



Seed and Seedling Extension Topics

Eric van Steenis — Editor

So what's new!? Well, the 1995 FNABC is just around the corner, and the world became two Thorpe's richer on June 23, i.e. congratulations to Susan at Northwood with her twin baby boys (Daniel & Nathan)! Also a new Van Steenis girl (Olivia Marie) on June 14 and...just arrived at Dave and Katie Trotter's...on July 20th, a 6lb-4oz baby girl (Maia Jeanne)!! Oh, hold on, one more!!! A new baby girl (Rianne Judith) at Paula and Ivan Haag's on July 26 (Summerland, PRT)....Talk about a nursery industry!?

Sad news is that our industry has lost two key players. On May 10, 1995 Ted Shurtliff (Peace River Greenhouses, Taylor, B.C.) passed away from cancer. Those of us that had the opportunity to get to know him will certainly not forget his jovial nature and vast experiences in life ranging from being agricultural advisor to U.S. president Richard Nixon to starting the most northerly nursery in B.C. On July 18, 1995 Mike Bruhm (Prince George Region Nursery Stock Coordinator) passed away from a fatal heart attack while working on a cutblock in Mackenzie. His involvement in B.C.

reforestation was key to many successes to date. His vast experience and personable nature made him very effective. I will miss them both.

Overall, progress is ongoing at all facilities. Aside from losses due to fire and hail (mostly in Alberta) greenhouse space devoted to forest seedling production is steadily growing. Seedling requests have not been diminishing in recent years as much as had been predicted, and larger containers are still capturing increasing market shares, maintaining almost 100% space utilization.

It has been difficult to obtain input for this edition of the newsletter so I would like to thank the present contributors doubly for making the extra effort. I will probably leave the arm-twisting to a willing (and unaware) associate here in extension services for the next issue so look forward to a new name above!

Eric van Steenis
Nursery Extension Services

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LETTERS TO THE EDITOR ??

What Happened to Rex Eng?

Many of us remember Rex from Red Rock Research Station and wonder about his quiet disappearance. Well, it's not "strawberry fields forever" but more like yew trees for awhile.

Rex is working for TPL Phytogen, a privately owned Canadian company that was incorporated in 1990. It specializes in the cultivation, extraction, and purification of natural products from medicinal plants for sale to international pharmaceutical and healthcare markets. Over the past five years, TPL Phytogen has developed facilities for research, plant tissue culture, and greenhouse production of superior plants.

The yew tree (*Taxus* species) is among one of the many medicinal plants being investigated. TPL Phytogen has been

researching the propagation and cultivation of the yew tree in both the field and in growth rooms. Some of the areas being researched include nutrition, pruning, hormonal growth control, and micropropagation. In addition, the company is developing techniques in the extraction and purification of paclitaxel from the yew tree. Paclitaxel has been approved for the treatment of ovarian and breast cancer.

TPL Phytogen is a rapidly growing company that has joint ventures with many universities and pharmaceutical companies. If your company is interested in collaborating with TPL Phytogen in forestry/horticulture, please contact Bryan Wilson at 604-525-5052.

Rex Eng
TPL Phytogen

Eric Van Steenis
Nursery Extension Services





GROWER'S NOTES

NATURAL STAND SEED Average Seedling (PSB 313B) yield per Hectolitre of Cones

The seedling yield tables for natural and seed orchard seed are based on the latest five year figures from the Tree Seed Centre. These figures are a best estimate for weighted averages for species using 313B stock type. Individual seedlots can be more accurately estimated based on the germination percent and seeds per gram for the seedlot. The average seedlings/Kg of seed is calculated by:

$$[(\text{seeds/g} \times \text{cavities/blk}) / (\text{correction factor} \times \text{seeds/blk})] \times 1000\text{g/Kg.}$$

SPECIES	AVE. SEEDS/G	AVE. GERM' %	CORREC' FACTOR	SOWING FACTOR	SEEDS/BLK (PSB313B)	AVE. SEEDLINGS /KG SEED	AVE. KG SEED /HL CONES	AVE. SEEDLINGS /HL CONES	HL CONES /MILLION SEEDLINGS
Ba	32	57	1.55	4	695	4,753	2.351	11,174	89.4
Bg	46	79	1.35	3	525	10,384	0.920	9,554	104.6
Bl	100	65	1.50	4	695	15,348	1.578	24,219	41.2
Cw	837	82	1.30	3	525	196,220	1.187	232,913	4.2
Fd*	102	92	1.35	2	355	34,053	0.777	26,459	37.7
Hm	424	91	1.35	2	355	141,555	0.884	125,134	7.9
Hw	487	88	1.40	2	355	156,781	1.045	163,836	6.1
Lw	279	76	1.35	3	525	62,984	0.619	38,987	25.6
Pl*	350	94	1.30	2	355	121,343	0.267	32,399	30.8
Pw	60	68	1.45	3	525	12,611	0.440	5,549	180.2
Py	21	84	1.30	3	525	4,923	1.599	7,872	127.0
Ss	435	91	1.35	2	355	145,227	0.694	100,787	9.9
Sx	503	92	1.35	2	355	167,929	0.877	147,274	6.7
Yc	209	40	1.85	4	695	26,008	1.446	37,608	26.5

SEED ORCHARD SEED Average Seedling (PSB 313B) yield per Hectolitre of Cones

SPECIES	AVE. SEEDS/G	AVE. GERM' %	CORREC' FACTOR	SOWING FACTOR	SEEDS/BLK (PSB313B)	AVE. SEEDLINGS /KG SEED	AVE. KG SEED /HL CONES	AVE. SEEDLINGS /HL CONES	HL CONES /MILLION SEEDLINGS
Cw	840	81	1.30	3	525	196,923	0.798	157,145	6.3
Fdc	86	93	1.45	1	195	48,665	0.389	18,931	52.8
Hw	443	92	1.50	1	195	242,325	0.692	167,689	5.9
Pli	245	94	1.45	1	195	138,864	0.344	47,692	20.9
Ss	417	97	1.40	1	195	244,396	0.508	124,153	8.0
Sx	378	92	1.50	1	195	206,769	0.523	108,140	9.2

June 1995

Source: columns B, C & H, from Tree Seed Centre data (weighted): 1988-1992;
 columns D, E & F, from Ministry of Forests Sowing Rules;
 columns G, I & J, calculated, Silviculture Branch.

*not separated coast or interior due to the limited number of coastal collections.

Janet Agnew
 Seed Production, Planning and Policy Section
 Silviculture Practices Branch





Precool for Better Seedling Vigour

The cold storage of conifer seedlings in plastic-lined boxes can lead to many problems if the seedlings are not cool before packing. Generally, seedling dormancy is considered the most important issue in relation to storage. While dormancy is an important criteria for storage, there is another issue which is just as important. A warm seedling placed into a plastic box liner inside a box will desiccate, even if the liner humidity is high. Water loss is primarily driven by the difference in temperature between the seedling and the air at the surface of the bag. Warm, moist air transpired by the warm seedling condenses on the cold surface of the liner. The liner is in direct contact with the cold storage room air. Delays in the cooling of the seedling intensifies the problem. Greater water loss will be experienced in a liner than in an open cold storage room because the liner protects the seedlings from the cold room air flow and as a consequence, the seedlings will cool at a slower rate.

When the temperature differential is large enough, water can be drawn from the seedling very rapidly - much

more rapidly than if the seedling were left in the ambient air without watering. A humidity of 95% or higher inside the liner will not negate the water flow driven by a large temperature difference. The result is a dehydrated seedling inside of a wet bag. Therefore an accumulation of condensation (or ice in frozen storage) indicates that this problem exists in the seedlings. The free water can also encourage storage moulds to develop and these can contribute to limiting the viability of the seedlings.

If seedlings are to be lifted in warm ambient temperatures, they should be precooled before packing into boxes. This would improve seedling quality. Seedlings could be precooled in a cold room for several hours prior to extraction from nursery containers. Alternately, a forced-air precooler can be designed to fit into the packing line system to cool them rapidly before they are bundled and packed.

Dr. Peter M.A. Toivonen

Agriculture and Agrifood Canada

Growing in Copper Treated Containers... Continued from Page 4, Vol. 7 - #2

In the last newsletter we discussed various issues surrounding the culture of seedlings in copper treated containers. Another growing season of experience has shed some more light on the issue and relaying these will probably be of value.

All of us have experienced iron-chlorosis for one reason or another, at some time or another. This is because iron is like the "runt of the litter", always at the losing end. What was interesting this year is the ease with which the above symptom was created. A number of factors, some in combination, have been fingered as possible causes. These were...wet spring/early summer weather, lower liming rates in acidic peat media, freshly treated copper blocks, and improper nutrient balance in fertilizer programs.

What copper has done, in my opinion, is forced us to grow very close to the edge with regard to iron chlorosis, etc. This year is probably not very different from previous years, ie.no farther from the edge, its just that we've ended up on the wrong side of it.

Copper, like Sodium or Ammonium, etc. is a positive ion (cation) which means it can be adsorbed to the CEC (Cation Exchange Capacity) of the growing media. In order to remove a cation from a cation exchange site it has to be displaced by another cation or adsorbed to a negative

"particle" which has a higher affinity for it than the growing media. Leaching with clear water will not remove adsorbed cations. It will however dissolve more copper ions from the container wall and allow them to travel to unoccupied exchange sites, leaching out only those which do not find a site before they get to the bottom of the cavity. In other words, clear water leaching can aggravate the situation, especially in the lower portions of the cavity.

If a cation (e.g. copper or sodium) is suspected of having taken over the CEC of the growing media and/or soil solution it would be better to leach with a 1/2 to full strength nutrient solution. Other cations will help displace the culprit and certain anions may complex with it to reduce its negative effects. The higher osmotic potential of a nutrient solution will also reduce the concentration gradient from the cavity surface inward. Lastly the nutrient solution will replace the existing solution (fertigate to adequate drain-through) leaving a more favourable environment for new root growth, a necessary requirement for continued element absorption and eventual recovery.

"Preventative fertigation" might include "watering in" a newly sown seedling crop with full strength fertilizer solution.

Eric van Steenis

Nursery Extension Services





TECH TALK

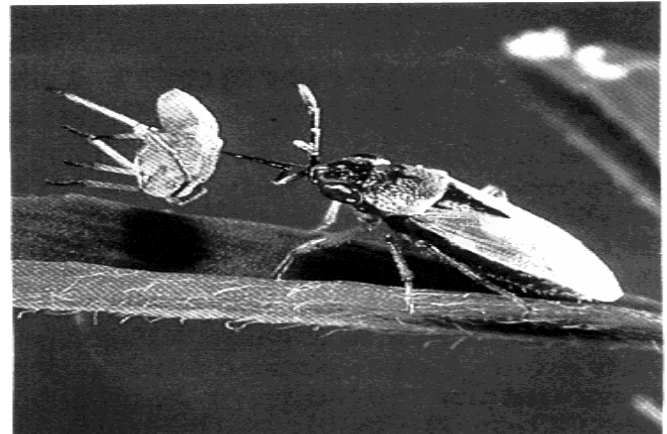
BIOLOGICAL CONTROL: A Component of Integrated Pest Management

Biological control could be said to have been first applied when people began keeping cats to protect stored grain from damage by rodents. This generalist vertebrate control is a simple action of a natural enemy preying on its natural prey, to the benefit of people and agriculture. After microbes and insect life cycles were discovered during the 19th century, attempts were made by forward-thinking scientists to use these organisms for biological control. Until World War II, in the absence of effective alternatives, the search for biological control agents thrived. After the war the advent of powerful synthetic organic pesticides largely quelled this search.

Today, with the development of resistance by certain pests to chemical pesticides and increasing production costs for new compounds, there is renewed interest and investment in biological control agents. In addition, increased awareness of the adverse environmental consequences of using certain toxic chemical pesticides has further enhanced the desire to use control agents that have no damaging effects on non-target species.

Biological control agents...

Broadly defined, biological control includes all pest control measures such as plant selection and breeding for pathogen resistance, and the use of natural enemies or their by-products (semiochemicals) to control pests. The agents of biological control include; parasites (organisms that derive nourishment from another living organism, e.g., nematodes on plants), parasitoids (usually insects that develop within the body of another insect and kill it, e.g., wasps on caterpillars), predators (organisms that capture and kill other organisms for food, e.g., cats catching mice), antagonists (organisms that harm or limit the activity of another organism, e.g., fungi against bacteria), competitors (organisms that actively require more food and/or space than is adequate for all organisms present, e.g., the competition for iron between bacteria and pathogens) and phytophages (organisms that use plants for nutrition, e.g., sheep browsing weeds). Targets include weeds, plant-feeding invertebrates, plant pathogens and disease vectors. The broad objective of biological control is to reduce the average abundance of a pest by using one or more populations of natural enemies, and in doing so to reduce the chance of future outbreaks.



* **Big-eyed bug adult feeding on lygus nymph.**

Mechanisms of biological control...

The classical biological control method is the introduction of exotic agents for long-term depression and regulation of pest populations. The cane toad was introduced from Africa to the sugar cane fields in Australia, to control snakes and rodents. Control was effective, however, the cane toad has no natural enemies in Australia and its populations have increased to where it is now a pest. Inoculation is a similar strategy, involving the periodic re-establishment of control agents in conditions where they cannot persist year round, hence each inoculation provides control over a number of pest generations. Examples of this type of control often involve microbial antagonists that compete for nutrients with a pathogen, and may form antibiotics that reduce germination of pathogen spores and subsequent growth. Augmentation involves the supplemental release of indigenous natural enemies to increase control of a pest, often strategically timed for a vulnerable stage of pest population growth. The gardener who collects ladybugs and places them on roses to control aphids is exemplifying the underlying principle of augmentation. Without this augmentation, biological control would not be as timely and effective. Finally, inundation involves the release of large numbers of agents to control a single pest generation, with no anticipation of effects on subsequent generations. The use of *Bacillus thuringiensis* to control caterpillars is an example.

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The application of biological control...

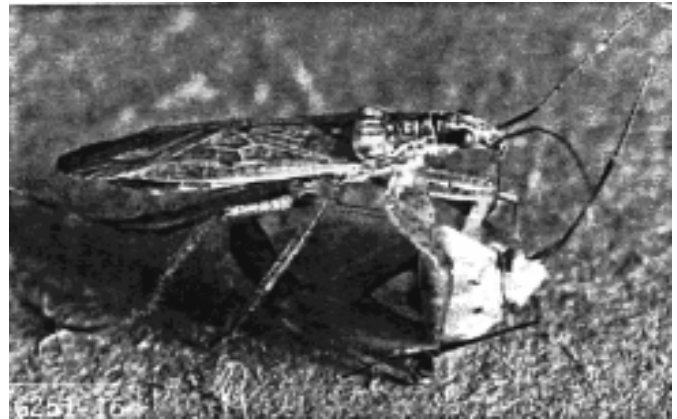
When employing biological control, it must be determined whether its use is to delay disease long enough for the crop to come through to maturity, to protect specific regions of the host, or even to reduce disease in one crop such that less pathogen inoculum is available for the next. In most instances, biological control strategies would be targeted against small pathogen populations to prevent or delay the buildup of disease rather than control existing high levels of pathogens. Often it is necessary to combine the use of microbial inocula with management practices designed to minimize disease losses. Changes in temperature or water relations during plant growth can have dramatic effects on the interactions between a pathogen and plant. In the case of host factors such as water potential, temperature and oxygen status, a resistant or susceptible combination/reaction can be near instantaneous. The application of biological control agents should be done before a problem develops.

Challenges to biological control...

A major problem for classical biological control using pathogens is demonstrating satisfactory specificity before introducing a new exotic pathogen. Public concern for the environment demands that introduced agents pose no threat to native fauna, flora and particularly to any endangered species. Failures in classical biological control have left a persistent public perception that a natural enemy once it has eliminated the pest, will become a pest itself. There is also a growing aversion to things foreign to the environment which has perhaps accompanied the progress made in genetic engineering research. Together these fears pose a new challenge in the development of biological control.

The risk of biological control agents becoming pests is minimized by selection and screening of host-specific agents against economically important species. The emphasis is on defining the host range as carefully as possible. With extensive testing of species closely related to the host, and close examination and interpretation of degrees of susceptible and resistant reactions, risks of introducing a new pest can be greatly reduced.

Also, there is a commonly held view that biological control agents are not effective pest control agents. Growers accustomed to the broad spectrum, rapid knock down and kill of many chemical pesticides find it difficult to accept the slower speed of most biological control agents. To improve user acceptance, it is important that unrealistic claims of control potential are not made, and that they are used intelligently, in strategies that exploit their strengths.



*Damsel bug adult feeding on lygus bugs.

*Beneficial Organisms Associated with Pacific Northwest Crops, PNW 343, A Pacific Northwest Extension Publication

Conclusions...

Perhaps most importantly, biological control should not be regarded as a sole replacement for existing control strategies, even for chemical control. Biological control is only one of many mechanisms that operate as part of a complex system in nature. The overall aim of biological control programs is to use the minimum quantity of pathogen sufficient to reduce the pest population below the maximum allowable damage threshold (could be physical or economic). The real challenge is to integrate biological control with other systems such as resistance, the environment, and other mechanisms of antagonism. In combination, these systems are the essence of integrated pest and disease management.

Harry Kope
Contact Biologicals





How To Conduct a Research Trial in Your Nursery

In my visits to nurseries over the years, I have always been impressed by the many trials being conducted by growers in their nursery. Often these trials have led to the adoption of new time and/or money saving techniques and better quality seedlings. Too often, the results of the trials have been misleading, or of no value, because the trials were not designed to provide the answers to the questions, the questions were not clearly defined, or the relevant parameters were not measured.

Conducting a trial can be time consuming. That is why I find it sad to see so much effort put into a trial only to have the results end up useless or misleading. Usually a few simple changes to design or sampling would have made the difference. A good example is trying CO₂ enrichment in one house with one pine seedlot one season. You got a "great" crop, concluded that the successful crop was due solely to the enrichment and installed CO₂ generators in every house at some expense. Unfortunately, in this example, such a "great" pine crop has never been produced again at that nursery! This is not a comment on the benefits of CO₂ enrichment, but rather on the design of the test. To improve the test, the enrichment could have been in two houses, or seedlings from several seedlots put in the one house, all other cultural and greenhouse environmental conditions should have been recorded, and several plant parameters measured. I also recommend conducting a trial for at least two growing seasons to take in the year to year variation in weather which affects the seedlings' response to cultural treatments.

In this article I will focus on the most common errors that I have seen in nursery trials and provide some simple solutions. First I will describe the flow of events or tasks required to successfully conduct a research trial. I will define some statistical terms, explain why they are important, and suggest how to incorporate these ideas into the next research trial at your nursery while emphasizing some of the problem areas I have encountered. This is not intended as an article on experimental design or sampling schemes or data analysis, so a reference list is provided for those who wish to learn more.

Flow of Events

The following steps should be rigorously followed when conducting a research trial in order to provide reliable results.

**RECOGNIZE THE PROBLEM
SEEK INFORMATION FROM EXISTING KNOWLEDGE**

**FORMULATE QUESTIONS TO BE ANSWERED
SELECT THE TREATMENTS**

**CHOOSE AN EXPERIMENTAL DESIGN
PLAN EACH STEP OF THE TRIAL**

**CONDUCT THE EXPERIMENT
ANALYZE RESULTS**

**INTERPRET RESULTS
IMPLEMENT CHANGES**

The first two steps, recognize the problem and seek information, are basic. If you are trying a new treatment (like CO₂ enrichment), you may not verbalize the research trial as a problem, but most likely the new treatment you want to test has the potential to improve on what you are already doing. Gather as much information as you can on the topic. Information is available through extension specialists, researchers, other growers, libraries and company sales representatives. The best studies are often the result of a thorough search of all available information so that the tests you conduct in your nursery need only address the questions specific to your nursery. For the CO₂ example, a grower could talk to the local extension specialists and the equipment sales representatives. They would provide information on who has been enriching either operationally or in research. You could find out what concentrations have been used on what crops and under what conditions.

From the information you now have, formulate clear concise questions that are to be answered by the trial you are about to implement. Write the questions down on paper and work hard on making them succinct, to the point, and able to be answered by the research trial. These questions are important because they are the guiding light for the rest of the study plans. The question should not be, "Will CO₂ enrichment produce bigger pine seedlings?", but rather a series of specific questions. "Will 800 ppm CO₂ applied from germination until I take the plastic off the houses increase stem diameter in 1+0 313 lodgepole pine seedlings?", would be a specific question that you could now use to begin planning the proper research trial to provide the answer.

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Next, you would select the treatments to be used including deciding on the experimental material to be tested. In the CO₂ example, CO₂ is the treatment you will apply and you have decided from the literature provided by the specialist to try 800 ppm. To keep things simple, use only lodgepole pine seedlings but use more than one seedlot because you do not have any large orders. In selecting treatments it is important to remember that you must always have a CONTROL treatment. That is, you must have a "treatment" which is a NO TREATMENT. In a research trial, a control, or untreated seedlings, is necessary to test the treated seedlings against. Without a control you have no comparison for your treated seedlings.

Now you design the experiment. I always recommend you keep it simple. Some important ideas to understand and use in designing your experiment are:

Experimental Unit: An experimental unit is a basic unit of experimental material to which one level of treatment or one combination of levels of treatments is applied (Bergerud 1988 Biometrics Pamphlet #5). Commonly in greenhouse experiments an experimental unit may be a styroblock, a group of styroblocs, some portion of the greenhouse, or a whole greenhouse.

Replication : A specific treatment is said to be replicated if it is applied to more than one experimental unit within an experiment. There are many ways this can be accomplished by the experimental design, but regardless of how it is done, it is ESSENTIAL (Bergerud 1988 Biometrics Pamphlet #2). It is essential because this is the only way you will be able to measure the validity of your conclusions from an experiment (Little and Hills 1978).

With my example of CO₂ enrichment, a whole house must be given a single CO₂ treatment. The experimental unit is then a house full of styroblocs. The best situation would be to have two houses with enrichment and two houses without (control treatment). This would give you replication. You could split each greenhouse in half and fill each half with one of two seedlots so both are present in each house. This would make it a split plot design with CO₂ enrichment as the main treatment and seedlots as the split plot treatments. A split plot design is only one of many possible designs, each one more suitable for testing different treatments in your nursery. If you cannot enrich two houses, I recommend repeating the experiment over at least two, if not three years, before deciding whether to switch to CO₂ in all houses.

Repeating experiments over time to compensate for the lack of replication does involve confounding the yearly results

with the annual weather. The weather is a variable which we cannot control and it often interacts with nursery treatments we apply. However, it is always preferable to replicate an experiment over time than not to replicate at all. Please just be careful about interpreting results from experiments conducted over time because of the possibility of this confounding effect.

Now you know what treatment(s) you plan to test and you know what the experimental unit will be. Before you put a single seed in a cavity or a styroblock in a house, plan the experiment from start to finish. In the CO₂ example, there will have to be two houses that are not enriched but have the same two pine seedlots and everything else the same. This is an important point in both planning and conducting any experiment. Within all human limits, you MUST keep all other variables the same among experimental units. To the very best of your ability everything in all four houses must be the same except the CO₂ enrichment. If all variables of temperature, media, styroblock size, time of sowing, irrigation, fertilization, extended photoperiod, etc. are not maintained similarly, you will never be able to say with any certainty that any differences you measure were due to the enrichment or some other factor. This attention to reducing any variation other than the prescribed treatments is critical and may require constant thought during the culture of the crop.

Know from the outset what you will measure and when. Measure only the things relevant to the questions you asked or you know to be affected by the treatment you are testing. Measure only as often as is needed to answer those same questions. There is no point in spending hours and days measuring seedlings when the information you get is not helpful in answering the questions. In the CO₂ example, seedlings could be measured for stem diameter, height, and needle, stem and root dry weight at the time the CO₂ treatment is stopped and again at the end of the season.

Sample size is often a difficult thing to determine. Sampling, with all its underlying theory, is a topic all of its own. I will just give some ideas to keep in mind for now. You want the mean from the measurements of the sample you take to reflect the mean of the whole population. In the CO₂ experiment, you could sample 100 seedlings randomly from within each seedlot in each house, both treated and untreated (enriched and not enriched). Often researchers pick at random a row number within a styroblock and sample the row of seedlings in say 10 styroblocs again picked at random throughout the house. However you do it, the important thing to remember is that you pick

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at random before going into the house and looking at the seedlings. Selection by human beings is never random once presented with many specimens from which to select. Be consistent with the sampling scheme you pick throughout the trial and among treatment units. Be guided in the number of seedlings to sample by how variable the seedlings are in height. If the crop is uniform, probably fewer seedlings need to be sampled than if the crop is extremely variable in the parameter to be measured.

Also, plan how you will record the measurements you will be taking. Pen and paper or electronic datalogger is one decision to be made. Either way of recording requires that you organize the data in a practical way for both collecting the data and manipulating it afterwards. Plan to monitor and record the environmental and cultural conditions as much as is possible. I mentioned before about the variation in annual weather and the importance of keeping all variables the same except for the treatments you are applying. Sometimes, the best we can do is to at least record temperatures, etc. even if we cannot control them. The environmental data can also be used in the data analysis as a covariate. By having complete environmental and cultural records, we can interpret the results of an experiment in light of what the other conditions were at the time. Without these records we can only scratch our heads and wonder.

Think ahead of how the data will be analyzed. The type of analysis depends on the experimental design, the stated objectives, and the variable you are measuring, i.e., categorical data (alive or dead), count data (number of seedlings at a certain stage), or continuous measurements (heights). The statistical tests you plan should specifically meet each of your objectives.

After all this planning, you are now ready to conduct the nursery trial. Stick to your plan as much as possible because it is a good plan. You have thought out every step ahead of time so little variation on the plan should be necessary.

Once you have concluded the experiment, do some exploratory data analysis. Plot out your data (line graphs, box plots, etc.) so you have a feel for what happened in the experiment. Measurements that look odd or incorrect can be spotted and either discarded or corrected. The actual analyses need not be complicated. A simple comparison of the treatment means is usually all that is required.

Interpretation of the results is usually the fun stuff. If means of replicates of the same treatment vary more than the differences between the treated and untreated, look at all the

other data you recorded on greenhouse temperature, fertilization, irrigation, stock handling, etc. This information may help you explain the differences in treatment response. This information is especially important when comparing results from a number of years. The data could be statistically analyzed, but please remember that what is important to you is what is biologically and economically important. Ask others for their interpretation. If you have clear documentation of the experiment and the results, any extension specialist or researcher could quickly read over the report and give an interpretation and recommendations.

Now you are in a position to implement changes if the results of the research you have conducted suggest that this is the case. In the nursery business it is always important to keep economics in mind, but this goes without saying. You can be comfortable knowing that you are making an informed decision based on the best research results available - your own done in your own nursery.

I hope the information I have provided is useful to you in planning your next research trial and I hope to see some excellent results on my next visit.

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Andrea Eastham

Canadian Forest Service, Prince George



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Botscan: A sampling system to forecast disease incidence of grey mould in container-grown conifer seedlings

INTRODUCTION

Large numbers of container-grown conifer seedlings continue to be culled in British Columbia every year because of grey mould (*Botrytis cinerea*) damage. Losses reaching 20% can occur if the disease is carried over as a storage mould and if these seedlings are outplanted, additional losses become apparent within 1-2 years. Initial infections are not easily detectable and the disease is often first noticed when outbreaks have become aggressively pathogenic and difficult to control. Thus, a monitoring system to forecast the progress of grey mould on container seedlings will allow more effective use of cultural controls and improve the accuracy of timing fungicide sprays, both of which could reduce losses by up to 80%.

Grey mould can infect living as well as dead tissue with signs of infected seedlings usually appearing in late August or early September. However, airborne *Botrytis* spores are known to occur in container greenhouses 6-8 weeks earlier, coinciding with seedling canopy closure (late-June to mid-July) (Peterson *et al.* 1988). Initial infections likely occur about this time when the closed canopy creates a favourable environment. From now onwards, free moisture often persists on foliage for as long as 120 hours after watering (Peterson and Sutherland 1990). This often results in temperatures of between 15-22° C, either in the presence of free moisture or when the relative humidity (RH) is greater than 98%. *Botrytis* infection can now take place rapidly in what are ideal conditions. Spores can germinate within 90 minutes of contacting wet plant surfaces and most spore germination occurs within 3-5 hours. Repeated occurrences of 3 consecutive hours with the above conditions can start a disease epidemic.

Following infection, *Botrytis* often enters a latent or resting phase until seedling physiology or environmental conditions favour aggressive disease spread. This results in both dead, and succulent healthy needles often becoming infected long before signs of a disease outbreak become apparent. During early disease spread, slow linear growth arises from repeated primary infections being initiated by outside inoculum. This is the "simple interest" phase of an epidemic when cultural controls are likely to be most effective. Unchecked, spread can change to rapid exponential growth with outside inoculum being aided by

mycelial infections and spores released from previously infected seedlings. This is the "compound interest" disease phase when control is more difficult. Thus, to benefit from accurate forecasting of disease incidence, monitoring procedures need to be initiated early in the growing season when latent infections predominate and growth is slow. This will allow cultural controls to be started early when they will have more effect than practices that rely on action taken when disease spread is rapid and aggressive.

Understanding the rate *Botrytis* spreads relative to seedling canopy microclimate has enabled the development of a system to forecast grey mould incidence on western hemlock and Douglas-fir seedlings. Called **BOTSCAN**, the plan monitors canopy microclimate and is based on cumulating the hours that ideal *Botrytis* infection conditions occur following canopy closure. If disease spread remains slow, cultural controls such as spacing or early morning watering may be sufficient to keep the accumulation of ideal infection periods low and fungicide application may not be necessary. Should spread become aggressive and growth rapid, fungicide sprays may be advisable. Forecasting grey mould on container seedlings is based on the knowledge of disease outbreaks as shown in figure 1.

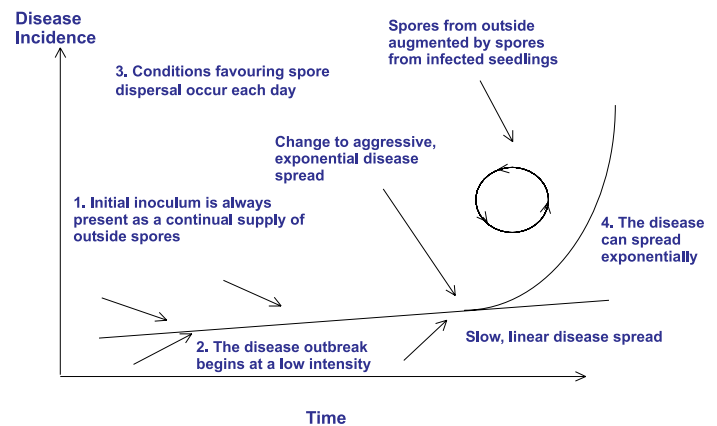


Figure 1. The infection process and spread of a grey mould outbreak on container seedlings.





To produce *BOTSCAN* it was necessary to know when initial infection occurs, how the resulting outbreak proceeds and if or when slow linear growth becomes exponential or steeply sloped. Following canopy closure, grey mould occurrence in Douglas-fir and western hemlock canopies was determined at weekly intervals and expressed as a percentage called disease incidence (**DI**). During the same period, dataloggers recorded temperature and needle wetness in each canopy to identify conditions ideal for *Botrytis* infection. These consisted of occurrences of 3 consecutive hours or more with temperatures between 15-22^o C combined with wet foliage. These were added to produce a cumulative infection period index (**CIPI**) in hours. The index is cumulative because grey mould outbreaks develop from both new infections as well as from latent ones established earlier in the season. Once calculated, **DI** and **CIPI** were compared to identify a **CIPI** value that coincided with change from slow linear, to rapid exponential increases in **DI**. This became the **threshold indicator of DI** with mean threshold **CIPI** indicators for western hemlock and Douglas fir from 1990, 1991, 1993 and 1994 experiments shown in figure 2.

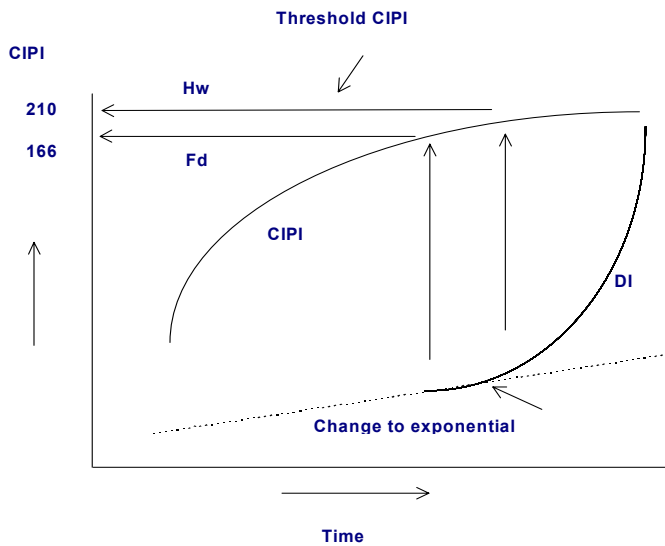


Figure 2. Mean **CIPI** (hours) threshold indicators of change in **DI** from linear to exponential growth for western hemlock and Douglas-fir from 1990, 1991, 1993 and 1994 experiments.

This is a useful way to forecast the risk of serious *Botrytis* outbreaks on seedlings using temperature and moisture data without having any specialised knowledge of how to quantify pathogen systems. However, as *BotsScan* has only just been developed, the hardware and software to use the model with

current greenhouse computers is not yet available as a package. Growers should therefore contact their computer supplier expressing interest in the potential for linking the model into their existing system. The temperature and needle wetness information is easily obtainable and once incorporated into greenhouse computer systems, a **CIPI** could be calculated and called up to a computer screen any time following canopy closure. These factors are more influential and thus more indicative of the state of the disease than are single relative parameters such as time since canopy closure.

RECOMMENDATIONS

With this information and using cultural techniques, growers can manipulate the canopy environment to avoid reaching the threshold **CIPI**. If **CIPI** remains below the threshold, damage will be low and fungicide use unlikely. As the threshold value is approached, the possibility of an outbreak becoming aggressively pathogenic increases and fungicide application may be required.

1. Following canopy closure, monitor seedling microclimate for ideal infection periods. Use cultural controls such as ventblocks, spacing or early morning watering to promote rapid drying and delay approaching a **CIPI** of: **210 hours in western hemlock and 166 hours in Douglas-fir.**

2. If grey mould appears to become more prevalent while **CIPI** increases beyond the above thresholds, fungicide application may be necessary as further spread is likely to become aggressive.

Development of *BOTSCAN*, indicates that by controlling the accumulation of favourable infection times, grey mould outbreaks may be held at tolerable levels. Thus, it may be possible to either eliminate unnecessary fungicide sprays or more accurately identify the most opportune time for their initial application.

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Peterson, M. J. and J. R. Sutherland. 1990. Controlling gray mold on container-grown Douglas-fir by modified styroblocks and under-bench forced air ventilation. *West. J. Appl. For.* 5 (3): 75-79.

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Alternate Orchard Design For Coastal Douglas-fir, An Approach For Improving Genetic Efficiency

As British Columbia's tree improvement and seed orchard programs move into their second phase of orchard development, genetic potential of orchard seed is being emphasized. Douglas-fir is one of the first established breeding and seed orchard species and several private and ministry orchards are now producing second generation seed that has an average percent gain in wood production of about 10-15%.

To achieve these values certain orchard dynamics are critical. All orchard parent trees must contribute equally and pollination from genetically related individuals (inbreeding) or from non-orchard pollen sources (contamination) must be minimized. The most demanding orchard requirements for coastal Douglas-fir is balancing parental contribution and reducing the negative genetic effect of contamination. To achieve these objectives, all second generation orchards on the B.C. coast use overhead irrigation to slow reproductive development (orchard cooling) and some supplement extra pollen to boost both pollen supply and the genetic value of the contributing orchard pollen parents.

Overhead irrigation of Douglas-fir orchards on the Saanich peninsula can slow reproductive development of orchard trees up to 10-14 days. This puts the pollination window (maximum seed cone receptivity) for most orchard trees beyond the heaviest shedding periods of most indigenous local Douglas-fir stands. By manipulating the paternal contribution through supplemental pollination the genetic potential of orchard seed can be further protected and enhanced. This technique can improve both the number of contributing paternal parents and/or the proportion of their contribution (genetic diversity) in the overall seed crop. Supplemental pollination can also enhance the genetic worth of the seed crop if the average genetic worth of the applied pollen mix is greater than the orchard's genetic worth. Finally, supplemental pollination can increase seed yields where within orchard pollen supply is low. Current experience with supplemental pollination suggests its best application is in younger orchards where crowns are smaller and access to the seed and pollen crop is relatively unimpeded. In mature orchards applying pollen to crowns of 6-8 meter (m) tall trees is difficult and labour intensive.

For Douglas-fir, some ideas from our New Zealand counterparts are being tested to see whether the design and management of mature orchards can be made more effective. New Zealand has pioneered the development of new orchard concepts including both "Hedged" and "Meadow" orchards for radiata pine. In the Hedged orchard,

stocking is at a density of about 500 stems per hectare (sph) whereas in the Meadow orchard stocking is about 5000 sph. In both, ramets are pruned as required to maintain crowns within 2 m height. The Hedged orchard stresses crown development prior to cone induction whereas Meadow orchard ramets are induced the year after establishment.



Douglas-fir "Micro" orchard specimen

(Continued)





Douglas-fir should be amenable to this approach because it is naturally fecund and responsive to cone induction technique. However, we have little experience with crown pruning regimes (height or form) and optimal spacing for area-based seed production in Douglas-fir orchards. To answer some of these questions a clonal-row orchard using the "Hedged" concept has been established. Two crown pruning regimes are being tested. The pruning regimes are not intended to hedge the trees but manage the crowns to enhance production of shoots with a high flowering potential and provide a convenient crown shape and size that facilitates both supplemental pollination and crop protection/collection. In the first pruning regime, crowns are topped to a maximum height of 3 m. In addition to height control, vigorous lateral shoots and some inter-whorl branches are pruned out to keep the crown structure open. In the second regime, tops are pruned back to a maximum 2 m height. An attempt is being made to slow apical dominance which is a challenge with this rather juvenile stock. By shaping and removing interior branching, the final shape of the crown becomes more bowl-like which will hopefully create a greater number of shoots with a higher potential for cone bearing. Initially, pruning was practiced every year (first two years) but can now be done extensively the year prior to cone induction and biennially there after. Since all of the irrigation/misting/cooling system are situated

overhead, orchard trees will never be allowed to exceed 3 m in height.

The design and approach of our Douglas-fir "Micro" orchard is to facilitate the production of genetically elite seed crops from advanced generation breeding material. We are into the third year of managing this orchard and have gained considerable experience in crown pruning and the application of flower induction technique. In addition to serving as a demonstration of alternate orchard designs, Michael Stoehr (Seed Production Research Scientist, Research Branch) is also using the material for research trials looking at inbreeding levels (a concern with clonal-row orchards) and pollination dynamics (factors affecting supplemental pollination efficacy including the effect of differential pollen viability on paternal success.). It is too early to judge the merit of this approach for future orchard establishment. However, small pilot scale trials have been initiated at the ministry's Bowser (Douglas-fir) and Kalamalka (interior spruce) seed orchards. Canadian Pacific Seed Orchards in Saanichton has also recognized the advantages of the clonal-row design for establishment of their second generation Western Hemlock orchard and their new blister-rust resistant White Pine orchard.

Joe Webber

Seed Production Research Scientist,

Glynn Road Research Station, B.C. Forest Service.

MARKETPLACE

This is your chance to buy/sell/trade or give-away! Send your requests marked "Marketplace" to the editor at the address on page 14.

For Sale: - 30,000 Capilino (198 cavity,white) blocks, priced to sell! Contact Ivan Haag at 604-494-9899

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Advanced Forest Pest Management Training Program (AFPM)

Fall, 1995. The Forest Insect Management Course, Sault Ste Marie, Ontario.

December 5-7, 1995. Forest Pest Management / Decision Support. Petawawa, Ontario.

For More Information Contact:

Eileen Harvey

Ph: 705-949-9461 Fax: 705-759-5700

Seed Orchard Management and Cultural Options for Quality Seed Production

A Tree Seed Working Group Workshop, held in conjunction with...

25th Annual Meeting of the Canadian Tree Improvement Association

August 28, 1995, Victoria, B.C. Canada

For More Information Contact:

David Kolotelo at 604-541-1683

or by EMAIL at DKOLOTEL@mfor01.gov.bc.ca.

Western Region of the International Plant Propagators' Society

36th Annual Meeting

September 14-16, 1995, Lion Columbia River Hotel, Portland, Oregon.

For More Information Contact:

Allan Elliott, Carlton Plants, P.O. Box 398, Dayton, OR 97114, 503-868-7971.

Forest Nursery Association of B.C. Annual Meeting

September 18, 19 & 20, 1995

Harrison, B.C., Canada.

For More Information Contact:

Bruce Morton, Hybrid Nurseries Ltd. 12682 Woolridge Road, Pitt Meadows, B.C. V0M 1P0

Ph: 604-465-6276 Fax: 604-465-9829

Can-West Hort Trade Show

September 20-21, 1995

Canada Place, Vancouver, B.C.

For More Information Contact:

BCNTA Office @ 604-574-7772

Silviculture/Seedling Growing Course-Module IV

October 31-November 2, 1995.

Northern Forestry Centre, Edmonton, Alberta.

For More Information Contact:

Al Nanka, Nursery/Tree Improvement Specialist. CFS, 5320-122 Street, Edmonton, Alberta, T6H 3S5

Ph: 403-435-7261 Fax: 403-435-7359

Native Plant Forum

Saturday, November 25, 1995

Vernon, B.C.

For More Information Contact:

Mike Carlson, 604-549-5681; Brian Barber, 604-356-6207; Nelly de Geus, 604-356-5954; Paulus Vrijmoed, 604-856-6408; Mishtu Banerjee, 604-278-4904; Rob Bowden-Green, 604-541-1683 or Diane Gertzen, 604-930-3309

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