennell Rd., RR#3
Ladysmith, BC VOR 2E0
Canada
Tel: 250-245-4635
Fax: 250-245-5935

Ron Planden
Coastal Seed Orchards
73 80 Puckle Road
Saanichton, B.C. V8M I W4
Canada
Phone: 604-652-8303
Fax: 604-652-4204

David Reid
Coastal Seed Orchards
7380 Puckle Road
Saanichton, B.C. V8M 1W4
Canada
Phone: 604-652-5600
Fax: 604-652-4204

Heather Rooke
Tree Seed Centre
18793 - 32nd Avenue
Surrey BC V4P 1M5
Canada
Phone: (604) 541-1683
Fax: (604)541-1685

Ward Strong
Kalamalka Seed Orchards
3401 Reservoir Rd.
Vernon, BC V 1B 2C7
Canada
Ph: 250-549-5696
Fax: 250-387-0046

David Trotter
BC Forest Service
Nursery Extension Services
14275 - 96th Avenue
Surrey BC V3V 7Z2
Canada
Phone: (604) 930-3302
Fax: (604) 775-1288

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