NURSERY AND SEED

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Seed and Seedling Extension Topics

Eric van Steenis — Editor

Well, no new babies to report this time, hope I didn't miss any! The proceedings for the 1995 FNABC are still being compiled by yours truly and will be out prior to the 1996 FNABC. A few diehard procrastinators out there still have not submitted their papers.

It seems that the spring and early summer of 1996 have been exceptionally poor for growing in general. So much so that "blaming it on the weather" might actually have some merit this year. Those graphing "accumulated growing degree days" at their sites are noting a lag of 1 to 3 weeks relative to last year. Hopefully seedling adjudicators are having some compassion, at least with respect to summer delivery crops.

As you can see I am still the editor, and unless our section goes the way of the dinosaur (not likely), will remain so for another issue or two. Articles have been contributed by a number of much appreciated individuals so read on! Our feature in this edition concerns itself with recent chlorophyll fluorescence research. It is hoped by some that chlorophyll fluorescence will provide a window into the physiology of the plants we deal with. I think that after reading the article you will see that it is getting closer all the time. Drs. Binder and L'Hirondelle should be commended for sticking by this project through the rough years.

Eric van Steenis
Nursery Extension Services

GROWER'S NOTES

Caloscypha on *Abies spp.*

The cold fungus (*Caloscypha fulgen*s (Pers.) Boud.) is generally thought to be a problem with spruce seeds, but several seedlots of *Abies* were seriously infected during 1996. The fungus infects cones in contact with the soil or litter layer and kills the seed, leaving the contents mummified. As most *Abies* seed is collected by helicopter it is surprising that *Caloscypha* is present.

The most probable explanation is that the landing site for cones is also the infection site. If conducting *Abies* collections one should ensure tarps are present to avoid cone and soil contact. *Caloscypha* and *Abies* can be a dangerous combination as the fungus grows well in cool, moist conditions and *Abies spp.* require long periods of these conditions to remove seed dormancy. It is essential that collectors avoid letting cones come in contact with the ground, especially for species requiring long stratification periods.

Dave Kolotelo
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TECH TALK

Quantum Leak Ñ Estimating Stress Damage in Nursery Seedlings

British Columbia forest nurseries grow almost 2000 seedlots of about 20 tree species each year. Assessing seedlings for morphology (height and diameter) and physiology at critical times in their growth cycle contributes to the current high quality of planting stock.

An example of physiological assessment is the fall "Storability Test" (-18°C freezing test), which estimates visible injury after freezing. Seedlings with less than 25% injury are judged ready for overwinter cold storage (Simpson 1990). This test seems to determine when seedlings can safely be lifted for storage, but it has some drawbacks. It takes 7 to 10 days for visible injury to develop, and estimating injury is subjective.

Nursery managers need faster results to increase flexibility in lifting stock and improve coordination of lifting schedules among species. Shortening the freezing portion of the test is not practical because the freezing rate affects the amount of damage (Binder and Fielder 1996b). However, shortening the time needed to detect injury is possible, as shown by the tests described below.

Another shortcoming of the standard storability test is that it is difficult to apply to deciduous species such as larch. Estimating visible damage to stems is slower and less quantitative than for foliage, so a faster, more accurate and precise test is needed. It is also desirable to be able to detect stock damage from stresses other than freezing, so that only high quality stock is lifted and stored. These improvements to storability testing are possible by adopting some of the physiological methods developed by researchers.

Two stress-physiology tests, chlorophyll fluorescence (CF) and stress-enhanced-electrolyte leakage (SEEL), are promising procedures for storability testing. These tests have been developed and used by researchers in horticulture, agriculture, and forestry. After discussions with Ministry of Forests Nursery Services staff, Research Branch scientists proposed transferring the tests to an operational setting for estimating storability of conifer seedlings.

Our goal was to provide evidence to forest nurseries that CF and SEEL can shorten the time needed to determine over-winter storability of conifer planting stock, can make assessments more quantitative, and can be used with deciduous species.

The New Procedures

Chlorophyll fluorescence determines at what efficiency the light-absorbing portion of a plant's photosynthetic system is functioning (Vidaver *et al*. 1991; Binder and Fielder 1996a, b). Quantum yield (QY) is an estimate of this efficiency. Quantum yield measurements are faster than measuring photosynthetic CO_2 uptake, are not affected by CO_2 level, and do not require calculation of leaf area. There is increasing use of CF in estimating the effects of environmental stresses such as freezing and heating on plants (Ball *et al.* 1995; Mohammed *et al.* 1995; Binder and Fielder 1996a, b).

We evaluated one of several commercial "pulse-type" fluorometer models (Mohammed *et al.* 1995; Binder *et al.* 1996) for operational use. The EARS-PPM is small and convenient to use, and can be used for measurements in the dark or in ambient light conditions. It pulses high intensity light (about two times sunlight) at the foliage, and records the amount of red light emitted as fluorescence. One person can measure about 2000 samples per day, and readings can be done within 24 hours of applying stress.

Stress-enhanced electrolyte leakage (SEEL) has been used for over 60 years to estimate the frost hardiness of plant tissues (Dexter *et al.* 1932, Calkins and Swanson 1990). This method is based on the assumption that excessive stress will cause cell membranes to be damaged (Steponkus 1984), allowing electrolytes to leak from the tissue when it is immersed in water. Increases in electrical conductivity are measured with a conductivity meter 24 and 48 hours after applying stress. Higher conductivities are assumed to correspond to higher stress damage.

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Test Results

The testing included two phases of using QY and SEEL to detect and predict damage: a preliminary laboratory study in Victoria, and operational trials in Vernon, Prince George, and Surrey. For the laboratory study, we report some data on detection and prediction of damage after freezing or heating Sitka spruce seedlings. For the operational trials, we report data on prediction of freezing damage after the -18^{o}C test for several species in the fall of 1995.

A) Laboratory Studies

Sitka spruce seedlings were removed from cold storage in the spring of 1995 and thawed. Seedlings were stressed by freezing or heating to different temperatures to produce a range of seedling quality from no damage to severely injured or dead. Physiological measurements were done in laboratory and growth chamber conditions 1 to 3 days after stress. Readings of QY were done in the light (400 *u*mol m^{-2} s^{-1} photosynthetic photon flux density, PPFD) or dark. Visible injury (VI) assessment of needles was done a week after stress. Results for QY and SEEL were compared with VI, and with shoot growth of seedlings after 8 weeks in a greenhouse.

Freezing damage to shoots was detected within 1 or 2 days by measuring QY and SEEL (Figure 1A). Injury was detected at -12^{o}C (by SEEL) and -18^{o}C (SEEL and QY). Light and dark readings of QY were strongly correlated with each other (r = 0.99) with light readings about 20% lower than dark (Figure 1A). Individual QY and SEEL values were closely correlated with each other (r = 0.84) and means were correlated with foliar VI(Figure 1B). The length of flushed branches (new shoot growth after spring bud break) (Figure 1B), a measure of field performance, could be predicted from QY (r^2 = 0.96) and SEEL (r^2 = 0.90).

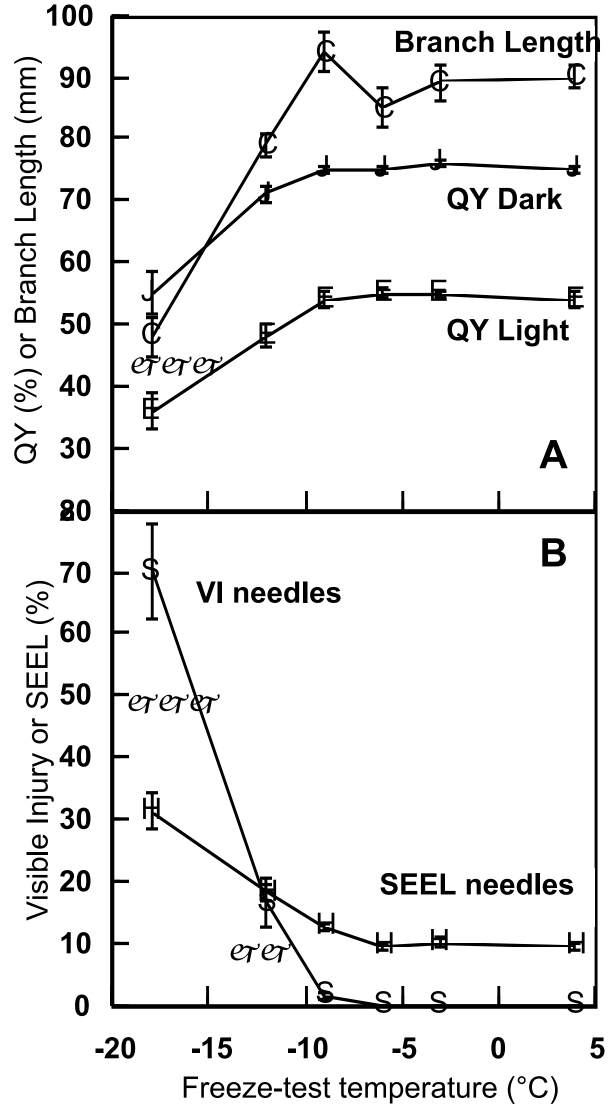

Figure 1. Freeze-test results for Sitka spruce, showing A) quantum yield (QY) in the light and dark, branch length, and B) visible injury to needles (VI), stress enhanced electrolyte leakage of needles (SEEL). Significant (** or ***) effects of freezing were found at -12^{o}C (SEEL) and -18^{o}C (SEEL and QY). Points are means $^{+}$ 1 SE of 16 seedlings.

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Damage after heating was also detected by QY and SEEL (Figure 2). For this stress, QY was more sensitive than SEEL at detecting injury. A one day exposure to 40°C resulted in dark QY values dropping by a third compared with controls, while VI and SEEL were hardly affected. Two days of heat reduced QY to less than half of controls, and there was a near doubling in RC, but there was only 9% VI. The length of flushed branches 8 weeks later was reduced by more than half for the 2 day treatment, showing that QY was a good predictor of heat effects on growth.

These results show that a pulse-modulated fluorometer or conductivity meter can be used to quickly determine if stock has been damaged by temperature stress. It may also be possible to predict growth potential from post-stress QY values.

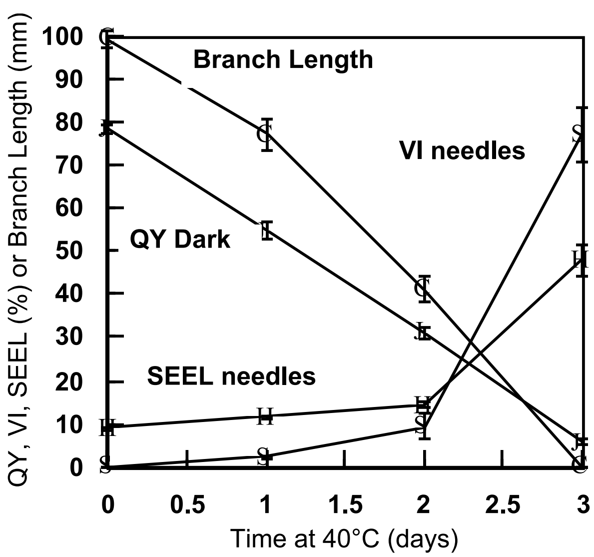

Figure 2. Quantum yield (QY), branch length, SEEL, and visible injury (VI) of Sitka spruce after heating. QY dark was measured 5 hours later, SEEL 2 days later, VI 5 days later, and branch length 8 weeks later. Points are means + 1 SE of 20 seedlings.

B) Operational Trials

Operational scale trials of QY and SEEL were done in conjunction with fall storability testing. At weekly intervals from September to December, -18°C freeze-tests were done for 18 seedlots of six species of conifers. These trials were done at Prince George, Vernon, and Surrey, with only a small part of the data reported below.

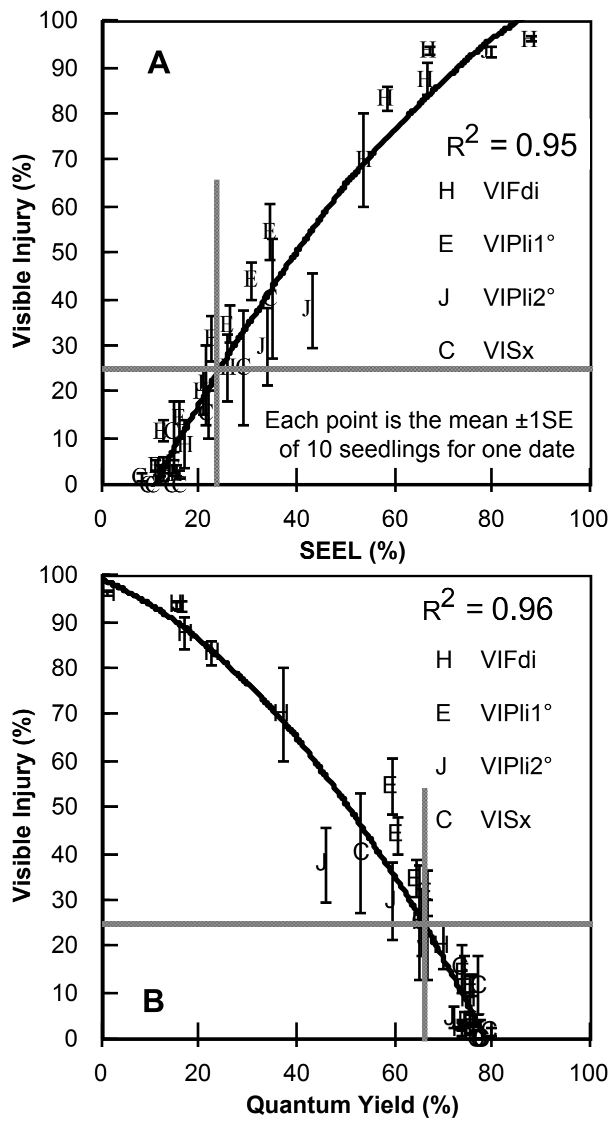

Figure 3. Relationship between visible injury (VI) to shoots and A) SEEL, and B) QY, for three species of conifers tested at Prince George. Fdi = interior Douglas-fir, Pli = interior lodgepole pine with primary or secondary needles, and Sx = interior spruce. The horizontal line shows 25% VI, and the vertical line the corresponding QY or SEEL reading. Tests were done on nine dates in fall 1995.

Both QY and SEEL were excellent predictors of visible injury after freezing for most species. When data were pooled over all dates, plots of seedlot means of VI against QY or SEEL show curves with R^2 values ranging from 0.89

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to 0.99 for Vernon and Prince George data. When data were pooled across species, the relationships were still strong (Figure 3A, B). Prince George data suggested that to meet the current criterion of less than 25% VI (Simpson 1990), seedlings should have less that 25% SEEL or greater than 65% QY.

For western larch measured in Vernon, QY and SEEL estimates did not exactly fit the general curve for the other species. This is because the VI estimates were for stems, and were very difficult to do accurately. Trends in QY and SEEL over time clearly showed the expected pattern of frost hardiness for different seedlots (data not shown), indicating that these estimates gave an accurate indication of when these deciduous seedlings can safely be lifted.

Conclusions

Comparisons of QY readings made in the light and dark showed that both were effective at detecting stress damage. This means that fluorescence measurements can be made in the dark at room temperature, without the need for a growth chamber, and can be standardized among test dates and facilities. Measurements of SEEL can also be standardized within species.

Compared with VI assessments, QY and SEEL are more sensitive, quantitative, and objective. Measurements of QY can be taken within a few hours of stress exposure, while SEEL requires about two days for electrolyte diffusion. Reading individual samples takes only a few seconds for each technique. The instruments are portable, convenient to use, can be used with small amounts of tissue, and data handling can be automated. For deciduous species after leaf-fall, stem tissues can be sampled for SEEL, and for QY if the tissues have enough chlorophyll. The cost of instruments range from about $500 for SEEL to about $12,000 for QY.

We believe that the laboratory and operational data suggest that QY or SEEL can replace visual damage assessment after the -18^{o}C test. This will save from four to seven days, and will result in more accurate assessments. Both QY and SEEL can be used with deciduous species such as western larch.

Disclaimer

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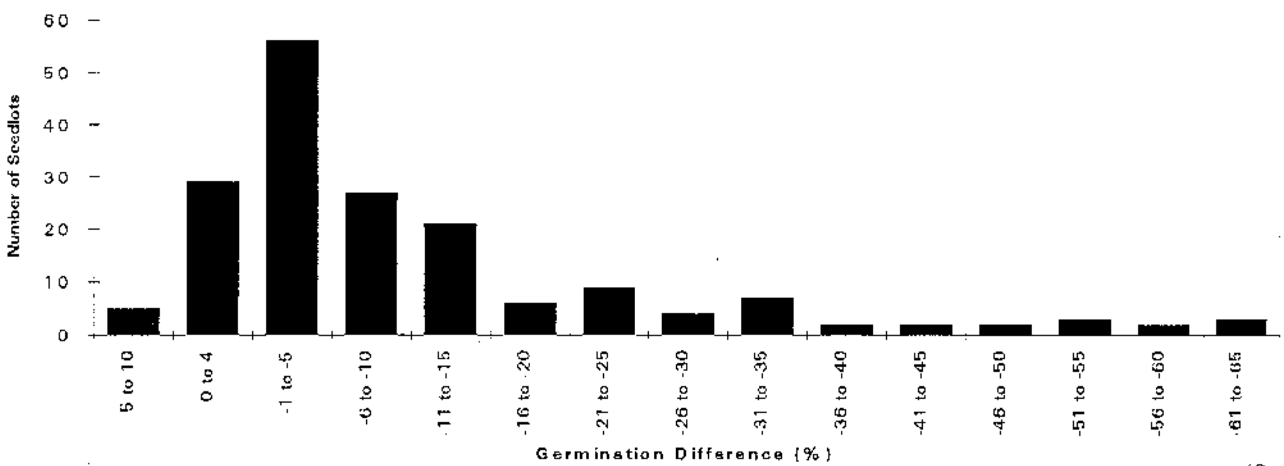
Western Redcedar Seed

This note addressing concerns over reduced nursery germination of western red-cedar (Cw) seed and the pelletting process. It also presents results of trial work on Cw at the Tree Seed Centre (TSC) that may be pertinent to nurseries.

Retesting

During the winter of 1996 the germination of 178 seedlots of western red-cedar was retested. Most of these seedlots had not been tested since 1990. For some seedlots large drops in germination were observed which have had large impacts on nurseries growing them. Below is a histogram illustrating the germination difference between the 1990 and 1996 tests (in 5% increments). A positive difference describes seedlots that have increases in germination over time while a negative difference indicates deterioration. We generally do not think of seedlots as increasing in germination over time. Small increases presented here are probably due to sampling variability between tests.

Approximately 19% of seedlots tested showed deterioration greater than 20%, with some as high as 65%. 75% of seedlots showing large downfalls were collected prior to 1982. Predicting germination decline is difficult because performance of most Cw seedlots is consistent over long periods of time. Cw Linear deterioration rate (using initial and current germination results divided by storage time) was updated to 1.35%/year from 0.77%/year based on the above retests. Deterioration rate of a seedlot was not related



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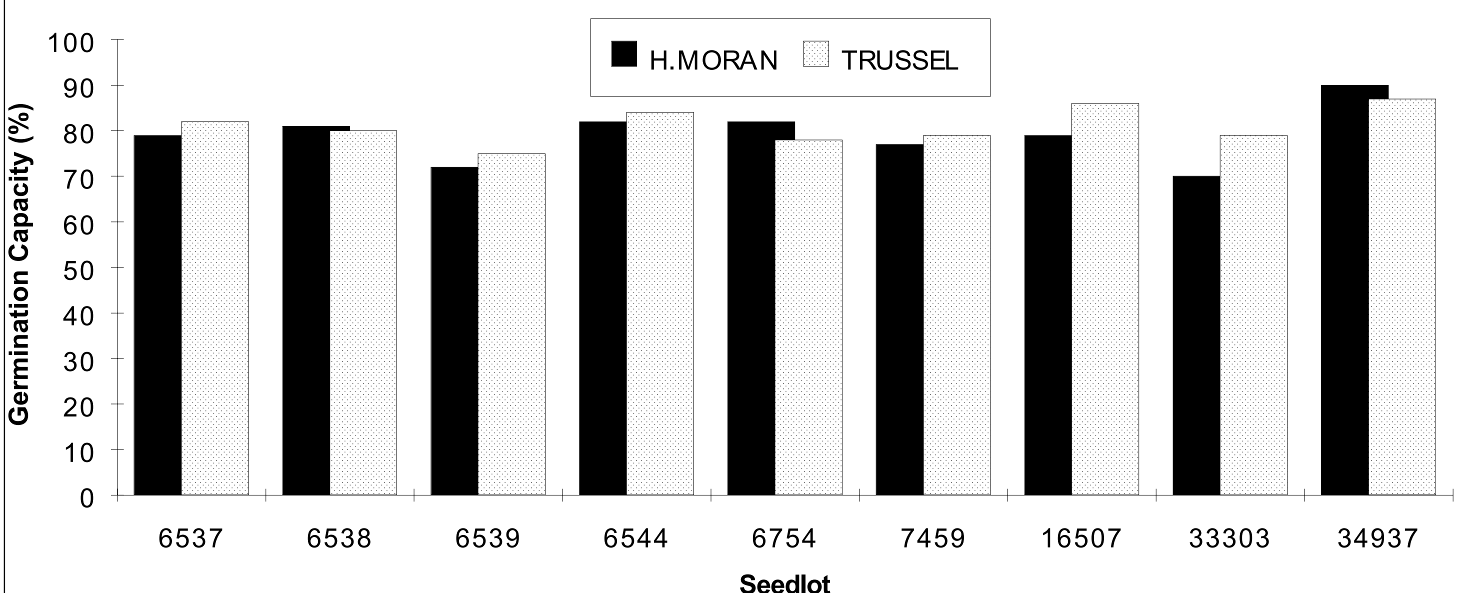
to its initial germination capacity. Although linear deterioration rates are useful in terms of prioritizing species the usual trend is for seedlots to perform consistently for a period and then drop-off rapidly. For many Cw seedlots the drop-off seemed to occur after about 4000 days in storage (»11 years). In the future, retesting of Cw seedlots will be conducted more frequently.

Pelletting

Pelletting was performed on all Cw sowing requests for greenhouse culture in 1996. It improves seeding efficiency by increasing individual seed weight and making the propagule shape more regular and easier to handle with most seeding machines. Cw does not require soaking or stratification treatments making it ideal for pelletting. Although pelletting can be performed on stratified seed the window of opportunity for use is greatly decreased. The disadvantage of pelletting is the reduction in germination rate because of the need to penetrate the pellet as well as the seedcoat (estimated at four days) Cw seed has a very small proportion of nutritive tissue (megagametophyte) and for seedlots of low vigour it is possible that seed reserves can be used up before emergence from the pellet.

Pelletizing is coordinated through the Tree Seed Centre and performed by Harris-Moran in California or on contract by Dr. Paul Trussel at the TSC. Choice of pelleter is based on sow date, size of request and whether any bulking of requests can take place. Some nurseries feel that one pellet type is superior, but the choice varies by nursery. In 1996 we tested nine seedlots that were pelletted by both Harris-Moran and Dr. Trussel. There was no difference in the germination capacity between the two as indicated in the Figure below. It is possible that a significant interaction occurs between pellet type and the equipment at individual nurseries, but results indicate that both pelleters can produce pellets of comparable quality.

The practice of pelleting adds an additional barrier to germination of Cw seed. It is crucial that after sowing pellets are not left to dry, but misted frequently to aid in pellet breakdown. Drying can cement the pellet to the seed restricting germination. The TSC has attempted various methods of assessing pellet breakdown (soaks, mists, germination dishes), but scoring was quite subjective and differences not clear. If anyone is involved in assessing pellet breakdown we would be interested in your methods and in helping to develop an industry standard for pellet quality.



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Stratification

It is generally assumed that no dormancy exists in Cw and that stratification would not have a beneficial effect on germination. This assumption was tested with 22 seedlots of Cw that were tested dry and with three weeks of stratification following a 24-hour soak. There was no difference in germination capacity (both 63%) and no appreciable difference in germination rate measured by the peak value (3.9 versus 4.1). This adds substance to the assumption that dormancy does not appear to exist in Cw and that there is no advantage in stratifying Cw seed. It was surprising that there was no appreciable gain in germination rate as stratification usually increases the rate of germination even if no increase in germination capacity occurs.

Soaking

Although stratification was not beneficial, a comparison of dry seed vs a 24-hour soak in aerated and non-aerated water was performed on three seedlots of Cw. The aerated soak was the best treatment (90%), followed by the non-aerated soak (86%) and the no soak treatment (78%). Although soaking and stratification are practical only for non-pelletized requests the option of soaking seed appears promising once one has decided not to use pelletized Cw seed.

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Tree Seed Centre.

Nursery Germination Comparisons

During the past three sowing seasons [1993, 94, 95] nurseries have provided information on the germination capacity of 324 sowing requests in the nursery. This note extends this information to all nurseries and hopes to solicit more feedback on the program. The comparison of nursery germination versus the latest lab germination [on SPAR] is presented in Figure 1 with the diagonal line representing a perfect relationship [Lab GC = Nursery GC]. While the germination of most sowing requests falls close to the line there are data points which show lab germination to be greater than nursery germination appearing to the right of the diagonal [nursery falldowns]. The relationship between germination just before shipping (Quality Assurance Testing) and nursery germination was similar, but only the latest TSC lab germination is included as it is more pertinent to the nursery.

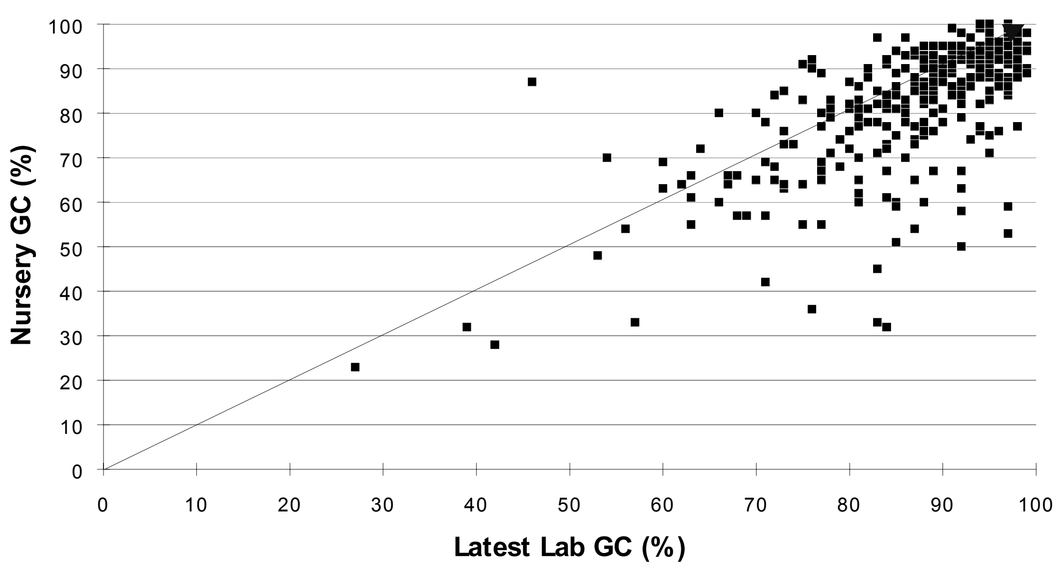

Figure 1. Latest Lab Germination Capacity (GC) of seedlots versus GC of sowing requests at the nursery. (Continued)

The data resulting from this program has several constraints, but I think it is useful in providing information on nursery performance, estimating average species falldowns and assessing priorities for seed research. It is the best information we have on a provincial basis for nursery performance versus lab data. I think that the issue of quantifying nursery falldowns is important and hopefully each nursery is conducting a similar comparison to improve the efficiency of their sowing program. The average species falldowns by species is illustrated in Table 1.

Table 1. Average nursery falldown in germination capacity by species (in %).

Species	# Requests	Lab GC	Nursery GC	Falldown
Ba	4	68	58	10
Bg	5	78	58	20
Bl	12	70	57	13
Cw	19	85	80	5
Fdc	18	92	88	4
Fdi	34	90	89	1
Hm	9	90	87	3
Hw	12	90	88	2
Lw	36	85	72	13
Plc	15	90	91	-1
Pli	32	94	90	4
Pw	9	77	78	-1
Py	22	86	80	6
SS	11	96	90	6
Sx	75	85	85	0
SxS	11	85	87	-2

Comments from nurseries on the usefulness of these comparisons have ranged from a desire to have the program expanded to include rate of germination with standard counting methods to being of no relevance to their operations. I would appreciate your comments on this program. Thank you.

Dave Kolotelo
Tree Seed Centre.

GALLERY® - A NEW PRE-EMERGENCE HERBICIDE FOR REFORESTATION NURSERIES

This year a new herbicide, isoxaben or Gallery®, was registered for use in reforestation nurseries. It was selected two years ago by the Canadian Forest Nursery Weed Management Association as a candiate for registration under the new URMUR (User Requested Minor Use Registration) pilot program. Trials were conducted across Canada and the reports were submitted by the URMUR forestry co-ordinator to Agriculture and Agri-food Canada. The following reports were submitted to include B.C. conifer species and to support the recommended use pattern on the Canadian label.

TOLERANCE OF FIVE CONTAINER CONIFER SPECIES TO THE HERBICIDE ISOXABEN - 1994

Objective: To study the effect of isoxaben (GALLERY®) on the germination, survival and growth of amabilis fir, western red cedar, Douglas-fir, lodgepole pine and white spruce container seedlings.

Location: Nursery Extension Services Test Nursery, B.C. Ministry of Forests, Surrey, B.C.

Site History: The seedlings were grown in styrofoam containers containing a 3:1 peat:vermiculite growing media with the addition of 3 kg/m^3 dolomite lime. The containers were 313B's which have 160 cavities per block.(764 seedlings per m^2). Seeding was done on May 6, 1994. Seeds of all species were double or triple sown to ensure one germinant per cavity, then covered with forestry sand. Species sown were amabilis fir, *Abies amabilis*; western red cedar, *Thuja plicata*; Douglas-fir, *Pseudotsuga menziesii*; lodgepole pine, *Pinus contorta*; and white spruce, *Picea glauca*. Seedlings were thinned three weeks later, and grown in a greenhouse until mid-July when they were placed in outdoor compounds for the remainder of the growing season.

Experimental design: Randomized complete block with six replications.

Application specifications: Isoxaben was applied with a motorized bicycle sprayer fitted with four even-spray 8003LP nozzles delivering a total spray volume of 400 l/ha at a pressure of 140 kPa. Rates of application were 0, 0.75, 1.5 and 2.25 kg a.i./ha for the pre-emergence spray and 0, 0.75, 1.5 and 3.0 kg a.i./ha at the post-emergence spray timing. Pre-emergence sprays were applied on May 9, 1994. Post-emergence sprays were applied August 1, 1994, 8 weeks after 80% of the conifer germinants had emerged in the container cavities.

Measurements: In October 1994, the number of seedlings in each replicate was counted and then fifteen seedlings per replicate were randomly extracted for morphological measurements (15 seedlings x 6 reps x 4 rates x 2 timings x 5 species = 3600 seedlings total). Each seedling was measured for height and root collar diameter (rcd). Tops and roots were placed in 3 groups of 5 seedlings per group per replicate, dried in an oven at 105^{0}C for 24 hours and then weighed for dry shoot and root weights. The data was subjected to analysis of variance and means were separated using Student-Newman-Kule's multiple range test ($p<0.05$).

Results: A summary of the results of the trial can be found in Table 1.

1. Seedling germination/survival

The pre-emergence sprays regardless of application rate significantly reduced seed germination in all but amabilis fir. This was particularily evident in white spruce in which the containers treated with 1.5 and 2.25 kg ai/ha had only 36.5 and 37.7 percent germination respectively. In contrast, the post-emergence sprays had no effect on seedling survival.

2. Seedling Morphometrics

Again, amabilis fir seedlings tolerated both the pre and post-emergence sprays with little or no effect on growth.The most susceptible species to the pre-emergence sprays were western red cedar, white spruce and lodgepole pine. With cedar and spruce, both height and root collar diameter were significantly reduced at the 1.5 and 2.25 kg a.i./ha rates. Similarly, both lodgepole pine and Douglas-fir seedlings were significantly shorter with increasing herbicide rates. In general, all 5 species tolerated the post-emergent applications of 0.75 and 1.50 kg a.i./ha but some reduction in height and rcd was found at the 3.00 kg a.i./ha in spruce.

Conclusions:

Pre-emergence sprays of isoxaben do not provide a viable weed control strategy due to their negative impact on seed germination and subsequent seedling growth. In contrast, seedlings that are 8-10 weeks old are able to tolerate these sprays with little or no effect on growth though high rates may have an impact on some species, i.e. spruce.

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Table 1. Morphological and germination statistics for five conifer seedling species subjected to three treatments and two timings of isoxaben (GALLERY®)

SPECIES	TIMING	RATE (kg a.i./ha)	GERM (%)	HEIGHT (cm)	RCD (mm)	SHOOT WGT (g)	ROOT WGT (g)
Ba	PRE	CONTROL	86.67 b	5.32 b	1.81 b	1.70 b	1.10 b
		0.75	96.46 a	6.00 a	1.88 a	1.99 a	1.21 ab
		1.50	94.58 a	6.01 a	1.86 ab	1.88 a	1.20 ab
		2.25	84.37 b	5.50 b	1.89 a	1.83 ab	1.27 a
	POST	CONTROL	90.00 ab	5.33 b	1.79 b	1.61 b	1.02 b
		0.75	96.04 a	5.69 a	1.86 a	1.77 a	1.16 a
		1.50	90.00 ab	5.77 a	1.87 a	1.84 a	1.22 a
		3.00	82.50 b	5.25 b	1.89 a	1.81 a	1.25 a
Cwr	PRE	CONTROL	87.92 a	12.14 a	1.84 a	2.28 a	1.01 a
		0.75	77.92 b	11.64 a	1.81 ab	2.07 a	0.99 a
		1.50	67.92 c	9.81 b	1.75 b	1.55 b	0.77 b
		2.25	62.08 c	9.69 b	1.73 b	1.78 b	0.96 a
	POST	CONTROL	85.42 a	11.38 ab	1.79 b	2.09 a	0.97 a
		0.75	82.50 a	11.64 a	1.87 a	2.10 a	1.03 a
		1.50	84.37 a	11.62 a	1.89 a	2.13 a	1.09 a
		3.00	78.96 a	11.08 b	1.85 ab	2.00 a	1.07 a
Fdc	PRE	CONTROL	95.42 a	16.09 b	2.35 a	4.01 a	2.30 b
		0.75	83.12 b	17.21 a	2.28 a	3.99 a	2.33 b
		1.50	73.54 bc	15.09 c	2.35 a	4.12 a	2.65 a
		2.25	70.83 c	14.67 c	2.31 a	4.23 a	2.75 a
	POST	CONTROL	94.37 b	16.57 b	2.21 b	3.93 b	2.25 ab
		0.75	98.96 a	17.73 a	2.30 a	3.93 b	2.14 b
		1.50	98.96 a	17.83 a	2.30 a	4.04 b	2.13 b
		3.00	98.54 a	17.63 a	2.31 a	4.42 a	2.36 a
Pli	PRE	CONTROL	96.04 a	8.69 a	2.13 a	3.12 a	1.84 b
		0.75	79.58 b	7.86 b	2.11 a	2.59 c	1.89 b
		1.50	48.96 d	6.16 d	2.19 a	2.66 bc	2.16 a
		2.25	65.83 c	6.97 c	2.20 a	2.92 ab	2.37 a
	POST	CONTROL	96.25 a	8.52 a	2.20 a	2.99 b	1.80 b
		0.75	95.83 a	8.84 a	2.15 a	3.17 a	2.02 a
		1.50	97.29 a	8.73 a	2.13 a	2.91 b	1.95 a
		3.00	97.29 a	8.68 a	2.22 a	2.92 b	2.06 a
Si	PRE	CONTROL	94.58 a	11.10 a	2.04 a	3.22 a	1.72 b
		0.75	64.79 b	9.00 b	1.98 ab	2.74 b	1.79 b
		1.50	36.46 c	8.06 c	1.90 c	2.77 b	2.05 a
		2.25	37.71 c	8.12 c	1.94 bc	2.88 b	2.10 a
	POST	CONTROL	93.96 b	9.92 ab	1.98 a	2.89 a	1.67 a
		0.75	93.96 b	10.33 a	2.02 a	2.81 ab	1.62 ab
		1.50	95.21 ab	10.12 a	2.01 a	2.83 ab	1.65 ab
		3.00	96.87 a	9.54 b	1.98 a	2.63 b	1.51 b

Note:
Species: **Ba** - Amabilis fir; **Cwr** - western red cedar; **Fdc** - Douglas-fir; **Pli** - lodgepole pine; **Si** - white spruce.
Timing: **PRE**: Isoxaben applied as a pre-emergent herbicide 3 days after sowing.
POST: Isoxaben applied as a post-emergent herbicide 8 weeks after 80% of conifer seedlings had fully emerged.
ANOVA was performed on data and means with similar letters are not significantly different ($p<0.05$) as separated by Student-Newman-Keul's multiple range test.

TOLERANCE OF THREE CONTAINER CONIFER SPECIES TO THE HERBICIDE ISOXABEN - 1995

Objective: To study the effects of isoxaben (GALLERY®) on the survival and growth of western red cedar, Douglas-fir and lodgepole pine container seedlings.

Location: Nursery Extension Services Test Nursery, B.C. Ministry of Forests, Surrey, B.C.

Setup: The seedlings were grown in styrofoam containers containing a 3:1 peat:vermiculite growing media with the addition of 3 kg/m^3 dolomite lime. The containers were 313B's which have 160 cavities per block. (764 seedlings per m^2). Seeding was done on March 28, 1995. Seeds of all species were double sown to ensure one germinant per cavity, then covered with forestry sand. Species sown were western red cedar, *Thuja plicata*: Douglas-fir, *Pseudotsuga menziesii*: and lodgepole pine, *Pinus contorta*. Seedlings were grown in a greenhouse until mid-July and then placed in outdoor compounds for the remainder of the growing season.

Experimental design: Randomized complete block with six replications.

Application specifications: Isoxaben was applied with a motorized bicycle sprayer fitted with four even-spray 8003LP nozzles delivering a total spray volume of 400 l/ha at a pressure of 140 kPa. Rates of application will be 0. 0.56, 0.75, and 1.5 kg a.i./ha. The post-emergence sprays were applied 4 (May 17,1995) and 8 (June 14, 1995) weeks after 80% of the conifer germinants had emerged in the container cavities.

Measurements: At the end of the growing season, the number of seedlings in each replicate were counted and then twenty seedlings per replicate were extracted for morphological measurements (20 seedlings x 6 reps x 4 rates x 3 species x 2 timings = 2400 seedlings total). Each seedling was measured for height and root collar diameter (rcd). Tops and roots were placed in 4 groups of 5 seedlings per group per replicate, dried in an oven at 105°C for 24 hours and then weighed for dry shoot and root weights. The data was subjected to analysis of variance and means were separated using Student-Newman-Keul's multiple range test ($p<0.05$).

Results: A summary of the results of the trial can be found in Table 2.

1. Seedling germination/survival

The 4 and 8 week post-emergent sprays had no effect on seedling survival.

2. Seedling Morphometrics

All treatments tolerated the post-emergence spray at 8 weeks at all of the applied rates. Western red cedar was the most susceptible to the spray at 4 weeks at all of the applied rates. Root collar diameter, shoot and root dry weights were significantly reduced compared to the application after 8 weeks. Douglas-fir was significantly shorter at the 3.00 kg a.i /ha rate and its shoot dry weight decreased with increasing herbicide rates. Pine was the least susceptible to the spray at four weeks, with only a significant decrease in shoot dry weight at all of the applied rates.

Conclusion: Post-emergence spraying of isoxaben should be done 8 weeks after emergence as seedlings are able to tolerate this with little or no effect on growth.

(Continued)

Table 2. Morphological statistics for the three conifer species subjected to three treatments and two timings of isoxaben (Gallery®)

SPECIES	TIMING	RATE (kg a.i./ha)	HEIGHT (cm)	RCD (mm)	SHOOT WGT (g)	ROOT WGT (g)
Pli	4 WEEKS	CONTROL	11.71 a	2.66 abc	5.69 ab	4.77 bc
		0.75	11.25abc	2.62 bc	5.18 c	4.57 c
		1.50	11.28 ab	2.61 bc	5.41 bc	4.62 c
		3.00	10.76 bc	2.58 c	4.72 d	4.90 abc
	8 WEEKS	CONTROL	10.18 d	2.70 a	6.01 a	4.77 bc
		0.75	10.72 c	2.63 abc	5.80 a	5.15 a
		1.50	11.59 a	2.67 ab	6.05 a	5.07 ab
		3.00	10.71 c	2.62 bc	5.92 a	5.05 ab
Fdc	4 WEEKS	CONTROL	26.28 bc	2.69 b	8.00 ab	3.49 cd
		0.75	26.55 ab	2.55 c	7.69 bc	3.62 bc
		1.50	25.57 cd	2.54 c	7.37 cd	3.46 cd
		3.00	23.23 e	2.64 bc	7.09 d	3.77 b
	8 WEEKS	CONTROL	25.18 d	2.63 bc	7.45 cd	3.36 de
		0.75	27.35 a	2.71 b	7.62 bc	3.20 e
		1.50	25.49 cd	2.81 a	8.16 a	4.13 a
		3.00	25.14 d	2.66 b	7.53 cd	3.70 bc
Cwr	4 WEEKS	CONTROL	31.61 d	2.45 ab	6.82 b	2.25 ab
		0.75	34.25 c	2.37 bc	6.86 b	1.96 cd
		1.50	36.25 a	2.25 d	6.86 b	1.81 d
		3.00	34.69 bc	2.30 cd	6.78 b	1.83 d
	8 WEEKS	CONTROL	35.50abc	2.52 a	7.61 a	2.11 abc
		0.75	35.91 ab	2.53 a	7.49 a	2.01 bcd
		1.50	32.51 d	2.55 a	7.38 ab	2.29 a
		3.00	34.60 bc	2.50 a	7.25 ab	2.13 abc

Note:
Species: Pli - lodgepole pine; Fdc - Douglas-fir; Cwr - western red cedar.

ANOVA was performed on data and means with similar letters are not significantly different ($p<0.05$) as separated by Student-Newman-Keul's multiple range test.

GALLERY® DowElanco Canada Inc.

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Surfactants Can Prevent Botrytis on Conifer Seedlings

INTRODUCTION

Large numbers of container-grown conifer seedlings are lost each year to *Botrytis*-caused disease, during both the growing season and the storage and thawing period. Unfortunately, cultural procedures produce cool, damp climates conducive to disease. Often, no cultural correction is economically possible to rectify a climate problem. To combat the disease, growers often use Benomyl/Captan mixtures to cut their losses. The purpose of this work done with the Ministry of Forests was to determine whether there existed any simple alternatives to pesticide use.

LAB TRIALS

To test the idea that surfactants could work to prevent disease, a trial was done in which fungal media was made, one mixture of which contained Triton X-100, a commonly available surfactant. As one can see in Table 1, across all three trials done, the Triton X-100 reduced the *Botrytis* growth on the fungal media 10-fold. With this in mind, an experiment was planned to test Triton X-100 on conifer seedlings.

Table 1. Effect of Triton X-100 on the growth of *Botrytis* (mm^2 of colony growth)

Treatment	Trial 1 (mm^2)	Trial 2 (mm^2)	Trial 3 (mm^2)
Untreated	1500.0 a[1]	1500.0 a	1311.0 a
0.2 % Triton X-100	166.2 b	63.8 b	176.6 b
0.01% Benomyl/Captan	0.0 c	0.0 c	0.0 c

1. Column means sharing the same letter are not significantly different according to Least Significant Difference test, p<0.05, n=100.

FIELD TRIALS

Efficacy of the Surfactant During the Growing Season

When the surfactant was tested in the field, Triton X-100-treated conifer seedlings had less *Botrytis*-caused disease than either water- or benomyl/captan-treated conifer seedlings. Triton X-100 was applied to the conifers in late July-August, during canopy closure. A 95% reduction in *Botrytis* was observed on western hemlock trees treated with Triton X-100 as compared to those treated with the water control, and a 60% reduction as compared to commercial Captan/Benlate control-treated trees (Table 2). *Botrytis* on Triton X-100 treated Douglas fir was 72% reduced as compared to trees treated with water alone, and 53% reduced as compared to those treated with the commercial control. No *Botrytis*-caused disease was observed on treated white spruce. These reductions alone would prompt the use of Triton X-100 in the forest nursery. However, the efficacy of the surfactant during storage remained to be addressed.

Table 2. Severity (percentage of tree height) of *Botrytis* on trial trees at the end of glasshouse nursery trial.

Treatment applied to trees	Tree species: Western hemlock	Douglas fir	White spruce
Water control	54 a[1]	61 a	0
1.2% v/v Triton X-100	3 b	17 b	0
0.01% w/v Captan/Benlate	8 b	36 a	0

1. Column means sharing the same letter are not significantly different, LSD test, α=0.05, n=4608.

(Continued)

Efficacy of the Surfactant During Frozen Storage/Thawing

Clean (no disease) seedlings were treated and placed in frozen storage. After thawing , Triton X-100-treated trees had the lowest amount of *Botrytis* for all three species of conifers tested (Table 3). While none of the infections observed were pronounced at the time of assay, after only three weeks of thawing, the infections on those Triton X-100-treated western hemlock, Douglas fir, and white spruce that were infected were still 64%, 90%, and 80% less severe, respectively, than those observed on the commercial control-treated infected trees. These trees had been sprayed 7 months earlier, and still the surfactant was effective. However, did the surfactant interfere with outplanting survival?

Table 1. Effect of Triton X-100 on the growth of *Botrytis* (mm^2 of colony growth)

Treatment	Trial 1 (mm^2)	Trial 2 (mm^2)	Trial 3 (mm^2)
Untreated	1500.0 a[1]	1500.0 a	1311.0 a
0.2 % Triton X-100	166.2 b	63.8 b	176.6 b
0.01% Benomyl/Captan	0.0 c	0.0 c	0.0 c

1. Column means sharing the same letter are not significantly different according to Least Significant Difference test, $p<0.05$, $n=100$.

Effects on Survival

After a season of growing in a field situation, the western hemlock, white spruce, and Douglas fir showed no yellow or dead needles. In addition, Triton X-100-treated seedlings were not different in height compared to those treated with water alone. This means that sprays of Triton X-100 can prevent *Botrytis* without causing long-term damage to trees.

CONCLUSION

Triton X-100-treated seedlings were dramatically less affected by *Botrytis* than seedlings treated with benomyl/captan or water. Therefore, Triton X-100, a surfactant with no toxic effects on humans or trees, is an effective, safe alternative to fungicides for the prevention of *Botrytis*-caused disease. Recent research with a more available surfactant, Agral-90, has revealed that it is very similar in composition to Triton X-100, and has 95% the efficacy of Triton X-100 when applied as a foliar spray. Agral-90 will most likely be the surfactant used should surfactants become an alternative to fungicides.

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GREENHOUSE TEMPERATURE AFFECTS DOUGLAS-FIR SEEDLING GROWTH AND ROOT DEVELOPMENT

ABSTRACT

Container-grown Douglas-fir seedlings subjected to frequent greenhouse air temperature above 30°C became morphologically inferior to those grown under cooler conditions. Shoots were taller, had smaller terminal buds and exhibited greater stem tapers. Root dry weight was significantly lower in these seedlings. *Fusarium* infection levels in roots were significantly higher for seedlings grown at high temperature and there was a general trend toward higher levels of *Fusarium* in their growing media. In addition, these seedlings appear to be more susceptible to insects and diseases.

INTRODUCTION

Root necrosis of container-grown Douglas-fir, which becomes evident late in the season, is thought to be caused by a complex of biotic and abiotic factors. In a recent survey of three coastal British Columbia forest nurseries, several cultural practices and environmental conditions were identified as possible causes, either individually or in combination (Dennis et. al 1995). Prolonged exposure to high air temperature was followed by a high level of *Fusarium* early in the season. However, root decay was not observed until nursery culture was changed from a regime promoting rapid shoot growth to one promoting hardening-off. This coincided with excessive moisture, high nitrogen fertilization and increased pH of the growing medium. These conditions have also been implicated in root colonization by *Cylindrocarpon* in other studies. Elevated nitrogen levels have been reported to increase disease susceptibility in plants.

A greenhouse study was carried out at Pacific Forestry Centre to test several cultural factors (frequent temperatures over 30^0 C, high growing medium moisture late in the growing season, and high nitrogen fertilization) singly and in combination. Later sowing of seeds and subsequent later implementation of irrigation and fertilization treatments prevented a high impact from these treatments. However, temperature effects on the growth of the Douglas-fir seedlings remained significant.

This report summarizes our results relating to the growth and disease susceptibility of Douglas-fir seedlings when grown under frequent exposure to greenhouse air temperatures above 30 °C. To insure pathogens were present, seedlings in all treatments were inoculated with *Fusarium* and *Cylindrocarpon* (previously obtained from container-grown Douglas-fir seedlings with root disease).

METHODS

Douglas-fir seeds (seedlot 6402) were sown May 9, 1995 into one hundred and twenty-eight styroblocks (type 415B, density 112 cavities). Growing medium contained peat, slow release fertilizer and micronutrients.

Seeds were germinated at 22 °C day, 18 °C night and misted with water until seedcoats dropped. Fertilizer and irrigation regimes suitable for growing Douglas-fir were used throughout the season. Short day (8 hours) treatment was implemented on all stock beginning September 5 (week 17) and ending September 25 (week 20). Temperatures in the greenhouses were gradually lowered from October 20 (week 23) to January 5 (week 34) to promote hardiness. All seedlings were inoculated with a mixture of *Fusarium* and *Cylindrocarpon* isolates on June 30 (week 7). Immediately following inoculation, seedlings were divided into 2 groups. Control seedlings were kept in a greenhouse where the upper temperature limit was set at 30 °C. Treated seedlings were moved to a greenhouse with the upper temperature limit set at 38 °C.

The following morphological measurements were made December 4 (week 30).

- Shoot length - to nearest 0.2 cm.
- Root collar diameter - to nearest 0.01 mm just below cotyledons
- Upper stem diameter - to nearest 0.01 mm, 2 cm below tip or bud.
- Shoot and root dry weight: after 100 °C for 24 hr.
- Root systems were examined for root necrosis.

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Statistical analysis of the seedling morphology data was done using Analysis Of Variance (ANOVA) followed by Student-Neuman-Kuels multiple range (SNK) tests.

RESULTS:

A. Temperature Observations:

Table 1: Number of days Greenhouse air Temperature exceeded various thresholds.

Temperature °C	30	32	34	36	38
	# Days with	temperatures	exceeding	above	values
Control seedlings	10	2	1	0	0
Treated seedlings	30	25	15	9	2

B. Seedling growth and health observations:

Foliage was lighter in colour and shoots were "softer" in the high temperature treatment. When the high temperature treatment was discontinued light coloured seedlings darkened, but never attained the dark green of seedlings grown at the cooler temperature. High temperature also appeared to make the seedlings more susceptible to grey mould and bud destroying larvae of tortricid larvae (needle-tiers).

C. Seedling Morphometric Measurements

Table 2

Treatment	height (cm)	diam. cot. (mm)	diam. tip (mm)	stem taper (mm/cm)	dry-wt. (gm) shoot	live root
Control seedlings	23.2a	2.65a	1.69a	0.41a	20.56a	9.097a
Treatment seedlings	24.8b	2.63a	1.44b	0.047b	20.42a	6.842b

High temperature treatment seedlings were significantly taller than the control.

Stem diameter measured at the cotyledons was not significantly different. However, shoot tip diameter in seedlings subjected to high temperature was reduced, resulting in significantly greater stem taper.

Stem taper = $\frac{\text{cot diam - tip diam}}{\text{stem height}}$ in mm/cm.

Root dry weight was affected by the treatment. Seedlings grown under "normal" temperatures had significantly greater total root mass. There was no significant difference in the incidence or amount of root infection in either treatment.

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D. Seedling Pathology Results

Results of assays of *Fusarium* and *Cylindrocarpon* from roots and growing media are given in Table 3.

Table 3: Seedling Pathology	Media *Fusarium* (**cfu)	Media *Cylindrocarpon* (cfu)	Root *Fusarium* (%)	Root *Cylindrocarpon* (%)
Control	5283a	3438a	34a	6a
High Temp.	8421a	9894a	47b	2a

**cfu = Colony Forming Units per gram of dry growing media.

High temperatures increased the level of *Fusarium* isolated from roots. The levels of *Cylindrocarpon* isolated from roots were not affected by high temperature. Pathogen levels in the growing media were higher in the temperature treated blocks, but the differences were not statistically significant at $\alpha = 0.05$.

Increased incidence of *Botrytis* and bud moths (*Tortricidae*) was observed on seedlings grown under higher temperature.

DISCUSSION:

Douglas-fir root rot is thought to be caused by a combination of biotic and abiotic factors affecting the health and susceptibility of seedlings. In a recent survey, seedlings experiencing temperatures over 30 °C exhibited root dieback when grown with high nitrogen fertilizer applied late in the growing season under excessive irrigation (Dennis et al. 1995). It was not clear which of the abiotic factors observed contributed to the cause of the dieback. Roots became infected with the root decay fungi *Fusarium* and *Cylindrocarpon*, but fungal impact on root dieback was thought to be related to the seedling growing conditions. The current study tested the effect of high temperature on seedling growth and root health.

It became clear early in this experiment that high temperatures had a large impact on the appearance and health of seedlings. Foliage was chlorotic and stems were “soft”, tall, wavy and thin. By the end of the experiment, seedlings grown under high temperature were significantly taller, had the smallest diameter shoots at the tip and had the greatest stem taper. These characteristics occurred in seedlings with root rot in the 1995 survey and have also been identified as symptomatic of seedlings with root rots. Seedlings grown under high temperatures also had less total live root dry weight.

No straightforward pattern for the effect of temperature on numbers of seedlings with root dieback was observed. This may have been due to the technical difficulty in accurate assessment of root decay and also the fact that some root rot had occurred immediately after *Fusarium* and *Cylindrocarpon* inoculation resulting in germinant mortality. Nevertheless, there was a significant increase in the *Fusarium* isolated from the roots of seedlings grown at high temperature.

The effects of temperature combined with other abiotic factors such as fertilization and irrigation are presented in Dennis and Outerbridge, 1996. Although it was difficult to determine individual effects contributing to growth and root disease, it was obvious that high levels of fertilization and excessive irrigation negatively affected the seedlings.

High temperature had the greatest impact, expressed through increased level of infection by *Fusarium* and shoot characteristics known to be symptomatic of root rot in Douglas-fir. It is recommended that when growing Douglas-fir, greenhouse temperatures be kept below 30 °C throughout the growing season.

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Insect Biological Control Initiatives in Reforestation Nurseries

Synthetic chemical insecticides have played important and beneficial roles in the control of nursery insect pests for many years but insecticides also pose real hazards. As a result, Nursery Extension Services has been committed to upgrading all reforestation nursery pest management strategies through operational trial and tech transfer programs. The focus has been to expand our knowledge of insect pest management to include all available control methods. This includes cultural, environmental, biological and even chemical controls. The approach is known as integrated pest management or IPM. The concept is to bring together into a workable combination the best parts of all control programs to limit damage from these pests to economically tolerable levels. One option that has received particular interest is biological control. In simple terms, it refers to the use of living organisms or their by-products to control other, less desirable organisms. The use of bio-control agents is a very active and growing area of research and development. The resurgence of interest in this area of pest control has been brought about because of the continuous use of chemical control over the last 40 years. Several problems have emerged such as the development of resistance in pest populations, increasing costs and regulatory restrictions, and reductions in yields. In addition, increased worker and consumer health issues, and the risk of environmental contamination, have all resulted in heightened interest in biological control techniques.

Reforestation nurseries represent a unique challenge as they are subject to insect problems originating from both the agriculture and forest pest complexes. In addition, conifer seedlings destined for reforestation sites are grown to strict specifications therefore significantly reducing the nursery's level of tolerance to pest damage. Yet, nursery managers are eager to reduce pesticide use to satisfy concerns expressed by nursery workers, tree planters and regulatory agencies. The following are a list of bio-control strategies currently under development and implementation in Ministry nurseries.

Aphids

Aphids are important pests in reforestation nurseries because of their feeding damage and the potential for transporting them to the field. Three species are of particular interest to nursery managers. They are the giant conifer aphid (*Cinara* sp.), the Cooley Spruce Gall adelgid (*Adelges cooleyi*) and the green spruce aphid (*Elatobium abietinum*). The giant conifer aphid can be found on all species of conifers grown in reforestation nurseries and can cause stunting and chlorosis. The Cooley Spruce Gall adelgid is a woolly adelgid found alternating between spruce and Douglas-fir while the green spruce aphid is primarily of concern on Sitka spruce seedlings. Like most aphids, these species have high reproductive rates so populations can get out of control very

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quickly. Two aphid predators, the convergent lady beetle or ladybugs (*Hippodamia convergens*) and the aphid midge (*Aphidoletes aphidimyza*) have been tested with promising success. Ladybugs are one of the best known of all insect natural predators. Both the larval and adult ladybugs feed voraciously on a variety of aphid species. In fact, a single ladybug larva can consume 50-60 aphids per day. Ladybugs can provide long-term, adequate aphid control in a release area only if they reproduce.

Test releases at both Green Timbers and Surrey Nurseries have found them to be successful in reducing aphid populations, particularly *Cinara* sp, but only when the aphid populations were considered high. A common problem that limits usefulness is that adult female beetles cannot produce eggs until they have fed on prey and will only lay eggs where prey is sufficient to support the resulting larvae. Otherwise, they will disperse in search of more abundant prey. Strategies developed to reduce the chances of dispersal include making releases at dusk (ladybugs do not fly at night), immersing the adults in a sugar solution, and watering the release area to increase moisture levels. Also, distributing the total release of adult ladybugs over a few days or weeks helps to increase the chances them finding favourable conditions to feed and lay eggs.

The aphid midge is a gnat-like fly that searches for aphid colonies to deposit her eggs. The eggs hatch out as tiny orange maggots that can feed on 3-50 aphids per day. The larvae are known to attack at least 60 different species of aphids and the adults are such efficient searchers that they can locate one aphid-infested plant among tens of aphid-free plants. Environmental conditions are important to the efficacy of the larvae. Adults prefer shady, humid conditions and require moist soil or organic matter for survival of the pupal stage. The larvae stop development under short daylength and overwinter as cocoons in the soil. This diapause can be prevented by the use of low-intensity supplemental lighting. Trial releases of the adult midges against Cooley Spruce Gall adelgid and the giant conifer aphid have shown them to establish in conifer crops and to reduce aphid populations. More effort is needed to develop an effective aphid monitoring program to facilitate the release of *A. aphidimyza* and *H. convergens*.

Fungus Gnats

Larvae of fungus gnats, most commonly *Bradysia* species, can be a problem in container nurseries where populations build up rapidly under favourable conditions. Larvae infest containers with no apparent host preference and tend to feed on the upper roots. In heavier infestations, larvae will strip the main roots and sometimes girdle entire stems. Though the adults themselves do not feed, they pose a threat of transmitting soil-borne and foliar pathogens and in high numbers are a nuisance to nursery workers. There are two biological control agents that have been tested for fungus gnat control. They are a soil-inhabiting mite, *Hypoaspis miles*, and entomopathogenic nematodes. The mite is a generalist predator that reproduces rapidly and moves well across soil, feeding on young stages of fungus gnats. This predator is well adapted to greenhouse environments and is most effective when used before fungus gnats become established or when the populations are low. Entomopathogenic nematodes are an alternative bio-control strategy if fungus gnat populations are high. These beneficial nematodes, *Steinernema* sp and *Heterorhabditis* sp, do not attack the plants but actively seek out insect hosts. The juvenile nematodes, called infectives, enter the insect body and release a bacteria that kills the host within 24-48 hours. After the nematodes have completed one or more generations, a new set of infectives emerge and begin the search for another insect host. Nematodes are effective at reducing high fungus gnat populations and can be used before the introduction of *H. miles*. The key to introducing these bio-control agents for fungus gnat control is an effective monitoring program. Adult populations can be monitored using yellow sticky traps. If numbers of fungus gnat adults are determined to be increasing, the modification of environmental conditions and supplemental applications of nematodes are effective in keeping fungus gnat populations in check.

Root Weevils

Both adults and larvae of root weevils can seriously damage seedlings, especially in coastal nurseries. The two most common species encountered in reforestation nurseries are the black vine weevil, *Otiorhynchus sulcatus*, and the strawberry root weevil, *O. ovatus*. Adult weevils usually

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affect young 1+0 container spruce seedlings though attacks on other species have been reported. The adults will girdle the stem in a band 1 cm wide, usually on the fleshy part of the hypocotyl. The larvae are of greater concern because one larva can consume almost all the roots of a seedling and may girdle the stem just below the ground line. Larvae are extremely difficult to control with pesticides and as such weevil control is aimed at killing the adults.

One bio-control organism that has shown promise in controlling weevil larvae is the previously mentioned entomopathogenic nematode. Numerous studies have shown them to be very effective against weevil larvae especially in greenhouse container environments. They can be applied through conventional spray equipment with little or no modifications. To ensure greater efficacy, certain environmental and cultural conditions must be maintained in the seedling cavities. The nematodes must be applied to warm (above 10^0C) moist soils and must not be exposed to ultraviolet light. Due to the low cavity volumes in our container system, irrigation or fertilizer events must be minimized to maximize the nematode retention time in the seedling plugs. To date, test trials have shown them to be most effective against the later instars of the root weevils. In contrast, they are ineffective against the pupae or adults. In essence, this has allowed nursery managers to target two root weevil life stages thus enhancing their management strategy.

Cutworms

Larvae of several moths occur incidentally in reforestation nurseries causing extensive loss of or damage to, container seedlings. Though most are not true cutworms (family Noctuidae) they are, for all practical purposes, grouped under the term cutworm. All conifer species can be attacked and the degree of damage varies greatly. Damage is generally confined to young succulent seedlings. A single larva can destroy many seedlings in one evening and only a few cutworms can destroy thousands of seedlings in a couple of weeks. Cutworms feed on foliage and often cut through the stems leaving a short stump. Traditional control methods have emphasized sprays with synthetic pyrethroids (chemical) or with the long established bio-control agent *Bacillus thuringiensis* or Bt. Pyrethroids are synthetic versions of pyrethrins which are extracted from Chrysanthemum plants. These insecticides are fast-acting and cause an immediate "knockdown" effect. Currently, most reforestation nurseries use permethrin (Ambush) for control of cutworm larvae.

Bacillus thuringiensis or Bt is probably the most widely used bio-control agent for insect control in agriculture, horticulture and forestry. The bacteria occurs naturally in most soils and can be easily cultured to produce formulations similar to traditional insecticides but without the disadvantages. The active ingredients of Bt formulations are the various proteins produced by the bacteria. These paralyze the gut of the feeding insects. In addition, different strains of Bt are selective to only certain insect groups therefore reducing the risk of affecting non-target insects. The most widely used strain, *B. thuringiensis* var *kurstaki* (Btk), has a broad spectrum effect on leaf-feeding Lepidoptera. Screening trials conducted by Nursery Extension Services has found Btk to be effective against most of the cutworms found in reforestation nurseries. Unfortunately, Bt is limited in that it is strictly a gut poison. To be effective, the insect must consume enough treated plant material to stop feeding and eventually die of starvation. This is a problem for reforestation nurseries as cutworm larvae would have to consume an enormous quantity of young seedlings before succumbing to the effects of Bt. To counter this limitation, nurseries have implemented intensive scouting programs during the most susceptible period of their crop culture to quickly identify the first signs of cutworm damage.

A new initiative to deal with cutworm damage has been to evaluate the effectiveness of another bio-control by-product called neem. It is an oil derived from the fruit of the neem tree, *Azadirachta indica*. The active ingredient is called azadirachtin and it is a complex mixture of organic chemicals that have different effects on a wide range of insect groups. In most insects, neem acts as an anti-feedant but it has also been shown to act as a repellent, growth regulator, oviposition suppressant, sterilant or toxin. Screening trials have shown it to be very effective against cutworm larvae with no phytotoxic effects on any conifer species currently grown in B.C. Further trials are on-going at the University of B.C. to evaluate neem's effectiveness against a greater range of insect pests. Neem has extremely low mammalian toxicity and has been used for centuries in Asia for medicinal purposes. Neem is currently not registered in Canada but it is likely to be

(Continued)

available in the very near future.

As with all new initiatives in pest management, and in particular with bio-control agents, care must be taken to understand all aspects of the control strategy to optimize its usefulness. The following should be integral components of any bio-control program;

1) ensure there is a favourable environment by reviewing traditional pesticide use compatibility and checking for adequate food and habitat conditions;
2) choose a bio-control agent appropriate for the pest;
3) time the application of bio-control agents to coincide with the susceptible life stage(s) of the target insect pest;
4) use appropriate release rates;
5) monitor efficacy of bio-control agents to gauge their effectiveness and the distributor's quality assurance;
6) experiment with the bio-control agents to develop a knowledge base for your nursery site.

David Trotter
Nursery Pest Management Specialist
Nursery Extension Services

EVENTS

Forest Nursery Association of B.C.

16th Annual Meeting, September 16-19,1996. Quesnel, B.C.
For More Information Contact:
Mike von Hahn
Ph: 604-992-8631 Fax: 604-992-6783

Can-West '96 Hort Trade Show

September 25-26, 1996.
Vancouver Trade and Convention Centre,
Vancouver, B.C. Canada.
For More Information Contact:
BCNTA Office @ 604-574-7772/Fax: 604-574-7773

Canadian Greenhouse Conference

October 17-18, 1996. Guelph, Ontario, Canada.
For more information contact:
Donna Cobbledick @ Ph: 905-945-9057

Insects and Insect Control, BCMAFF/BCNTA Short Course.

Sheraton Guildford, Surrey, B.C. Canada.
For more information:
Ph: 604-556-3044

Expert Committee on Weeds - East/West Joint Meeting

December 9-12, 1996 Victoria Conference Centre, Victoria, B.C.
For more information contact:
Dr.. Phil Comeau, B.C. Forest Service.
Ph:604-387-6721
Fax: 604-387-0046

New Plants and Crop Diversification, BCMAFF/BCNTA Short Course.

Sheraton Guildford, Surrey, B.C. Canada.
For more information:
Ph: 604-556-3044

NTV '97 International Horticulture Trade Fair,

November 4-7, 1997 Amsterdam RAI, Netherlands.
For More Information Contact:
your local travel agent or...
Mr. Jan van der Molen
Tel: +31 (0)20-5491212

(Continued)

Nursery Tree Seed Workshops

October 01 - 10, 1996

Tree seed workshops will be held late September, early October, 1996 in four locations in BC (see Table below). The workshops were originally planned for November, but conflicts with northern lifting schedules forced us to move the dates up one month. We hope that these dates are more convenient for everyone.

DATE	LOCATION	FACILITY
Sept. 30/96	Nanaimo	Schooner Cove Resort
Oct. 3/96	Surrey	Nursery Extension Services
Oct. 8/96	Vernon	Village Green Hotel
Oct. 10/96	Prince George	Esther's Inn

The cost for the workshop will be $25.00 per person and will cover the costs of room rental, coffee and treats. The price will not include lunch, but lunch will be available at the facilities restaurant or through catering (Surrey).

The agenda is based on the results of the survey that was forwarded to nurseries this spring. The most wanted lecture topics were:

1. Seed Upgrading
2. Germination Environment
3. Seed Preparation for Sowing
4. Seed Germination
5. Nursery Falldowns
6. Seed Handling & Leftover Seed

The most wanted demonstration topics were:

Demonstrations

1. Quick Viability Tests
2. Pathogen Identification
3. Seed Upgrading

We have tried to incorporate all of these topics into the workshop this year with the attached agenda. For perspectives on Seed upgrading from a nursery perspective, Susan Lockhart from Skimikin has agreed to speak in Vernon and Susan Thorpe has agreed to speak in Prince George. If anyone is interested in providing a 15-20 minute presentation on nursery perspectives of seed upgrading in either Nanaimo or Surrey please contact us.

For all of the workshops our goal is 35 people and we will definitely not entertain more than 40 people per location. For those who have supplied a tentative number of people attending we must now have a firm number. Registration will be based on a first-come first served basis. Payment in advance is preferred as we can have receipts prepared and not delay the morning presentations. Cheques can be made payable to the Minister of Finance and Corporate Relations. Please forward names of people attending and location with payment to the Tree Seed Centre or to Eric or myself at the FNABC meeting. Thank you!

AGENDA

8:00	Introduction/New Sowing Rules	
8:15	Seed Upgrading I	Dave Kolotelo
8:35	Nursery Perspectives	Various
8:55	Seed Pathology	John Dennis Dave Trotter
9:15	Seed Germination	Dave Kolotelo
10:00	**COFFEE**	
10:20	Seed Upgrading Demo	Dave Kolotelo
	Pathogen Identification	John Dennis Dave Trotter
	Mycorrhizae demo	Shannon Berch
12:00	**LUNCH**	
1:00	Morning Recap/Intro.	Eric van Steenis
1:15	Seed Prep. & Handling	Jol Hodgson
1:45	Germination Environment	Eric van Steenis
2:30	**COFFEE**	
3:00	Germ. Environment Demo	Eric van Steenis
	Quick Viability Test Demo	Dave Kolotelo
3:45	Discussion of Seed Issues	

Schooner Cove Resort
Box 12
Schooner House
3521 Dolphin Drive
Nanoose Bay BC
V0R 2R0
(604) 468-5384

Nursery Extension
14275 - 96th Ave.
Surrey BC
V3V 7Z2
(604) 930-3311

Village Green Hotel
4801 - 27th Street
Vernon BC
V1T 4Z1
(604) 542-3321

Esther's Inn
1151 Commercial Drive
Prince George BC
V2M 6W6
(604) 562-4131

For more information contact:

Dave Kolotelo
Ph: 604-541-1683

Eric van Steenis
604-930-3303

MARKETPLACE

For Sale: 5000+ 160/90ml Beaver Plastics styroblocks. Contact Rick Hammer @ 604-465-3600.

Liquidation: McGuire Evergreen Plantation, RR#3, Harley, Ontario, Canada.
Contact Lana McGuire @ Phone: 519-863-3690 / Fax: 519-863-3390

- 5000+ Styroblocks	- 160's	3 & 5 seasons used
	- 198's	3 seasons used
	- 240's	New
	- 240's	3 & 5 seasons used
	- Can Am 67's	black.
- Greenhouses	- 27' x 140' double poly Vary with Resnor heataers, exhaust fans, shutters, jet fans, thermostats, misting equipment, benches, lights, gable ends, etc.	
	- 27' x 100' Omni double poly complete as previous.	
	- 2 - 16' x 100' cold frames with gable ends	
- Equipment	- backpack and handheld sprayers	
	- peat/vermiculite mix by truckload	
	- vacuum seeder + plates, etc.	
	- 3 Water walkers - 2 with booms, hoses & electrical	
	- 2 Sensophone computers	
	- 2 Dosmatic injectors	
	- Farm Truck/Trailer/Blade/Planter	
	- Electric Golf Cart	
	- Tree Planting Equipment	
	- 3/4 acres of dig your own - maple, oak, pine, cedar	

Liquidation: - Kirkwood Forest Station, near Thessalon in Central Algoma, Ontario.
- 17 greenhouses, equipment, etc.
- To receive request for proposal contact:

Community Development Centre for East Algoma
16A Woodward Avenue
Blind River, Ontario P0R 1B0
Ph: 705-356-1152 Fax: 705-356-1711
or... Ph: 705-253-8920 Fax: 705-253-9932

For Sale: Vancouver Bio block filler.
Contact Barry Kasdorf @ 604-545-0643

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In Memorium

John Wildey Maxwell

John W. Maxwell, formally the provincial bareroot specialist, passed away on August 10th, 1996. He was with our Nursery Extension Section from 1977-88. John was instrumental in developing and enhancing the provincial conifer bareroot system and instituting the pest management extension program. John came to us after 10 years with the Ministry of Agriculture as one of their extension specialist for the Southern Interior. In addition, he brought a wealth of knowledge from his varied experiences; managing the family allspice plantation in Jamaica, officer training in the British Army, navigator in the Canadian Air Force, a constable with the Winnipeg Police Force, Division Commander with the Overseas British Constabulary in Jamaica and field manager with Fraser Valley Frozen Foods. After his retirement from the Forest Service, John directed his efforts to the Ministry of Environment's pesticide residue surveys, pesticide applicator courses and a review of the 1992 Gypsy Moth spray program. His expertise, devotion to service, compassion and sense of humour will be sorely missed by his friends and colleagues.

David Trotter
Nursery Pest Management Specialist

DEADLINE FOR CONTRIBUTIONS TO NEXT ISSUE

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