TREE IMPROVEMENT

Volume 3, Number 2 September 1990

Seed and Seedling Extension Topics

Extension Services Section - Editor, Gwen Shrimpton

You will again have noticed a change of editor with this issue of the newsletter. We have decided to split the duty between the seed orchard and nursery sections. I will be the editor for the fall 1990 and spring 1991 issues with the help of Dave Trotter and Eric Van Steenis. The task will then revert back to Don Summers.

We have made a particular effort with this issue to solicit contributions from nursery and seed orchard growers and managers. We are interested in any hands-on advice, observations or results from operational trials that you may have. Information of this nature can usually be immediately adapted and implemented by other facilities. In this vein, I would like to thank Jim Kusisto, Rob Bowden-Green, Jim Sweeten and Hans Lussenburg for their contributions.

It seems that our unit is still in the process of change. The culturist position formerly held by Glen Matthews is being re-classified to a management level, but the incumbent will still have some cultural duties. We are looking forward to the return of Rona Sturrock from FRDA administration at Pacific Forestry Center. She will again be doing pathology research in cooperation with Jack Sutherland as of January 1991.

Grower's Notes

Stem Lesions on Pine Caused by *Sirococcus strobilinus*

Most nursery personnel are familiar with *Sirococcus* blight which affects spruce and pine in both container and bareroot nurseries. It has been found rarely on 2+0 bareroot Douglas-fir seedlings and was recently found for the first time on western hen-dock germinants. *Sirococcus* is seed-borne on spruce and affects container stock most seriously in the germinant stage. Under cool, wet, cloudy conditions, the fungus produces spores and spreads to the surrounding germinants. Infections at this stage kW the seedlings. Trees in the 2+0 stage are not fatally damaged but new growing tips that are infected are killed. A particularly susceptible stage is after bud break, during shoot elongation. This often coincides with moist weather and heavy spore release in the surrounding forests.

On both lodgepole and yellow pine seedlings, the fungus appears to infect juvenile needles, travels down the needle, and produces a moist, purple lesion on the stem at the base of the needle. This lesion may be healed over leaving a small scar, or it can completely girdle the stem. Large scars create weak areas in the stem which make the seedlings unacceptable for planting. Stems with lesions break easily when handled or when under snow pressure. The main stem can be infected anywhere along it's length.

Laboratory culture tests at the Pacific Forestry Centre (PFC) on *Sirococcus* from stem lesions indicate that the B.C. Production Guide recommendations for *Sirococcus* blight should control the disease. However, preventing *Sirococcus* stem lesions has been difficult. This may be due to rain washing away sprayed material in open compounds or due to the difficulty in getting adequate fungicide spray penetration. Early detection and rouging affected material before the fungus produces spores and spreads to other seedlings is very important.

Sirococcus produces small, black fruiting structures which aid in identification. Care should be taken not to confuse them with fruiting bodies of other stem infecting fungi. Both *Phoma* and *Sclerophoma* produce black spore producing structures but these fungi are usually secondary to mechanical damage, drought stress or frost damage. They are good indicators of cultural or environmental stresses and should not cause alarm. To prevent losses due to *Sirococcus* stem lesions, seedlings showing moist, purplish lesions on succulent stem tissues should be sent to PFC for examination and identification.

John Dennis
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BRITISH COLUMBIA
Ministry of Forests

Agribrom[R] Algae Control Product

Until now, there has been no safe and effective method for eliminating algae from irrigation lines, soil surfaces, benches, walkways and cooling pads. Agribrom is a new algae control product that works by disrupting the cell membrane. Algae cannot develop resistance to this type of action. It works only on contact and there is no residual activity. It must be constantly present at low levels in the irrigation water to keep the algae from building up. It can also be applied to other surfaces in the greenhouse to dissolve algal growth, or at lower rates to prevent build up. There is a frothing action when Agribrom is in contact with algae, indicating that it is working. With Agribrom, there appears to be no risk of phytotoxicity.

Agribrom is currently registered for "greenhouse ornamentals and agricultural premises". The label does not specifically include forest tree seedling nurseries, so Westgro Sales has approached the manufacturer to have tree seedling nurseries included. Although Agribrom is registered for algae control, there was some question of moss and liverwort control, both preventative and curative. Westgro has arranged with Carol Barnett of the British Columbia Ministry of Agriculture and Fisheries to test the efficacy of Agribrom for algae, moss, and liverwort control on several nursery crops. These tests will be conducted over the full growing season on a variety of nursery crops, so that phytotoxicity can be assessed. Tests will also be conducted at Saanich Test Nursery on a variety of conifer species and stock types during the 1991 growing season.

Jim Matteoni
Westgro Sales, Delta

Block Sanitation

In British Columbia, most forest seedlings are produced in styrofoam containers. Over time algae and root-rotting fungi such as *Fusarium, Phoma,* and *Cylindrocarpon spp.* build-up on the used container blocks. Applied Forest Science Ltd. has completed a study to identify materials and methods for sanitizing nursery container blocks.

Experiments were conducted in three trials where compounds or methods were examined for their sanitizing efficacy. The most effective methods for reducing fungal and algal propagules on used containers were: steam (95°C for 1 minute); heated soaps (Safer's DeMoss and Ivory soap, 10-second dip in a 5% solution at 80°C); bleach (10-second dip in a 0.5% solution buffered to pH 7.0); hydrogen peroxide (10-second dip in a 10% solution); sodium metabisulphite (10-second dip in a 5% solution) and sulphur dioxide fumigation. None of these treatments affected lettuce seed germination or growth.

A user's guide for block sanitation based on the most effective methods is currently in production and will be available later this year.

Mike Peterson
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Simazine for Weed and Liverwort Control in 2+0 Spruce Containers

This trial was originally conducted to determine if weeds (primarily Fireweed) could be controlled during the second growing season without damage to the crop.

Simazine, at 1.0 L 50% EC/ha, was broadcast sprayed on rising 2+0 spruce just prior to bud burst which is mid to late April at Skimikin. Irrigation was applied immediately after spraying for one hour using solid set with 1.5 mm (1/16") nozzles. Our experience has been that too much irrigation may cause the product to leach out.

Excellent control of weeds was achieved with no visual damage to the crop. Liverworts and mosses were controlled until late June but slowly returned to a limited degree prior to lifting and shipping. Control blocks were heavily infested.

Morphologies were done at time of harvest on both treated and control blocks. Average height and root collar diameter were greater and shoot to root ratio was less on the treated trees. Recoveries per block were also slightly greater in the treated blocks.

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Possible Sources of *Fusarium* Inoculum

This year, one pathogen that has caused significant damage to seedlings grown in B.C. forest nurseries has been *Fusarium.* At a recent IUFRO meeting held at the Pacific Forestry Centre, Dr. Bob James of the U.S. Forest Service gave a *Fusarium* workshop on identification, avenues of disease expression, inoculum sources and suggested strategies to reduce infestation levels. The following is a summary of the topics covered with some closing remarks on inoculum sources recently found in B.C. container forest nurseries.

Fusarium disease can be expressed in a variety of ways. It may appear as seed decay, pre- and post-emergence damping-off, cotyledon blight, stem canker, top blight or root rot. In general, traditional fungicide applications have had marginal to no success at reducing infestations. The exception has been with fungicide applications to control damping-off. Most researchers agree that cultural amendments and sanitation procedures are key areas to focus on when trying to reduce the risk of disease.

An integrated pest management program to reduce Fusarium-related disease must involve, the reduction of pathogen inoculum, enhancement of host resistance through cultural methods, encouragement of competing and antagonistic organisms and minimal use of fungicides. One major thrust has been to concentrate on reducing the possible sources of inoculum. Numerous trials have been conducted to reduce the amount of Fusarium contamination on seeds. These trials have involved imbibing seed in running water with subsequent dip treatments in bleach, hydrogen peroxide, ethanol and fungicides. Other areas of concern include the sanitation of containers and greenhouse interiors with commercially available disinfectants. The elimination of weeds in the growing area can result in a significant reduction of *Fusarium* inoculum. Both air and water have been suggested as possible sources of infection. Roguing of diseased seedlings in a known infested area will help in reducing the spread of further inoculum. At this stage, no fungicide has proven to be successful at eliminating or reducing established infestations. In all fairness, it must be stated that not all species and/or isolates of *Fusarium* are pathogenic. Therefore, tests, particularly in the field under operational conditions, must be done to verify the virulence of these potential pathogens.

In B.C., container blocks are loaded with growing media, usually peat, then seeds are sown into the filled cavities and subsequently covered with a layer of grit. The container blocks are then loaded onto wooden pallets and placed in greenhouses or outdoor compounds. Recently, samples of grit and wood from pallets have been screened by the Disease Clinic at PFC and were found to have both *Fusarium* and *Pythium* inoculum. A preliminary trial was initiated to determine if inoculum levels could be reduced using conventional methods. Grit samples were incubated after being washed only with water or with a water/bleach solution and then compared to a control. Washing solely with water or with the addition of bleach eliminated *Pythium* from all the tested samples but only reduced *Fusarium* contamination. Uniform heating of the grit to 70°C was suggested as a way of eliminating the *Fusarium* spores from the grit. In samples taken from wooden pallets of outdoor 2+0 container spruce, *Fusarium* was isolated from all samples. As an aside, in a greenhouse with 1+0 spruce infested with *Pythium,* wood samples were all found to have inoculum. The only exception was in stock treated with metalaxyl (Ridomil) in which only 20% of the wood samples were found to have *Pythium*. It is premature to assess the origin of the inoculum but these observations are interesting when considering the management of these pathogens.

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NOTE: Mention of commercial products in this newsletter does not constitute endorsement by the Ministry of Forests.

Sequential Sampling System for Fungicide Application for Grey Mould.

Each year, large numbers of seedlings have to be culled at the nursery during the lifting phase because of grey mould. These losses increase at the planting site if the disease has carried over as a storage mould. Storage mould has been identified as the number one seedling research priority for 1990 by the B.C. Nursery Technical Committee (comprised of ForCan and BCMF scientists and private industry nurserymen). Annual losses due to grey mould and storage mould often reach 20%. If moulded seedlings with reduced vigour are outplanted, the losses become even higher due to poor survivability. This often does not become apparent until 1-2 years after planting, making the loss in dollars even higher. It is anticipated that the development of an effective fungicide application decision plan for grey mould could reduce these losses by up to 80%.

Grey mould symptoms on container grown seedlings usually become evident in late August or early September. However, airborne *Botrytis cinerea* conidia have been observed in container greenhouses 6-8 weeks earlier than this and seedlings are thought to be susceptible to infection at this time (Peterson et al. 1988). Following canopy closure in late June to mid-July, free moisture has been observed to persist on seedling foliage for as long as 120 hours after watering via overhead irrigation booms. This creates conditions optimum for spore germination and infection (temperature 15-20°C and relative humidity (RH) 98% (Nelson, 1951; Jarvis, 1962; Bulit *et al.,* 1970; Trolinger, 1983). As a facultative saprophyte, *B. cinerea* is capable of living on dead tissue but can also infect living tissue. This ability to infect live needles has been demonstrated by Dugan and Blake (1989). Following infection, *B. cinerea* has the ability to enter a quiescent phase until environmental conditions favour aggressive pathogenicity. Thus, it is possible that grey mould infection may occur on both senescent as well as succulent, healthy needles long before signs of a disease epidemic become apparent. Because of this, it is important to initiate disease management procedures early in the growing season at the time of initial infection while any disease epidemic is still in a linear or simple interest growth phase.

Grey mould management requires careful use of fungicides combined with effective cultural controls. Fungicide use is becoming more difficult because disease resistance has developed and more fungicide-tolerant grey mould strains have now been identified (Clover et al, 1987). Apart from pre-canopy closure and pre-lift storage sprays, one cultural strategy to reduce grey mould and storage mould losses is that of hot lifting and planting seedlings. However, this is not always possible; i.e. for Queen Charlotte Island destined stock due to the logistics of shipping. The prolonged use of pre-canopy closure and pre-lift, fungicide storage sprays will only increase the development of disease resistance, and further aggravate the problems of worker's reluctance to handle seedlings with high fungicide residues.

At present, a study is being conducted to develop and assess the effectiveness of a presence-absence sequential fungicide application decision plan for grey mould and storage mould management on western hemlock, western red cedar and Douglas-fir seedlings. This may enable growers to develop more accurate timing for initial fungicide spray so they coincide with initial infection periods when the fungus is most susceptible to them.

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Tech Talk

$C0_2$ Reduces Evapotranspiration (ET)

Plants transpire water vapour via their stomata. These openings in the "skin" of the leaf are influenced by many factors. Timing (day or night), light intensity, humidity and $C0_2$ concentration in the air all play an important role in stomatal control.

Stomata form the connection between the internal leaf environment and the outside world. By opening and closing they can regulate the transfer of materials between the leaf and surrounding environment. Gaseous materials, specifically, $C0_2$ and water vapour, as well as air pollution, enter via the stomata.

$C0_2$ forms the basis of all plant growth, and water is also necessary for many other plant processes. Regulating gas exchange is thus very important. This happens to a large extent passively, along concentration gradients from high to low when the stomata are open. Normally on a sunny day this would be $C0_2$ in and H_20 vapour out. However, the stomata can also regulate gas exchange actively through changing the size of the aperture. Resistance to gas exchange increases with decreased size. The rate of $C0_2$ and H_20 vapour exchange is thus dependent on the concentration within the stomata, the size of the stomata] aperture, and the concentration in the immediate vicinity of the leaf. Regulation of the stomatal aperture is by means of the guard cells, the mechanism of which is driven by photosynthesis in the cells surrounding the stomata.

What this means is that the rate of photosynthesis, or $C0_2$ uptake, has a direct influence on the degree of stomatal opening which, in turn, also has a partial influence on $C0_2$ uptake. Overall, it is obvious that the more open the stomata, the greater the photosynthetic ability of the leaf. Stomatal apertures are smaller during periods of low light, poor nutrition, and in aging foliage.

Besides these factors the $C0_2$ concentration in the greenhouse and the water status of the leaf also has an influence. A water shortage within the plant causes the stomata to partially close thereby curbing water loss. Water stress also increases the sensitivity of the stomata to other environmental factors.

It is more difficult to describe the effect Of $C0_2$ concentration. The plant requires adequate $C0_2$ inside the stomata to keep photosynthesis going, therefore as light intensity increases the stomata open further. However, if there is a lot of $C0_2$ available outside, the aperture need not be as large to effect the same internal concentration (a larger concentration gradient can maintain adequate internal levels even through a smaller opening). Thus, at higher external $C0_2$ concentrations the stomatal opening is partly closed.

Stomata close further as $C0_2$ concentration rises. The sensitivity of the reaction increases if the plant is in poor condition, i.e. under heavy fruit load, moisture stressed, diseased, etc. With moisture stress, it is the hormone abscisic acid (ABA) which increases the degree of stomatal response. ABA production increases under conditions of drought stress. In most cases, this response is beneficial for the plant even though it means an associated decrease in $C0_2$ uptake. Water conservation takes priority. Only during periods of very low or very high light intensity can the braking effect of $C0_2$ on the ET rate be detrimental.

Optimum $C0_2$ Concentration

On dark days we often want to stimulate ET. This is facilitated by some heating and the setting of minimum ventilation. In some cases **a** high concentration of $C0_2$ can work against you. It decreases ET by partially closing the stomata. This response, when added to the same response effected for low light intensity, may render the plant almost inactive. For this reason, raising the $C0_2$ concentration above 600 ppm during periods of low light intensity barely raises the photosynthetic rate, and may actually be detrimental when one considers the negative impact on ET.

During sunny weather, adequate ET is required to effectively cool the foliage through evaporative cooling. For a healthy plant this is normally not a problem, and lowering the $C0_2$ concentration with the objective of stimulating ET and subsequent foliage cooling would not be warranted. However, a plant in below optimum condition would react more strongly to $C0_2$ concentration. Thus during periods of water stress (physiological or induced), stomatal closure would be greater than normal at high $C0_2$ concentration, leading to decreased ET. The danger is that "sensitive" plants under sunny conditions may, due to decreased ET from high $C0_2$ concentrations, end up with too high a leaf temperature (30°C) which, when coupled with low humidity (50%) can lead to foliar damage.

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If one is dealing with a sensitive crop, ET can be stimulated by venting earlier and keeping the $C0_2$ concentration at or below 400ppm. This prevents the air temperature from rising too high and does not slow ET, reducing the chance of too high a foliage temperature. We do have to apply these techniques in moderation, as over stimulation of ET in a sensitive plant may also cause problems.

E. Nederhof and A. De Konig
translated from Tuindery, January 18, 1990

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Liverwort Life History and Management

In B.C. conifer seedling nurseries, liverworts have been a problem in container stock almost since the advent of this culture. With the development of large 2+0 outdoor compounds problems with these small primitive plants have become significant, especially at coastal facilities.

Normally liverworts are limited to moist areas because they are still dependent on water as a medium in which the sperm swims to the egg. In this context they are sometimes referred to as amphibious plants. Liverworts tend to grow very well in damp, burned soil and grow in large numbers after forest fires especially in burnt-out swampy areas. They are often used as indicator plants in forests to determine moisture condition, and the ultimate capacity of forest sites.

The species found in B.C. nurseries is *Marchantia polymorpha.* This plant is much hardier than other species of liverworts, with a thicker firmer vegetative body. It grows in drier situations and spreads very rapidly. It has become a serious weed in nurseries in New Zealand, England, Oregon, Washington and B.C.

The life history of *M. polymorpha* is quite complex. The green vegetative body or thallus is the gametophyte and each one is either male or female. The thallus contains chlorophyll for photosynthesis, but the tissues are not well organized like higher plants. Specialized conducting tissues for water and nutrients are absent. For this reason the plants must grow close to the ground and are usually small in size. On the undersurface of the thallus are hair-like structures known as rhizoids. Some are oriented vertically for absorption and anchorage, and some grow laterally to channel surface water inward toward the thallus. In the thallus the growing tips or outer edges are the most resistant portion, and this often remains alive when the rest of the plant has been killed. Plants can spread by outward growth of the thallus, or if mechanically broken the thallus will regenerate into a new plant. If Conditions are suitable a whole new liverwort plant can regenerate from a single cell. This makes it difficult to achieve complete kill with any control methods used.

On the surface of the thallus there are usually small cup shaped structures. Within each cupule there appear minute buds called gemmae. The entire structure resembles tiny green eggs within a small cup or nest. The gemmae break off and are usually washed away by rain. On a suitable growing medium they will become a new thallus, and can grow to 10 times their original size in one week. A low supply of nitrogen prevents the formation of gemma-cups. A low supply of phosphate induces the formation of large numbers of gemma-cups with many gemmae.

Another way in which liverworts spread is through sexual reproduction. This occurs in the umbrella-like growths on the thallus surface. Continuous light is the determining factor in the induction of the male and female sexual structures. Optimum air temperatures seem to be IOC and high humidity is important.

Male sexual structures called antheridiophores are shallow discs approximately 6mm in diameter on a short stalk. The male structures are the first to form and initially 66% of the reproductive structures formed are antheridia. Presence of reddish-brown coloration in the centre of the disc indicates that the sperm are mature. Sperm must swim to the egg and require a film of water from dew or rain; splashing or raindrops will aid the transfer. They are attracted to the females by a chemical stimulus. Any reduction in the amount of water at this lime will help break the sexual reproductive cycle.

The female sexual structures called archegoniophores are shallow eight-spoked discs on short stalks. After fertilization the egg develops into a structure known as a sporophyte which contains many spores. Spores can be seen as a yellow mass on the undersurface of the disc. Mature spores burst from the spore sac and disperse by wind or water. Each spore will develop into a new gametophyte or vegetative thallus. Spore production is the main method of dispersal

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Control

It has been very difficult to reduce the growth and spread of liverworts in container facilities. There are no known insects or diseases that attack liverworts although they are occasionally injured by pill bugs. Hand-weeding is very difficult if not impossible. The plants must be removed in their entirety because a new thallus is able to regenerate from any amount of vegetative material still present.

Over the past 6 years, a number of fungicides and herbicides have been tested against liverworts in B.C. nurseries. The fungicides Dithane M45, Thiram, Equal, algicidal soap and the herbicide Goal failed to provide satisfactory control. Skimikin nursery has had some success at reducing the establishment of liverwortss on rising 2+0 container spruce using Simazine at 0.5 kg ai/ha. Tests with Tenoran at nurseries in Quebec provided promising results but availability of this herbicide in Canada is being discontinued by the manufacturer. Applications of Captan at 12 g product in 1 litre of water can be effective at reducing germination of liverwort spores.

The most effective control of liverworts is achieved by modifying cultural practices:

- Care should be taken to ensure there is an adequate layer of grit at least I cm thick on the top of the cavities. Blocks should be moved carefully between the sowing line and compound, and care should be taken during the thinning process to ensure the grit is not dislodged.
- Liverwort spores are very small and can possibly be caught in cracks and breaks in the container blocks. Sanitizing agents used during the block washing process to reduce inoculum from root pathogens should also control liverwort spores.
- It is very important to reduce liverwort populations on the nursery site especially on the floor of green- houses and under the pallets in outdoor compounds. A slurry of copper sulphate, rock salt, or herbicides such as Round-up and Simazine are effective.
- Water management is critical for liverwort control. Any practices that keep the microenvironment warmer and drier will reduce liverwort growth.
- Liverworts make greater growth with high nitrogen regimes provided all other ions are present. Feeding the conifer seedlings to an adequate level and avoiding luxury consumption should be help to reduce liver- worts. There is also some evidence that they do better on calcium than ammonium nitrate. Low nitrogen levels will also reduce production of gemmae while low phosphate levels will induce their production.

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Container Seed Inventories

Inventories are intended to provide customers with a reliable estimate of the number of plantable seedlings in each request key. To develop a reliable estimate the morphological contract specification for seedling development must be actually examined. This inventory procedure has been well tested and has proven to provide an accuracy of 5%.

Procedure

1. Empty cavity count

The objective is to provide an accurate assessment of empty cavities which translates to a green tree count. At the time of thinning count and record the empty cavities in 1.0% of the blocks to a maximum of 25 blocks. These blocks must be selected on a random basis to cover the whole seedlot.

2. Morphological Assessment Sub-sample

The objective is to describe the distribution of height and root collar diameters of the entire seedlot population. Scatter diagrams are prepared to provide a visual description of the morphological parameters. This representation is necessary to project future growth and to quantify any required stock specification changes. The sub-sample procedure is based upon systematic sampling with a random starting point. This process assumes a normal distribution of height and calliper. The accuracy is within 5% of the mean 95% of the time.

Should there be an unusual distribution, for example a large number of empty cavities resulting from disease, then these areas should be stratified, recounted, and live tree count amended. The stratified areas should be treated as a separate seedlot for sampling, as should seedlots grown under more than one facility type, i.e. greenhouse vs. outdoor compound.

When establishing samples, the objective is to select 80 individual plants for measurement on a systematic basis. The important factors are to sample the entire seedlot population and to cover the whole of the sample block.

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(a) Sample Block Selection:

In any random manner, select a starting point, e.g. 40th block from the north east comer. The number of blocks in the seedlot are known. Divide this number by 8 to provide the interval of unsampled blocks between sample blocks, e.g. If the interval is calculated as 100 blocks the second block to be sampled would be the 140th block, the third the 240th, and so on.

(b) Sample row selection:

(i) Within each selected sample block, systematically select one row per block. The following table can be used as a guideline.

Sample Block Number

	1	2	3	4	5	6	7	8	Cavities per block
	1	4	7	10	13	15	18	1	240=211
Row to be	1	4	7	10	13	15	18	1	198=313A
Sampled	1	4	7	10	13	15	1	4	160=313B
	1	4	7	10	13	1	4	7	112=415B

Standardize the location of row 1, i.e. south end of the block.

(ii) Height and root collar diameter are measured and recorded for the first 10 seedlings in each selected row of the sample block. Root collar diameter is measured within one centimetre below the cotyledon node. Height is measured from the same point to the top of the bud.

(iii) If the sample row has less than 10 seedlings, continue sampling from the next row until 10 seedlings are measured. If there are more than 10 seedlings in a row, only measure the first 10 seedlings encountered.

(iv) These collected data are then transposed on a height diameter graph or scatter diagram.

(v) Records are kept during measurement of stock condition, that will affect the inventory, e.g. lack of roots, disease, insect damage etc.

(c) Inventory Volume Calculations

(i) Number of green trees = Cavities sown x % filled cavities.

(ii) Using the scatter diagram calculate the percentage of the crop having projected minimum or greater morphological specifications. Gross plantable = numbers of green trees x % morphologically acceptable.

(iii) Discount the gross plantable by the percentage noted with damage, disease, poor plugs, damage to lifting etc. Net plantable = Gross plantable x % physically acceptable.

(iv) The final number is the inventory.

As experience is gained with the use of this method the regimented selection of block and row can be modified. It is important that the total seedlot and total block is sampled during the course of the inventory, and that there are no individual biases introduced.

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Acidification of High pH Peat Media

The pH is one of the most important chemical properties of any growing medium. For container conifer seedling production, it should be about 5.0-5.5 to avoid nutritional problems (Carlson, 1983; Landis et al., 1989; Matthews, 1971). Unfortunately, the pH of the medium may change to unacceptable high or low levels during the growing season. This article describes problems associated with a high pH peat medium and one approach to lowering pH to an acceptable range.

On March 15,1988 at Red Rock Research Station (RRRS), stratified spruce *(Picea* spp.) seeds from six seedlots (Se, Sw, SxS) were sown in BC/CFS 313B container blocks (160 cavities per block) containing the following medium mix: 2 peat: I vermiculite (v/v), 1 kg gypsum per m^3 of medium mix, and 900 g of 12 mesh lime per m^3 of medium mix.

During the germination and juvenile stage, air temperatures were maintained at or above the desired day and night heat setpoints (The heat setpoints (°C) from March 15-july 19 were: March 14-18: day-20, night-20; March 19-April 17: day-20, night-11; April 18-july 19: day-19, night-13). However, medium temperature may have been below the air temperature due to the moist medium and abundance of cloudy, overcast days.

Germination was greater than 75% as expected. However, after germination seedling growth slowed, and foliage and stems became exceedingly purplish. These symptoms were attributed partly to the rise in medium pH, and partly to the low night temperatures from March 19 - April 17.

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Although the initial medium pH was 4.5, samples taken on May I revealed an increase in pH to 6.1. The increase can be explained by the combined addition of fine lime to the mix and the high pH irrigation water (pH 7-2). To lower the medium pH, 95.5-96.5% sulfuric acid was added to the fertilizer solution to bring the pH of the applied solution to 4.5-5.5. The following is a guide, describing the procedures that were undertaken at RRRS to accomplish this tack. These procedures may need to be modified to accommodate for the water source, and type of acid and fertilizer used.

To determine the amount of sulfuric acid required, a serial dilution was performed (Table I). The dilution was accomplished by adding 1 ml of acid to 999 ml of 60 ppm-N 20-8-20 fertilizer solution to make a total volume of 1000 ml. The concentration chosen, 60 ppm-N, was intermediate between the lowest (30 ppm-N) and highest (85 ppm-N) concentrations commonly used at RRRS. The pH difference between the lowest and highest concentrations was 0.2. Since there was such a small difference in pH among the different concentrations used, only one fertilizer solution (60 ppm-N) was used in the titration. One ml of acid was chosen because it can be measured easily and accurately. Using larger volumes of acid would require either more dilutions or larger volumes of fertilizer solution. A total volume of 1000 ml was selected because it was a large enough volume to give accurate data, and yet small enough to manage.

Table 1. Serial dilution of 95.5-96.5% sulfuric acid and resultant pH.
Note: These results may vary, depending on the water source and fertilizer solution used.

Volume of fertilizer solution (ml)	Volume of acid (ml)	Total volume (ml)	Per cent acid (%)	pH
1000	0	1000	0	7.3
999	1	1000	0.1	2.1
999.5	0.5	1000	0.05	2.2
999.75	0.25	1000	0.0250	2.5
999.875	0.125	1000	0.0125	2.9
999.9375	0.0625	1000	0.00625	5.9

After measuring the pH of this 0.1% acid mixture, 500 ml of this solution was diluted with an equal volume (500 ml) of fertilizer solution to form a 0.05% acid mixture. Again, the pH of the 0.05% mixture was determined and was further diluted in the same manner. These series of dilutions and pH measurements were continued until a pH of 5.9 was reached.

A sudden increase in pH from 2.9-5.9 was measured in the serial dilution. To observe a more gradual change in pH between 5.0-5.5, a second dilution was performed. Since 0.0125% acid mixture was the lowest acid concentration prior to the sudden pH increase, this concentration was chosen as the starting concentration for the second dilution (Table 2). To the 0.0125% acid mixture, there were continuous additions of small amounts of fertilizer solution (usually 50 ml) and continuous pH measurements on the resultant acid mixture until a pH of 6.0 was obtained. Based on the collected data, 0.089 ml and 0.106 ml of 95.5-96.5% sulfuric acid were added to enough fertilizer solution to make 1000 ml to obtain a solution pH of 4.5 and 5.5, respectively.

Table 2. Serial dilution of 1.25 x 10^{-2} % sulfuric acid and resultant pH
Note: These results may vary, depending on the water source and fertilizer solution used.

Volume of fertilizer solution (ml)	Total Volume (ml)	Percent acid (X 10^{-2})	pH
999.875	1000	1.25	2.9
1049.875	1050	1.19	3.2
1099.875	1100	1.14	3.4
1149.875	1150	1.09	4.0
1174.875	1175	1.06	4.5
1199.875	1200	1.04	4.8
1249.875	1250	1.00	5.1
1299.875	1300	0.96	5.3
1349.875	1350	0.93	5.4
1399.875	1400	0.89	5.5
1449.875	1450	0.86	5.6
1499.875	1500	0.83	5.7
1549.875	1550	0.81	5.7
1599.875	1600	0.78	5.8
1649.875	1650	0.76	5.8
1699.875	1700	0.74	5.8
1749.875	1750	0.71	5.9
1799.875	1800	0.69	5.9
1849.875	1850	0.68	5.9
1899.875	1900	0.66	6.0

From May 5 onwards, all fertilizer solutions applied were acidified to a pH of 4.5-5.5. Frequency of fertilization was increased to quickly return the medium pH to the acceptable range (Increased frequency of fertilization needs to be practiced with caution since constant moist conditions may lead to root rot). Fertilization was applied when the first sunny day occurred, or at least weekly. Using this method, the medium pH returned to an acceptable level of 5.5 by mid-June. Seedling recovery signs were evident in mid to late May.

Although not practiced, an alternative method of acidification would be to use a lower than optimum pH (4.0) fertilizer solution. This would overcome the high medium buffering capacity more quickly (Pers. comm. E. Van Steenis).

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Cottonwoods Rediscovered in British Columbia

In British Columbia nearly 29% of the 930,000 square kilometres of provincial land area is considered "working forest". Most of this working forest is classed as mixed conifer/hardwood with estimated softwood and hardwood volumes of over 7 billion m^3 and 210 million m^3 respectively. As in other parts of northwestern North America, BC's forest products industry has historically concentrated its energies into the harvesting and milling of a vast supply of coniferous old growth.

Until recently, commercial utilization of the hardwood resource has been limited to Scott Paper's 100,000 m^3 per year harvest of black cottonwood *(P. trichocarpa)* for production of tissue products and various other small volume projects using cottonwood, trembling aspen

(P. tremuloides), red alder *(Alnus rubra),* paper birch *(Betula papyrifera)* and bigleaf maple *(Acer macrophyllum)*. Large sound cottonwood peeler logs from the north coast have occasionally been sold to Japan. high quality aspen of the northern interior has been used for chopstick manufacture, barn floor boards, shakes and decorative panelling. Red alder has been sawn into furniture stock, while paper birch and bigleaf maples have been used for furniture, countertops, panelling and, more commonly, high heat-value firewood.

With such an abundance of high quality softwoods little attention has been paid to commercial utilization or management of our broad-leaved species. B.C. foresters have looked upon hardwoods as a nuisance; their destruction an extra site preparation cost and their control in established conifer plantations increasingly difficult with tightening controls on herbicide use and rising costs of brushing labour. The combination of little market for hardwood logs coupled with a strong "conifers at any cost" bias taught in our western forestry schools has resulted in our ignoring the broad-leaved component of BC's forests.

This attitude is changing however, due to changes in utilization technologies, public concerns about forest management and the environment and the availability of a new group of promising hybrid cottonwood clones from the University of Washington breeding project. A newly constructed oriented strand board (OSB) plant in northeastern B.C. uses aspen and cottonwood exclusively and permits for additional OSB and kraft pulp mills are now under review. Premium red alder logs to be used for furniture making, are commanding an excellent price on the southern B.C. coast while lesser grade logs are being chipped for shipment to Japan for making a product we cannot seem to do without today - computer paper. Next, our harvesting and management practices, particularly as they relate to non-timber values are undergoing changes with the result that hardwood species are now often considered acceptable choices for reforestation and management. Lastly, the University of Washington hybrid popular breeding project has, in the last 10 years, made available hundreds of two and three-way interspecific hybrid clones for our testing and use. These hybrids include: *P. trichocarpa* x *deltoides* (TxD), *P. trichocarpa* x *maximowiczii* (TxM) and *(P. trichocarpa x deltoides)* x *maximowiczii* (TxD)xM) crosses.

The largest collection of hybrid poplar clones in B.C. is at the B.C. Ministry of Forests Kalamalka Research Station in the southern interior near Vernon, B.C. (50°N). We currently have over 100 clones in the clonebank and stoolbeds. More than half of these are from the University of Washington breeding program with the remainder representing several interspecific combinations used in Europe and eastern Canada. Growth and adaptation trials have been established in both interior and coastal environments with samples of all interspecific hybrid cross types. Of particular interest is the observation that most of the TxD clones tested to date in the southern interior and on the coast appear to be cold hardy (to the ages of two-four years) even though many of the *P. deltoides* pollen parents are from as far south as Mississippi State 33N). As a group, these TxD hybrids have more rapid early growth than most of the other hybrid cross types tested in B.C.

The Scott Paper Company of New Westminster, B.C. is harvesting cottonwood from the Fraser River flood plain lands east of Vancouver (49N) and replanting mostly with TxD clones. Scott is currently developing production stoolbeds at a nursery site near Chilliwack, B.C. to supply future planting stock needs and is carrying out it's own series of performance trials. The Skeena Cellulose Company, operating on the northern B.C. coast, is also developing stoolbeds near Prince Rupert using a mixture of TxD and *P. euramericana* hybrids for commercial planting in the Skeena River system (55N). Pacific Regeneration Technologies Thornhill and Chilliwack nurseries have established stoolbeds and a cottonwood performance trial has been established at Surrey nursery. In addition to these and several smaller scale reforestation and land rehabilitation projects using hybrid poplars, there is a municipal waste water renovation project near Vernon, B.C.

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The practice of applying relatively large volumes of municipal waste water to forest lands for the purpose of cleansing" this water prior to its re-entry into natural water courses, is becoming popular in eastern and southeastern regions of the United States. For the past seven years the City of Vernon has successfully disposed of nearly four million cubic meters of municipal wastewater annually on 700 hectares of nearby range lands. With annual heat sums of 2,150 degree-days on a 5C base, a frost-free growing season of 175 days, an abundance of well drained range lands nearby and reliable, nutrient rich water supply, irrigated poplar plantations seemed a natural.

In 1988, 17 hectares of land were cultivated and planted to a variety of tree species and grass. More than nine hectares were planted with 14 hybrid poplar clones. Thirteen hectares are under solid set irrigation controlled by programmable timers. This is a joint project of the City of Vernon, the B.C. Ministry of Forests and the University of British Columbia. Long term objectives include determining the comparative biological and economic efficiencies of poplar plantations and grassed areas in the detoxification and utilization of waste water. Six years of experience with the TxD hybrids under effluent irrigation on the Kalamalka Research Station site suggest that a plantation grown hybrid cottonwood will reach merchantable size (25 cm dbh, 20 m ht) in 8-10 years. At present there is no market for cottonwood logs in the Vernon area, but perhaps that will change as it has for B.C. hardwoods in general in the last few years.

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Seed Cleaning Treatments on Douglas-fir

Nurseries in B.C. have become increasingly aware of the role of sanitation in combating pathogens that have commonly caused significant stock losses. With concerns over environmental issues, worker exposure and disease resistance, fungicide applications are now under constant review and over-reliance on these products is not compatible with long term gains. One organism that has caused major damage to conifer seedlings has been *Fusarium.* As mentioned in the Grower's Notes section, Fusarium may affect seedlings at a variety of stages and traditional methods are proving ineffective.

One area that may help nurseries to minimize the devastating effects of this and other pathogens is the reduction of pathogen contamination on seeds. This is particularly effective in Douglas-fir which is highly susceptible to *Fusarium* infestation. Research has found that the level of disease may vary greatly among seedlots (James, 1985). For Douglas-fir and ponderosa pine, James (1987) found that most of the seedlots he tested had less than 10% seed-borne contamination with Fusarium. Although infection levels appear low, they may be sufficient to cause wide spread disease. Pathogenicity assays on Douglas-fir conducted by Paige Axelrood at B.C. Research have demonstrated a high degree of virulence for a majority of the isolates from some *Fusarium* species.

Numerous methods have been suggested or evaluated in an effort to reduce or eliminate seed-borne contamination. One method has been to apply fungicides directly to the seedcoat. Unfortunately, the evidence indicates that these generally have adverse effects on germination and provide inconsistent results in controlling seed-borne pathogens (Locke and Sutherland, 1975). A second method has involved rinsing seed in running water for 24-48 hours to wash off fungal spores (James, 1987; James and Genz, 1981). A third method recommends soaking seed for a determined time period in chlorine bleach, ethanol or hydrogen peroxide to disinfect the seedcoat (Dumroese *et al,* 1988). These two latter methods have shown to give significant reductions in fungal inoculum while maintaining or enhancing germination percentages. Therefore, a trial is being conducted on Douglas-fir seed to determine the effect of various seed cleaning techniques on seed germination, seedling performance and on reducing the incidence of seed-borne Fusarium.

The study, which started in 1989, is being done in collaboration with Paige Axelrood at B.C. Research, Jack Sutherland and John Dennis at PFC, Heather Rooke at the Seed Center, and Gwen Shrimpton, Nursery Extension Services. Based on past screening trials conducted at B.C. Research, five seedlots of Douglas-fir were selected on the basis of percent germination and described levels of seed-borne *Fusarium.* A sample of seeds from the chosen seedlots were then subjected to a variety of pre- and post-stratification treatments. The treatments consisted of soaking seed for 24 hours in standing or running water with dry seed as the control.

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Five hundred seeds per treatment from each seedlot were then plated on a selective medium and assessed for the presence of *Fusarium.* A second set of seeds from the above standing and running water treatments were then stratified as per standard procedures. After stratification, seeds from each seedlot were subjected to the following treatments:

a) 10 minute soak in 2.1% sodium hypochlorite followed by a 48 hour running water rinse, **b)** 3 minute soak in 70% ethanol followed by a 48 hour running water rinse, **c)** a 48 hour running water rinse and d) untreated. An additional treatment consisting of a 4-hour soak in 3% hydrogen peroxide followed by a 48 hour running water rinse was added this year.

Five hundred seeds per treatment per seedlot were then evaluated for percent germination in the laboratory and field and for levels of Fusarium. Preliminary results indicate that the pre-stratification running water soak reduced the incidence of *Fusarium* compared to standing water imbibition. The post-stratification treatments of running water, sodium hypochlorite and hydrogen peroxide did not adversely affect germination in the laboratory or field. Seedlings sampled met Ministry standards for height, calliper and root quality. The ethanol treatment reduced seed germination by 50% and seedlings in the field were significantly smaller. The effect of these treatments on seed-borne Fusarium was not consistent for all the tested seedlots. Two seedlots with moderate levels of Fusarium contamination (1% and 2% of sampled seed) showed, in all but one case, reduced levels of Fusarium contamination in the treatments with running water imbibition. One seedlot with relatively low levels of Fusarium contamination (0.25% of sampled seed) showed little or no change in Fusarium levels regardless of the treatment compared to the control.

Assays on one seedlot rated as having a high level of seed-borne Fusarium (11% of sampled seed) found that none of the treatments were successful in significantly reducing the degree of infestation. In addition, the percentage of contaminated seeds in the pre-stratification running water treatments was generally higher than the standing water treatments.

The above seedlots and treatments, with the exception of ethanol, are being reassessed this year under a grant awarded to B.C. Research.

Due some of the aforementioned anomalies, it was suggested that *Fusarium* levels might be increasing during the stratification process. Seeds subjected to standing and running water imbibition were sampled once a week for 21 days to evaluate the amount of seed-borne Fusarium. Preliminary results indicate that the number of contaminated seeds are lower in the running water treatment in the seedlots with moderate to low levels of seed-borne Fusarium. Both treatments were unsuccessful in reducing the levels of seed-borne Fusarium on the 11% infested seedlot. In general, the levels of seed-borne *Fusarium* did not significantly increase over time with the exception of the 11% infested seedlot. A more intensive screening is currently being conducted at B.C. Research.

The potential for reducing the levels of seed-borne Fusarium shows good promise though certain inconsistencies still need to be addressed and corrected for operational use.

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Germination Per Cent, Germination Value, Seed Vigour

The germination figure currently reported in the Tree Seed Register and Inventory System (T.S.R.) for each seedlot is the total number of normal germinants counted in germination test expressed as a percentage. It is the average of four replications counted over 21 or 28 days depending on species. Counts are made three times per week. Seed treatments for each test type parallel treatments used to prepare seed for nursery use. That is soaking, stratification, pre-chilling, stratification re-drying etc. This total germination percent figure is a useful indicator of seedlot quality. It is used in determining the number of seeds to sow per cavity and the oversow factor.

Seed vigour has been defined in several ways. One easily understood definition is as follows: "Seed vigour is that property which enables seeds to germinate quickly under a wide range of conditions, and endows germinants with the ability to establish quickly and resist disease." Vigour has been expressed in several ways including: measurement of germination value, low temperature stress test indicators, measurement of level of seed reserves and measurement of seed respiration levels.

The seed vigour value that we will be reporting in the T.S.R., as well as total germination percent, is Germination Value (GV). It is a well known measure, devised by Czabator in 1962. in which total germination and speed of germination are combined in to a single value. This value has no defined units. The good, poor and average values for each species and test type are determined and published.

Germination Value (GV) is calculated by the following formula:

GV = MDG x PV where MDG is the Mean Daily Germination. The quotient is obtained by dividing the number of normal germinants by the number of days of the test. Peak Value (PV) is the maximum quotient obtained by dividing daily accumulated normal germinants by the corresponding number of days.

Table 1 is a Graphic Illustration of Total Germination Values for some of the various species of the 1989-90 natural stand cone collections. This table points out the difference between species. A Germination Value of 30 would be considered poor for Douglas-fir or spruce but would be considered good for western red cedar.

Table 1

Days	3	5	7	10	12	14	17	19	21
Replications	**Number of Germinants**								
1	0.0	17.0	66.00	7.00	0.0	0.0	0.0	0.0	0.0
2	0.0	14.0	65.00	12.00	2.0	0.0	0.0	0.0	0.0
3	0.0	19.0	64.00	10.00	0.0	0.0	0.0	0.0	0.0
4	0.0	14.0	62.00	6.00	2.0	0.0	0.0	2.0	0.0
Mean	0.0	16.0	64.25	8.75	1.0	0.0	0.0	0.5	0.0
Cumulative Germ.	0.0	16.0	80.25	89.00	90.0	90.0	90.0	90.5	95.5
Cumulative Germ. per No. Days	0.0	3.2	11.50	8.9	7.5	6.4	5.3	4.7	4.3

Total Germ. % = 90.5
M.D.G. = 4.3
Germination Value G.V. = 4.3 x 11.5 = 49.5

TABLE 2 Total Germination Percent and Germination Value Average and Range by Species — 1989 - 90 Crop Year

Species	Total Germination per cent		Seed Vigour Germination Value (GV)	
	Average	Range	Average	Range
Douglas-fir	92%	74-79%	50.3	36.6-60.4
spruce	92%	1 collection	50.3	1 collection
lodgepole pine	95%	74-99%	63.8	32.0-83.0
western larch	57%	02-96%	23.6	00.0-72.6
white pine	84%	83-85%	26.0	25.0-26.0
yellow pine	91%	86-96%	47.6	36.8-57.3
western red cedar	84%	79-85%	24.0	18.0-30.0

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Ministry of Forests Initiates Zonal Nursery Growers Award of Excellence Program

Nursery and Seed Extension Services, a section within the Ministry of Forests Silviculture Branch, decided late in January 1990 that it was time to recognize private, licensee and Ministry nurseries for meeting Ministry standards of quality and quantity in the production of forest nursery seedlings. It was also decided that this recognition should be on a regional basis to allow for the significant difference in cultural techniques necessitated by growers in these different regions. Similarly, it was felt that the difference in growing bareroot seedling versus 2+0 container seedlings versus 1+0 container seedlings would also have to be accounted for. Theoretically then, a nursery producing all 3 of these stock types could receive an award in each category. Finally, it was decided that these Zonal Nursery Growers Awards of Excellence would only apply to stock produced for the spring planting season; as this is, by far, the largest program each year.

As with all new initiatives some growing pains have been experienced, resulting in new developments. Hans Lussenburg, Manager for Northern Zone Nursery Services, was the first to initiate the new Awards Program at the Northern Growing Meeting held in late January, 1990. At that time, it was decided to reward all those growers, within any one of three categories, if they had met the requested amount on each and every request key, as well as meeting the Ministry of Forests quality standard of equal to or less than 6 percent cull on all audits within a given category. Theoretically then, since 8 out of the 10 nurseries under contract in the north produce 1+0 container stock, all eight nurseries could receive the 1+0 container award if they met or exceeded the standards specified above. Clare Kooistra, Manager for Southern Interior Zone Nursery Services, took this one step further at the Southern Interior Growers Meeting held in mid-February, 1990. Like the North, Clare decided that if more than one grower met the standards outlined above, that all would receive an award in that category. However, Clare chose his standards slightly differently. The criteria for amount delivered was that the nursery must meet the requested amount by species/stock type rather than each individual request key. With regards to the quality standard the criteria was identical.

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Unfortunately, both Growers Meetings for the South Coast and Vancouver Island Nursery Zones had already come and gone by the time this program was initiated. No doubt, some new awards will be made this fall in these two zones. As for the Fall 1989 lift, two nurseries in both the Northern and Southern Interior Nursery Zones received Awards. In the case of the North Zone, Industrial Forestry Services Ness Lake Forest Nursery, based out of Prince George and Summit Nurseries Ltd., based out of Telkwa, both received the Ministry of Forests - Northern Zone, Nursery Growers Award of Excellence for producing Quality 1+0 Container Seedlings.

In the Southern Interior Zone, Pacific Regeneration Technologies Inc., Vernon Nursery, received the Southern Interior Zone Nursery Growers Award of Excellence for producing Quality 1+0 Container Seedlings, while the Minis" of Forests Skimikin Nursery, based out of Salmon Arm, received the Southern Interior Zone Nursery Growers Award of Excellence for producing Quality Bareroot Seedlings.

Rod Massey, Sue Anderson, Francis Donnelly, Art Lindstrom

Nick Roblin, Brad Cober, Mustafa Kantarli, Melanie Buerge, John Kitchen, Nola Pacock

Hans and Clare are currently revising the award criteria in an effort to standardize them for all Administrative Zones. To the growers who have as yet not seen the awards, they are an elegant plaque which growers can display at their Nursery Offices. For further details, growers can contact the Nursery Administration Centre in their zone.

Congratulations are extended to the I.F.S., Summit, Vernon and Skimikin nurseries.

Hans Lussenberg
Northern Admin. Centre, Prince George

Literature Review

Forest Nursery Notes Database

The Forest Nursery Notes Database is an accumulation of over 3,000 references relating to nursery technical literature that have been entered into a computer storage system. The articles have been filed by author, title, tree species and a range of other key words. A software program searches the Database and generates a list of articles on that particular subject. The Database is continually updated with new technical literature each quarter for Forest Nursery Notes. The FNN Database is the most current, nursery-specific source of information available but it only extends back as far as 1982. The Database is offered in two formats,

Pro-Cite and ASCII. Pro-Cite is a very sophisticated software package written specifically for managing bibliographic information. You will need to purchase it separately from:

Institute for Scientific information
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The price is $295.00 U.S. plus shipping. You will need an IBM-compatible personal computer with a hard disk as the Database requires approximately one MB and the Pro-Cite software another 400K.

The ASCII format is for individuals who may want to import the Database into their own particular software package or system.

The initial subscription costs approximately $60.00. This includes operating instructions, the current FNN Database, plus one year of quarterly updates. The only other cost is a yearly maintenance fee of about $40.00 to keep you supplied with subsequent quarterly updates. Foreign mailing is extra. For more information contact:

Donna Loucks
Forestry Information Specialist
P.O. Box 638
Centralia, WA 98531
(206) 736-2147

$C0_2$ Enrichment in the Greenhouse

by Peter R. Hicklenton, Timber Press Growers Handbook Series Vol. 2.

Covers such topics as $C0_2$ and plant growth, sources and control systems, possible problems, crop responses, economics, etc. Whether you have $C0_2$ or are considering it, this book will be of practical assistance. Available for $13.95 U.S. from Timber Press, 999 S.W. Wilshire, Portland, Oregon, USA 97225

Practical Woody Plant Propagation for Nursery Growers

by Bruce MacDonald

This book leaves nothing to the imagination when it comes to woody plant propagation. It is an immense source of information, covering items such as seed propagation, cuttings, sticking, layering, grafting, micro-propagation, facilities, media, tools, containers, diseases and more. An excellent reference. Available for $59.95 U.S. from Timber Press, 999 S.W. Wilshire, Portland, Oregon, USA 97225.

Management of Diseases With Macro and Microelements

compiled by Arthur W. Engelhard

An up to date collection of papers on the subject of disease control through nutrition. Includes no magical cure-all remedies but certainly much valuable and applicable information. Available for $31.00 U.S. from the American Phytopathological Society Press, 3340 Pilot Knob Road, St. Paul, Minnesota, USA 55121.

Container Tree Nursery Manual, Agricultural Handbook 674

This manual is being published as a series of seven volumes. Two volumes of the Manual have been printed so far: Volume Four - Seedling Nutrition and Irrigation, and Volume Five - Nursery Pests and Mycorrhizae. The remaining volumes are in various stages of completion, and will be published over the next couple of years.

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Single copies of these Agricultural Handbooks will be provided by the USDA-Forest Service, Cooperative Forestry at no charge - contact:

Tom D. Landis
USDA-Forest Service, CF
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Additional copies can be ordered from the U.S. Government Printing Office using the following stock numbers:

Vol. Four	Seedling Nutrition and Irrigation	1989 001-001-00635-1 $15 U.S. each
Vol. Five	Biological Influences: Nursery Pests and Mycorrhizae	1990 001-001-00633-5 $30 U.S. each

Forest Nursery Pests: Agriculture Handbook No. 680

This is a helpful directory of nursery pest problems. The 58 different chapters were contributed by pathologists and entomologists from across North America, and discuss a broad spectrum of pest problems in forest tree nurseries. Each chapter contains information on hosts, distribution, damage, diagnosis, biology, and control, and is well illustrated with colour photographs. This medium-sized book also contains sections on Diagnosis of Pest Problems, Integrated Pest Management, Evaluation of Nursery Losses Due to Pests, Soil-Pest Relationships, Mycorrhizae, and Pesticide Regulations, as well as a list of Pesticides Registered for Use in Forest Nurseries and a glossary of technical terms.

Copies can be purchased for $18.00 U.S. from the U.S. Government Printing Office. Ask for it by the title, publication number (AH-680), and GPO stock number (001-001-00639-4) from:

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Regenerating British Columbia's Forests

Edited by D.P. Lavender, R. Parish, C.M. Johnson, G. Montgomery, A. Vyse, R.A. Willis, and D. Winston.

Reforestation is a subject vital to the economy of British Columbia which depends heavily on its forests - a valuable but expendable resource. This book provided silviculturalists with a broad reference to the science and technology of reforestation in the Canadian province that forms the single most diverse forest region in North America. The work combines, for the first time, both experience recorded from practical reforestation projects and the results of scientific investigations.

The chapters of Regenerating British Columbia's Forests were complied and received by experts in each field of discussion.

Regenerating British Columbia's Forests will assist those responsible for planning reforestation projects to reach informed decisions and will challenge them to consider primarily the biological factors basic to reforestation success rather than short term costs and production technology. Although its main audience is practicing foresters and forestry students of British Columbia, the text will be of considerable interest to foresters in other parts of Canada, the United States, and Europe who manage reforestation.

For the forest nursery industry the following chapters may be of special interest:

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