United States
Department of
Agriculture

Forest Service

Pacific Northwest Region

State and Private Forestry

Cooperative Programs

R6-CP-TP-18-96

Forest Nursery Notes

July 1996

Forest Nursery Notes Production Team

Tom D. Landis, Principal Author and Editor
USDA Forest Service
Cooperative Programs
P.O. Box 3623
Portland, OR
E-mail: 2061340 @mcimail.com
Phone: 503-326-6231
Fax: 503-326-5569

Aleta Barthell, Design Layout, Printing, and Mailing List
USDA Forest Service
Cooperative Programs
P.O. Box 3623
Portland, OR
Phone: 503-326-6665
Fax: 503-326-5569

Donna Loucks, Library Services
Weyerhaeuser Research Center
505 N. Pearl St.
Centralia, WA'
E-mail: loucksd @ localaccess.com
Phone: 206-330-1740
Fax: 206-330-1742

Stayce Webb
Portland Habilitation Center, Inc.
5312 N E 148th
Portland, OR 97230-3438

This technology transfer service is funded by:
USDA Forest Service, State and Private Forestry

Cover Photo: This beautiful photomicrograph of a Douglas-fir seed was taken by L.E. Manning of the Pacific Forestry Centre in Victoria, BC. Approximate scale = 40X

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Thought for the Day—

"Aun aprendo (I am still learning)"

The Spanish artist Francisco de Goya wrote this on a painting when he was almost 80 years old. I like this quotation for a couple of reasons. First of all, it emphasizes that we're never too old to learn, but more importantly, it is the product of a positive attitude. Goya became famous by mid-life when a near fatal illness made him permanently deaf. Then, due to changes in the Spanish monarchy, he fell into political disfavor leaving him cynical and disillusioned. So, I am more impressed by Goya's ability to continue to try and improve his talents in the face of personal and political adversity -an important lesson for us all in these times of personnel downsizing and budget cuts.

Comments Cards

Speaking of downsizing and budget cuts, all US government programs are currently being re-evaluated as to whether they are still needed. The USDA Forest Service is going through an organizational and spiritual renewal by reaffirming its basic mission—"Caring for the Land and Serving People". To assess how we are doing, the Forest Service is surveying its customers and cooperators (that's you!!) to get their opinions. *Forest Nursery Notes* is a technology transfer service of State and Private Forestry, and we would like to know how well we are meeting your needs. A customer survey sheet is included in this issue which features a self-addressed, stamped postcard. No postage is necessary if it is mailed in the United States, but foreign subscribers will have to mail the card back in an envelope if they want to participate. Like so many of these things, all of the survey questions aren't particularly relevant, but there is a section for specific suggestions. FNN can only continue if you think that it is worthwhile, so let them know what you think.

Spanish Version of FNN

Due to budget problems, we were unable to produce a Spanish language version of the January, 1996 issue. Since then, we have acquired the funding to publish a combined 1996 FNN Spanish issue that will contain all the information from both the January and July, 1996 English versions. It should be ready for distribution by the first of August or so. We are maintaining a separate mailing list for those who want to receive this and future Spanish versions, so please **check the box on the Literature Order Form** if you are interested.

Nursery Meetings

Nursery Meetings and Workshops

The **Western Forest and Conservation Nursery Association** will held on ***August 20-23, 1996*** at the Quality Inn Conference Center in Salem, Oregon, which is less than one hour south of Portland. Our host will be Mark Triebwasser of the Weyerhaeuser Aurora Nursery. The agenda will consist of morning meetings and afternoon field trips. Focus topics include: Methyl Bromide Phase-out and Alternatives, Biocontrol of Soilborne Pests, Recent Advances in Seed Technology, Customer Perspectives, and Nursery Projects from Around the World. The afternoon field trips include the WEYCO Aurora and Turner Nurseries, IFA Canby Forest Nursery, Heritage Farms, and the FarWest Show of the Oregon Association of Nurserymen. An optional pre-meeting trip to see the reforestation and restoration projects on Mt. St. Helens is also scheduled. If you returned your meeting interest form, you should have received the registration packet already. If not, contact Mark immediately and he'll send you one:

Mark Triebwasser
Aurora Forest Nursery
Weyerhaeuser Company
6051 S. Lone Elder Rd.
Aurora, OR 97002 USA

Tel: 503-266-2018
Fax: 503-266-2010

The **Northeastern State, Federal, and Provincial Nursery Association Conference** will be held at the Radisson Inn in New London, Connecticut, on ***August 19-22, 1996***. The agenda covers a wide variety of nursery and reforestation topics, including an open discussion of marketing techniques. A day of nursery and forest industry tours will be capped by a New England style shoreline clambake at the Mystic Seaport. For more information, contact:

Martin Cubanski
Pachaug State Nursery
Box 190, Sheldon Road
Voluntown, CT 06384 USA

Tel: 860-376-2513
Fax: 860-376-5839

The **Forest Nursery Association of British Columbia** will be meeting at the Quesnel Community Centre in Quesnel, BC on ***September 16-19, 1996***. The agenda consists of morning technical sessions that will focus on Environmental Concerns Affecting Forest Nurseries, Nursery Production Systems, and a "Grower's Free-ForAll". Afternoon field trips to outplanting sites, local forest industries and nurseries will round-out the meeting. For the latest information, contact:

Mike von Hahn
Hi-Gro Silva Nursery Ltd.
Box 4366
Quesnel, BC V2J 3JA CANADA

Tel: 604-992-8631
Fax:604-992-6106

A 3-day **Tree Seed Pathology Meeting** will be held in Opocno in the Czech Republic during the ***second week in October, 1996***. The meeting will feature workshops, invited papers, and field trips to a tree seed processing facility and ISTA-approved seed testing laboratory. The meeting is jointly sponsored by the ISTA Tree Seed Pathology Committee and the Ministry of Agriculture of the Czech Republic. The $300 (US) registration fee will cover all ground transportation to and from Prague, room and board, the field trip, and even a visit to a wine cellar. Interested persons should contact:

Jack Sutherland Or	Zdenka Frochazkova
Pacific Forestry Centre	VULHM UH. Hradiste
506 W. Burnside Rd.	686 04 Kumovice
Victoria, BC V8Z IM5	CZECH REPUBLIC
CANADA	Fax: 42-632-549119
Tel: 604-363-0639	
Fax: 604-363-0775	
E-mail: jsutherland@al.pfc.forestrv.ca	

An international conference on **Nursery and Establishment Operations for Difficult Sites** will be held on ***October 6 - 12, 1996*** at the Parmar University of Horticulture and Forestry Campus in Solan, Himachal Pradesh, INDIA. This meeting is sponsored by three IUFRO Working Groups, including 53.02-03 Nursery Operations and will include five plenary technical sessions plus field trips to visit nurseries, as well as afforestation and soil conservation outplantings. The organizing committee will be accepting both formal papers or posters until July 31, 1996. For more information, please contact:

Dr. Parvinder Kaushal
Regional Centre, NAEB
Dr. Y.S. Parmar University of
Horticulture and Forestry
Nauni - 173 230 Solan (HP) INDIA

Tel: 91-1792-52324
Fax: 91-1792-52242

The third annual **Southwestern Container Growers' Meeting** will be hosted by the Colorado State Forest Service Nursery in Ft. Collins, CO on ***October 22-23, 1996***. Randy Moench and his staff will be our hosts. The meeting will consist of morning technical sessions on the focus topics on Diagnosis of Nursery Pests, Mycorrhizal Inoculation, and Propagation of Native Shrubs, and we'll have afternoon field trips of the nursery, as well as Colorado State University. John Harrington of the Mora Research Center at New Mexico State University will be sending out the first meeting announcement in a couple of weeks. If you don't get one, you can call either John or Randy for more information:

John Harrington or	Randy Moench
New Mexico State U.	Colorado State Forest Service
Mora Research Nursery	Nursery
PO Box 359	Foothills Campus, Bldg. 1060
Mora, NM 87732	Ft. Collins, CO 80523
USA	USA
Tel: 505-387-2319	Tel: 970-491-8429
Fax: 505-387-9012	Fax: 970-491-8645
E-mail: joharnn@nmsu.edu	

A **Tree Seed Workshop for Great Plains Nurseries** is being planned for ***November 5-7, 1996*** at the Bessey Nursery in Nebraska. The workshop is being presented by the personnel from the USDA Forest Service, National Tree Seed Laboratory, and will specifically address seed collection, processing, storage, and testing problems that are faced by nursery managers when dealing with Great Plains species. Because the emphasis will be on informal discussions and hands-on demonstrations, attendance will be limited so be sure and signup early. For more information, contact:

Clark Fleege
USDA Forest Service
Bessey Nursery
P.O. Box 38
Halsey, NE 69142 USA

Tel: 308-533-2257
Fax: 308-533-2213

Secondary Nutrients-Magnesium

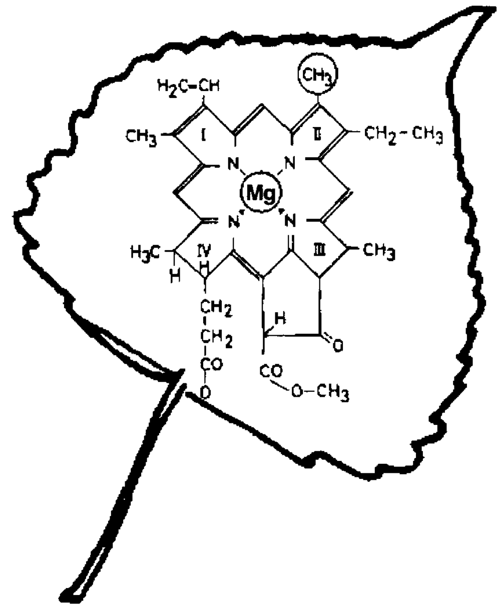
In the last FNN issue, we took a more detailed at the three "secondary" mineral nutrients, beginning with calcium. We'll continue with magnesium in this issue, and finish-up with a discussion of sulfur in the next one. Again, Eric van Steenis of the British Columbia Ministry of Forests contributed to the writing of this section.

Role in Plant Nutrition

Although magnesium concentrations are typically less than 1% of plant tissue (Table 1), this essential mineral nutrient serves some critical structural and physiological functions. Magnesium is most well-known as the only metallic constituent of the chlorophyll molecule where it occupies a critical central position, similar to that occupied by iron in blood hemoglobin (Figure 1). This structural function accounts for only about 25% of the magnesium in plant tissue, however, so this critical element also serves several other important physiological functions:

* **Cellular pH regulation and cation-anion balance.** Magnesium ions with their double charge (Mg^{2+}) are very mobile within cells, which allows them to be involved in the regulation of cellular pH and cation-anion balance. Because they are quickly transported through the phloem, magnesium ions can quickly be transported to other areas of the plant where concentrations are below optimal levels.

Figure 1. Magnesium forms the structural "heart" of the chlorophyll molecule.



*__Energy transfer.__ Magnesium functions in enzyme activation and the transfer of energy-rich phosphoryl groups (ATP) within cells; it helps regulate energy-requiring reactions, such as mineral nutrient uptake and the transport of photosynthates.

Table 1. The three "secondary nutrients": Calcium, Magnesium, and Sulfur

Element	Symbol	Average Concentration in Plant Tissue"%	Adequate Range in Seedling Tissue (%) Container	Bareroot
Nitrogen	N	1.5	1.20 to 2.00	1.30 to 3.50
Potassium	K	1.0	0.30 to 0.80	0.70 to 2.50
Calcium	Ca	0.5	0.20 to 0.50	0.30 to 1.00
Magnesium	**Mg**	**0.2**	**0.10 to 0.15**	**0.10 to 0.30**
Phosphorus	P	0.2	0.10 to 0.20	0.20 to 0.60
Sulfur	S	0.1	O.10to0.20	0.10to0.20

***Enzyme stabilization and "bridging".** Magnesium ions can form both ionic and covalent bonds; they function as a bridging element, making structures more stabile. Within enzymes, this bridging helps establish the precise geometry with their substrates; it also facilitates the ribosome subunits during protein synthesis.

Availability and Uptake

Magnesium is found naturally in many soils and becomes available for plant uptake as the minerals weather. The magnesium canons are held on canon exchange sites on clays or organic matter particles until they are taken up by plant roots (Figure 2-A). Deficiencies most typically occur in coarse-textured soils in humid regions, such as the coastal plain of the Southeastern United States. Magnesium availability is not a problem in most bareroot nurseries unless soil pH is allowed to drop too low. If soils become too acidic, magnesium can be leached below the effective rooting zone (Figure 2- B).

Because it is a chemical constituent of vermiculite, magnesium is found at low levels in many artificial growing media; however, this is not enough to supply the needs of rapidly growing seedlings. Therefore, container nurseries must supply it as dolomitic limestone or in soluble fertilizers.

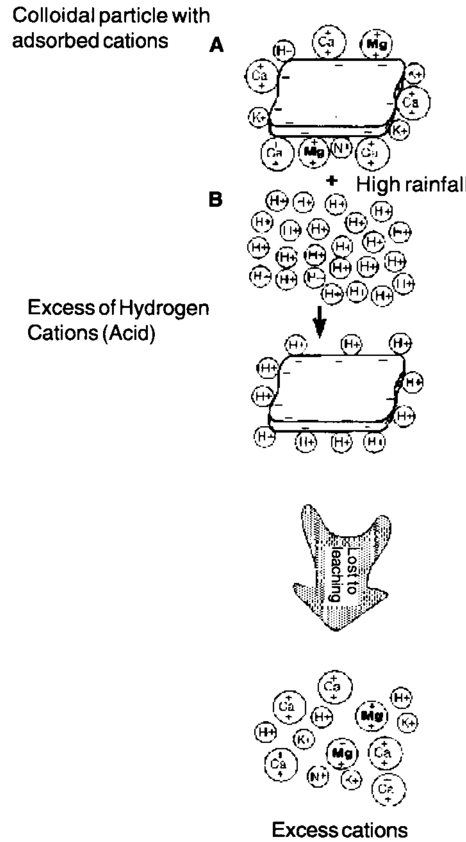


Figure 2. The ideal level of magnesium for plant growth is when it occupies about 10% of the cation exchange capacity of the soil (A). Under acidic, high rainfall conditions, however, it can be rapidly leached from the rooting zone and become deficient (B).

Diagnosis of Deficiencies and Toxicities

Foliar chlorosis is the typical symptom of magnesium deficiency, but the position, pattern and timing of the symptoms are most diagnostic:

Conifers:

Yellow tips of young needles which can turn into tip necrosis in extreme deficiencies. In classic experiments with Sitka spruce, the chlorotic needles of the upper shoot were described as "hard yellows" because they stood out rigidly from the stem. The symptoms characteristically develop late in the growing season and typically occur in patches surrounded by normal green seedlings.

Broadleaves:

Hardwood seedlings show very characteristic interveinal chlorosis which can become necrotic.

Because magnesium is mobile within plant tissue, translocation from older to younger foliage will occur, causing deficiencies to show in older tissue first. Note that visual symptoms do not develop until the magnesium deficiency is severe, by then, serious growth loss has already occurred. Soil and tissue testing can identify a potential problem much more quickly so that corrective actions can be taken.

Magnesium toxicity has not been found to be a problem in horticultural situations, although excesses could induce deficiencies of other mineral nutrients, especially calcium and potassium.

Monitoring

Bareroot nursery managers should use annual soil tests to determine the base magnesium levels in their soils, but, in most cases, maintaining pH in the recommended 5.5 to 6.5 range is a more practical concern. Container growers who fertigate can monitor the applied fertilizer solution for both the magnesium concentration and its ratio to other nutrients. Analysis of the saturated media extract and leachate can also give a good indication of magnesium availability and seedling use. Because magnesium is a common component in irrigation water, nursery managers should have their irrigation water analyzed. Some "hard" irrigation waters contain enough magnesium to meet all nutritional requirements, but growers also have to consider the calcium : magnesium ratio. Plant tissue analysis can be useful in diagnosing magnesium deficiencies (Table 1), especially if growers have established base-nutrient levels for their own species.

Magnesium Management

* **Analyze your irrigation water.** A complete water quality analysis will indicate both magnesium and calcium concentrations, and be sure that calcium and magnesium levels are balanced.

* **Monitor soil and growing medium pH.** In bareroot nurseries, maintaining a soil pH between 5.5 and 6.5 keep magnesium available unless a specific deficiency has been identified. Dolomitic limestone ($CaCO_3$ •$MgCO_3$) is the best choice for raising pH because it contains both calcium and magnesium in the proper nutrient ratio. The nutrient release-rate is dependent on particle size, and the magnesium fraction is much more soluble than the calcium fraction. Other liming materials, such as calcic limestone ($CaCO_3$) and hydrated lime [$Ca(OH)_2$] contain no magnesium, whereas magnesia (MgO) contains no calcium (Table 2). The proper application rate of dolomite depends on initial pH, soil texture, and organic matter content; easy-to-use tables are available to calculate this rate.

* **In container nurseries, formulate well-balanced fertigation solutions.** Although some commercial growing media contain incorporated dolomitic limestone, fertigation is the only way to insure that magnesium will be available at the proper concentration and ratio. Custom-mixed fertigation solutions should contain a target concentration of around 40 ppm magnesium with a Ca:Mg ratio between 2.1 and 3:1, and a K:Mg ratio from 2.5:1 to 4:1 on a ppm basis. Be aware that most commercial soluble and slow-release fertilizers do not contain calcium or magnesium, due to problems with solubility in concentrated stock solutions. The Peters Excel® line of fertilizers is specially formulated so that they are compatible with soluble magnesium fertilizers. Although their "All Purpose" formulation contains no magnesium, the specialty formulations "Cal-Mag" and "Magnitrate" contain from 2 to 9% Mg (Table 2). If you incorporate slow-release fertilizers in your media, check the product labels to be

Table 2. Fertilizers containing magnesium for bareroot or container seedlings

Fertilizer	Magnesium Content	Other Nutrients	Use in Nurseries
Magnesia	56%	None	A cheap source of Mg and will also raise soil pH
Mag-Amp®	15	Nitrogen	Slightly soluble fertilizer for high pH Phosphorus soils
Dolomitic container	6 to 14%	Calcium	Pre-sowing incorporation in bareroot seedbeds and growing media limestone
Sul-Po-Mag@; K-Mag®	11%	Sulfur Potassium	A soluble fertilizer that can be used for multiple deficiencies
Magnesium sulfate (Epsom salts)	10 %	Sulfur	Sole source of Mg in custom fertigation solutions for containers. Use as a foliar spray on bareroot stock
Peters Excels "Cal-Mag"	2%	All except Sulfur	Container seedling fertigation
Peters Excel® "Magnitrate"	9%	N+Micros	Container seedling fertigation

sure that they contain magnesium. Heavy nitrogen fertilization, especially with ammonium forms of nitrogen, can induce deficiencies of magnesium. Limiting ammonium nitrogen to 25% of the total nitrogen supply is recommended, especially under low light conditions.

* **In bareroot nurseries, apply fertilizers or amendments containing magnesium if warranted.** If a magnesium deficiency is suspected, then the best type of fertilizer will depend on the soil pH. Dolomitic limestone is usually all that is needed in acidic soils but, in neutral or alkaline soils, specialized magnesium fertilizers are available (Table 2). Epsom salts ($MgSO_4$) are a very soluble fertilizer that can be applied anytime during the season as a foliar spray. Sul-Po-Mag® is another soluble source of magnesium that also supplies sulfur and potassium.

In conclusion, magnesium is a critical mineral nutrient that can be easily overlooked in normal fertilization programs. Remember that nutrient ratios with calcium and potassium can be as important as the actual concentration of magnesium itself. Annual soil tests will tell bareroot nurseries whether they need to lime their soils, as well as the rates of dolomitic limestone to be used. Container growers should include magnesium in their fertigation solutions, rather than rely on incorporated dolomite in growing media.

Sources:

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Marschner, H. 1986. Mineral nutrition of higher plants. San Diego, CA: Academic Press, Inc. 674 p.

Mengel, K.; Kirkby, E.A. 1979. Principles of plant nutrition. Bern, Switzerland: International Potash Institute. 593 p.

Palomaki, V. 1995. Effects of magnesium deficiency on needle ultrastructure and growth of Scots pine seedlings. Can. J. For. Res. 25 (11): 1806-1814.

Parnes, R. 1990. Fertile soil: a grower's guide to organic and inorganic fertilizers. Davis, CA: agAccess. 190 p.

Ylimartimo, A.; Paakkonen, E.; Holopainen, T.; Rita, H. 1994. Unbalanced nutrient status and epicuticular wax of Scots pine seedlings. Can J. For. Res. 24 (3): 522-532.

Errata: In the January, 1996 issue, I said that the Peters Excel@ line of fertilizers contains calcium, but not all formulations do. What is unique is that they are compatible with other calcium fertilizers so that solubility in the stock solutions is not a problem.

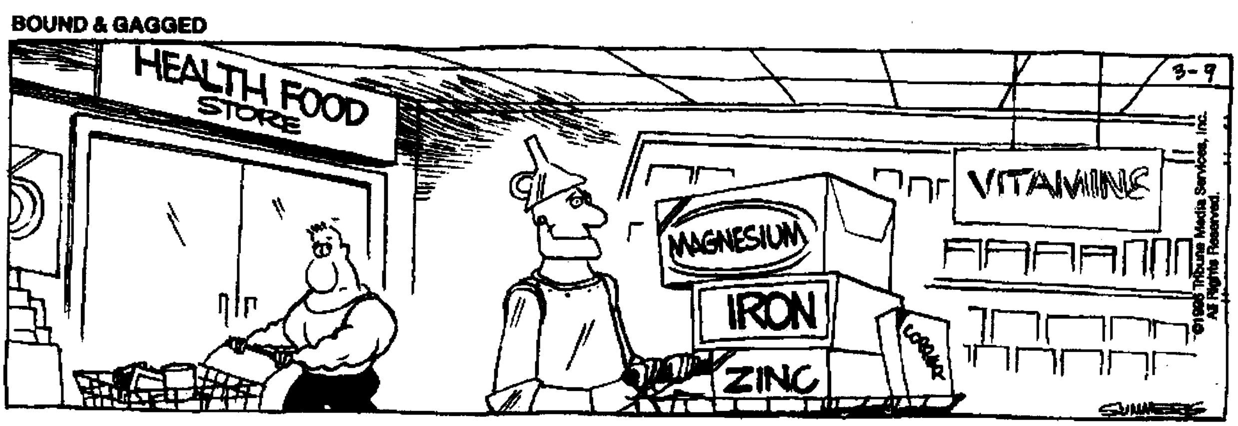

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Figure 3. Even the tin man had enough sense to know that secondary mineral nutrients are important to good nutrition.

Seed Treatments To Overcome Dormancy

Seeds of most horticultural crops have been genetically selected to germinate immediately after sowing. This is not the case for many forest and conservation species, however, whose seeds become dormant after they mature. **Seed dormancy** refers to a physiological state in which otherwise viable seeds will not germinate, even when placed in growth conducive environments. Although seed dormancy is an annoyance to growers, it is actually a fascinating ecological adaptation that works to spread germination out over time and space. Some types of dormancy insure that seeds will only germinate when weather conditions, especially moisture and temperature, are favorable to the survival of the seedling. Other seeds need to pass through the digestive tract of a bird or animal before they can germinate, which means that they will be carried away from the mother plant.

The **type** of dormancy is genetically controlled, and is usually the same for a given species, or even genus. As with most things in nature, however, there are always exceptions, and the genus *Quercus* is a good example. Most species in the red oak group have immature embryos that benefit from stratification, whereas most species in the white oak group do not. Even within each group, however, there are oak species that are exceptions to this rule. The **degree** of dormancy varies between ecotypes of a species, seedlots collected in different years, or even between individual seeds from a given plant. This variation is an adaptation that insures that all seeds will not germinate at the same time, but that germination will be spread over several years.

Seed dormancy can be caused by several different factors, and there is no universal agreement on the best terminology. For it to be relevant to nursery managers, a dormancy classification system should be both logical and operationally useful; six different types of seed dormancy have been proposed (Table 3). The major types of dormancy can be overcome with seed treatments. In the case of secondary dormancy, however, the best solution is preventing the condition in the first place by proper seed handling and storage.

Seedcoat dormancy

This condition is often called "external dormancy" because the restricting factor is the tissue surrounding the embryo (Table 3). The degree of seed coat hardness varies between species, but also depends on the ecotype and weather conditions during the seed ripening process. Several treatments can be used to soften the seedcoat, but keep in mind that the objective is to just increase its permeability to water and gases. Overly severe treatments may injure the embryo, so start with the gentlest

Table 3. Seed dormancy can be caused by several different factors

Dormancy Class	Causal Factors	Examples
Seedcoat (External)	1. Seed is impermeable to water or oxygen	1. Many legumes: *Acacia* spp.; *Robinia* spp.
	2. Seedcoat physically restricts developing embryo	2. *Pinus* spp.; *Quercus* spp.
Embryo (Internal)	1. Inhibiting substances within the embryo or surrounding tissue	1. *Betula* spp.; *Magnolia* spp.
	2. Physiological immaturity	2. *Juniperus virginiana.*
Morphological	Embryo is not completely developed	*Fraxinus* spp.; *Pinus* spp.
Double	Embryo dormancy in both the radicle and epicotyl	*Prunus* spp.; *Quercus* spp.
Combined	Results from 2 or more primary dormancy factors	*Tilia* spp. have a very hard seedcoat plus embryo dormancy; *Crataegus* spp.
Secondary	Results from poor seed collection, handling, or storage	*Pinus taeda* after exposure to high temperatures and moisture during storage

method, then increase the severity of the treatment until the seedcoat is permeable. *Be sure to keep good notes on the treatment method and timing, so that you can develop a seed treatment guide for each species or ecotype.*

Hot water soaks—This is the traditional treatment for hard-seeded species such as legumes, or seeds with waxy seed coats. Prepare a container with a volume of water that is approximately 4 to 6 times the volume of dry seeds. Bring the water to a boil, immerse the seeds, and then remove the container from the heat and allow it to cool. The embryo of some seeds can be damaged by high temperatures, so for these species, the water should be heated to only 65 °C to 70 °C (149 °F to 158 °F). The seeds can be removed and dried when they swell and become gelatinous to the touch. With some species (e.g. *Tilia* spp.), the imbibed seeds sink to the bottom of the container and the floaters must be removed and retreated. Although some growers use a standard treatment period for the hot water soak, it is better to experiment with each species and seedlot because of variations in seed coat thickness. Treated seed is subject to bacteria and fungus infection, and should be sown within a few days. One problem with hot-water treated seeds is that they stick together, making them difficult to use in mechanical seeders. One remedy for this is to place the treated seeds in moist peat moss for a few days.

Dry Heat—Fire treatments have been used on the seeds of some woody shrubs (e.g. *Arctostaphylos* spp.) from fire-dependent plant communities, and for some species of Eucalyptus spp. Dry heat treatments are not recommended, however, because the amount and duration of the heat that reaches the seed cannot be accurately controlled.

Scarification—The process of **scarification** involves weakening the hard seed coat just enough to allow imbibition, and several techniques are effective:

Mechanical abrasion—The seedcoats of small quantities of relatively large seeds can be treated by hand: nicked with a triangular file or sharp knife, rubbed against coarse sandpaper, or burned with an electric soldering iron or wood-burning tool. Be sure to scarify the rounded side of the seed to avoid damage to the radicle of the embryo (Figure 4). Workers should always wear protective gloves and small seeds can be held with tweezers. To treat large seedlots, a rotating drum that is lined with sandpaper or a cement mixer filled with gravel has been used. Whatever technique is used, it is important to regularly check the seedcoats to make sure that the treatment has not gone too far.

Acid soaks—Another scarification method is to soak the seeds in a strong acid solution which chemically digests the hard seedcoat. Concentrated sulfuric acid is preferred, but growers must be aware that this is an extremely caustic material, and that safety must always be a foremost consideration. MacDonald (1986) presents an excellent step-by-step procedure. Because the treatment time will vary considerably with species and seedlot, it is a good idea to conduct some small-scale trials first by removing a few seeds at regular time intervals, and cutting them to assess the thickness of the seedcoat. When properly done, acid scarification is a very effective way to soften seedcoats and stimulate quick germination. Although acid-scarified seeds can be stored for a few days, it is best if they are sown immediately.

The best choice of scarification treatment will depend on the biological requirements of the species and the skill and experience of the grower.

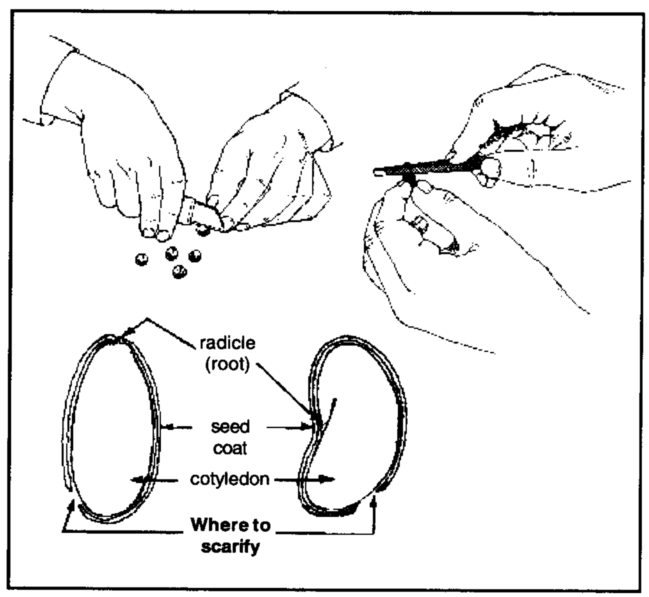


Figure 4. Hard-coated seeds can be hand scarified with a knife or file, but be careful not to damage the embryo.

Embryo or morphological dormancy

These "internal" types of dormancy can have two different causes (Table 3), but in both, the cultural treatment must overcome a physiological or morphological condition within the seed itself. As was the case with seedcoat dormancy, the degree of dormancy can vary considerably from species to species, as well as between ecotypes, again, the need to try different treatments and keep good records cannot be overstressed.

Cold, moist stratification—For commercial forest tree species, stratifying seed under cold and moist conditions is the most common treatment to overcome seed dormancy. Cold, moist stratification originated from the historical practice of placing layers of seeds between alternating layers ("strata") of moist peat or sand. Cold, moist stratification satisfies several important physiological functions, including: activating enzyme systems and converting starches to sugars for quick metabolism. Although the exact mechanism is unknown, stratification also changes the balance between chemical inhibitors and promoters within the seed, acting as a "switch" to chemically stimulate germination. Even species that do not exhibit true dormancy can benefit from cold, moist stratification with faster and more complete germination.

The traditional practice of mixing seeds within a moist medium is still used for some forest and conservation species. Some nurseries mix seeds with damp Sphagnum moss in a plastic bag and place it in a refrigerator. The condition of the seeds is checked weekly and they are sown after the prescribed stratification period, or planted as germinants. Naked stratification involves soaking seed in water to obtain full imbibition, draining off the excess water, and placing the seeds in polyethylene bags in refrigerated storage where the temperature is held slightly above freezing. Running water rinses are preferred to standing soaks because the bubbling water keeps dissolved oxygen levels high, and also cleanses the seedcoat of pathogenic organisms.

Successful stratification requires that four conditions be met:

1) proper seed moisture content
2) adequate aeration
3) low temperatures
4) the appropriate treatment time

Moisture and aeration—Operationally, these two factors must be considered together because they can be inversely related in the stratification environment. Effective stratification requires that seeds be fully imbibed and not allowed to dry out for the entire treatment period. Soaking in running water at room temperatures for 24-48 hours is usually adequate. If the seeds are not fully imbibed, the stratification will be less effective, and will be reflected in slow or irregular germination. After imbibition, the seeds are drained and placed in polyethylene bags. The volume of seed per stratification bag should be kept relatively small to insure good aeration throughout, and the bags should be no thicker than 0.102 mm (4 mil). This thickness of plastic allows some oxygen and carbon dioxide exchange-remember the seeds are alive and "breathing"! (Some nurseries insert a hollow tube in the top of the bag to increase aeration.) Placing the bags on wire mesh racks insures air exchange under the bag, and some nurseries hang the stratification bags from hooks. It is also a good practice to have someone move and massage the bags weekly; this moves seeds from the interior to the outside, and insure that no anaerobic conditions exist.

Temperature—The best temperature for cold, moist stratification is dependent on the species and ecotype, but most trees and shrubs from colder climates need temperatures slightly above freezing. The optimum temperature range for most temperate zone species is 1 °C to 5 °C (34 °F to 41 °F). Growers should make certain that their refrigeration units are functioning properly, and that temperature monitoring equipment is accurate, because freezing desiccates the seeds and stops the stratification process.

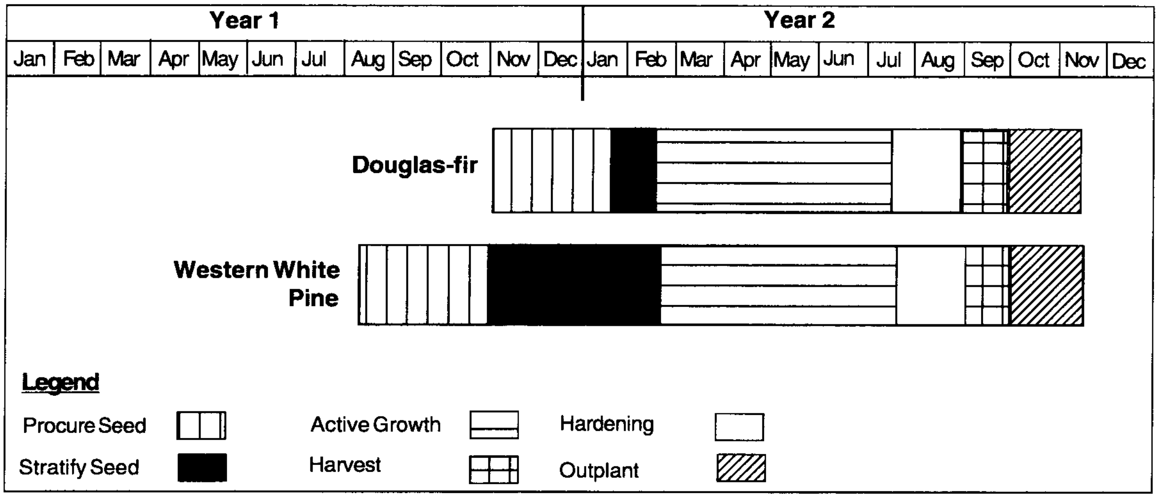


Figure 5. Seedling growing schedules must allow enough time for pre-sowing seed treatments which can take 4 months or even longer.

Duration of treatment—The prescribed length of the cold stratification treatment can vary from 4 to 20 weeks depending on species, variety and ecotype. Longer stratification periods erase the inherent differences within a seedlot, and improve the speed and uniformity of germination, resulting in a more uniform crop of seedlings. This is especially important when germination conditions are not optimum. Nursery managers must allow enough time in their growing schedules so that sowing can proceed on time (Figure 5).

In conclusion, most forest and conservation species have seeds with some sort of dormancy. To assure complete and timely germination, growers must learn the biological requirements of each species. Pre-sowing seed treatments take time, and this time requirement must be worked into the growing schedule so that the crops can be sown on time.

Sources:

Bonner, F.T.; Vozzo, J.A.; Elam, W.W.; Land, S.B. Jr. 1994. Tree Seed Technology Training Course - Instructor's Manual. General Technical Report SO-106. New Orleans, LA: USDA Forest Service, Southern Forest Experiment Station. 160 p.

Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. Manuscript in Preparation. Seedling Propagation, Vol. 6, The Container Tree Nursery Manual. Agric. Handbk. 674. Washington, DC: USDA Forest Service.

Macdonald, B. 1986. Practical wood plant propagation for nursery growers, Volume I. Portland, OR: Timber Press. 669 p.

Cost of Mycorrhizal Inoculation

David South of the Auburn University Nursery Cooperative sent me the following information in response to my article on "Mycortree Root Dip Inoculant" in the Equipment, Products and Services section of the last FNN. As usual, David has made some valid observations and rightly reminds us to always consider the cost of any chemical treatment or cultural practice. Many different types and brands of mycorrhizal inoculants are now available, and costs can range from as low as $0.43 per thousand seedlings to as high as $0.10 per seedling (Table 4). The most expensive treatments are those applied to seedlings at the time of outplanting.

David goes on to point out that, in spite of most people's perceptions, there are actually only a few published mycorrhizal inoculation. Still, there have been so many articles on the potential benefits, that most people are convinced that there is a positive economic benefit. The one benefit that is difficult to assess, however, is customer acceptance. If a customer believes that mycorrhizal inoculation is beneficial and is willing to pay the difference, then the cost is inconsequential. Like the old saying goes—"the customer is always right"!

Seedling Storage, Part Deux

Because of delays with access to reference material, the second article in this series will be included in the January, 1997 issue of FNN.

Table 4. Cost of various types of mycorrhizal inoculations

Type of Inoculum *	Seedling Stock Type	Application Time	Application Rate per Seedling	Application Cost per Thousand Seedlings
P.t. spores	BR	At time of sowing	2.6 mg$	0.43
P.t. spores + Humate	C	Incorporated into media before sowing	156.0 mg	1.52
P.t. spores	C	At time of sowing	1.0 mg	2.00
P.t. spore pellets	BR	At time of sowing	36.0 mg	2.75
VAM spores + clay carrier	C	Incorporated into media before sowing	2.2 mg	5.00
P.t. mycelia	BR	At time of sowing	0.75 ml	7.50
P.t. mycelia	BR	At time of sowing	1.00 ml	10.00
VAM spore pellets	BR	At time of sowing	1.00 ml	10.00
P.t. spores + Gel+ Others	BR	Before outplanting	425.Omg	40.00
P.t. spores + VAM spores + gel + others	BR Conifers	Before outplanting	425.Omg	51.00
P.t. spores + VAM spores + gel + others	BR Hardwoods	Before outplanting	850.0 mg	103.00

* P.t. = inoculum of the ectomycorrhizal fungus *Pisolithus tinctorum* ectomycorrhiza;

VAM = vesicular-arbuscular inoculum

Scouting

One of the basic foundations of Integrated Pest Management is the detection of a potential pest or the observation of a cultural problem before it becomes serious. This means scouting. Unfortunately, many nursery managers consider IPM scouting a normal part of every nursery worker's job, and it isn't done systematically and comprehensively. Yes, it's true that the entire nursery crew should be alert to possible problems during their normal duties. The problem with this approach is that the crew doesn't always get out among the seedlings on a regular basis, and there is always the tendency to assume that someone else is going to mention a problem. Pests don't work normal 8 to 5 hours, so it is important to look for pests early or late in the day, or even at night. For example, black vine weevils are nocturnal, and are rarely seen during the day, so an IPM scout may have to occasionally stop by the nursery at night to check.

So, it's a good idea to assign the responsibility of scouting for pests and cultural problems. This will insure that the job gets done regularly, and that the information will be permanently recorded in the nursery logbook or computer. And, although we are all equal in God's eyes, some people have unique abilities that make them better IPM scouts than others. The attributes of a good IPM scout include a knowledge of nursery practices and crop development, good eyesight, an inquisitive attitude, attention to detail, and patience. Often, the person who monitors seedlings growth and development, and inventory, makes a good scout because they are around the seedlings often enough to notice when something just doesn't look right.

Scouting tools include a hand lens, binocular scope (Figure 6), camera with close-up lens, notebook, and computer record keeping system. IPM scouts should also have access to a good library of books that identify and describe nursery pests and other cultural problems. Good record-keeping is essential; scouts should keep a daily log in a notebook, or record their observations on a standardized record form on a computer. Pest thresholds will vary from nursery to nursery, and this observational information is essential to developing them for your own situation.

Scouting Techniques

There are some relatively simple tricks of the trade that make scouting more effective:

* ***Sticky cards***—Yellow and blue sticky cards are an inexpensive, but effective, way to keep track of flying insects pests like aphids, fungus gnats, and thrips. Yellow works well for most critters but thrips are more attracted to blue.
* ***Indicator plants***—Some plants are just more attractive to pests, or sensitive to environmental stresses than the crop seedlings. For example, bigtree redwood *(Sequiadendron giganteum) is* extremely sensitive to the fungus *Botrytis cinerea,* so some growers place a few seedlings of this species amongst their crop, and monitor them closely. When they see the first signs of the fungus, it's time to spray protective fungicides.
* ***Sequential sampling***—A new, more-efficient method of IPM scouting has been developed for whiteflies in poinsettias but could be modified for any large crop. The technique consists of inspecting plants in a pre-determined sequence until you can make the determination of whether the problem has reached the critical threshold. Sequential sampling requires specific data on the relationship between the number of pests per plant and damage caused, so it would only be applicable after the basic relationships between pest levels and damage have been established. See Sanderson and others (1994) for specific details.

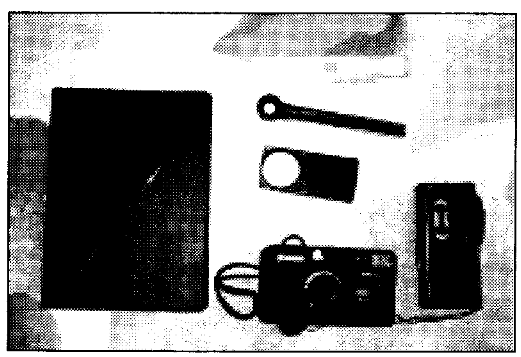


Figure 6. Scouting is an essential part of an Integrated Pest Management Program and requires some specific tools.

The scope and intensity of IPM scouting must be determined by the size and complexity of the nursery, so don't let techniques or procedures deter you. The important thing is to just get out there, start scouting, and recording some observations.

Sources:

Cuny, H. Why aren't you scouting? Greenhouse Management & Production 14(1): 24-26.

Sanderson, J.; Davis, P.; Ferrentino, R. 1994. A better, easier way to sample for whiteflies on poinsettias. Greenhouse Manager 13(6): 71, 73-76.

Disinfectants

Sanitation is one of the keystones of IPM, and disinfectants, such as household bleach and alcohol, traditionally have been used to stop the spread of disease in nurseries. In recent years, newer commercial disinfectants such as the benzalkonium chlorides have entered the market. All the commonly-used chemicals control both pathogenic fungi and bacteria with the exception of alcohol (Table 5). Some of the newer products are even effective against viruses. Bleach, alcohol, and hydrogen peroxide have the advantage of being both inexpensive and readily available. The name brand disinfectants are relatively more inexpensive, but are not so expensive as to be prohibitive.

Nursery managers must also consider the safety and environmental risks of every chemical that they use. Household bleach is irritating to use, especially in closed areas, and may pose environmental risks (Table 5). Bleach breaks down in hypochlorite ions that form very stable organochlorine compounds that accumulate in animal tissue and may cause health problems. Although they are more expensive, the benzalkonium chlorides and hydrogen peroxide are just as effective, and have no potentially damaging breakdown products.

Disease prevention is the primary objective of any nursery IPM program, and disinfectants are an effective and economical way of eliminating bacteria and fungi in the propagation area. Although economics are always an important consideration, growers must also be aware of the safety risks and possible environmental hazards of any chemical that they use.

Source

McClelland, M.T.; Smith, M.A.L. 1994. Alternative methods for sterilization and cutting disinfestation. Combined Proceedings, International Plant Propagators' Society (1993) 43: 526 - 530.

Table 5. Properties of common disinfectants used in nurseries

Product	Chemical Formula	Efficacy	Economics	Safety and Environmental Risks
Bleach	$NaClO$ $Ca(ClO)_2$	Controls fungi and bacteria	Cheap and Available	Fumes are irritating; organochlorides may pose risks
Isopropyl alcohol	$CH_3(CH\text{-}OH)CH_3$ all bacteria	Doesn't control	Inexpensive	Dangerous to breathe
Physan, Green-Shield, Triathalon, Naccosan*	Benzalkonium chlorides	Controls fungi and bacteria	"Economical"	None: Inert by-products
Hydrogen peroxide	HOOH and bacteria	Controls fungi	Twice as Expensive as Bleach	None: breaks down into water and oxygen

* = See Equipment, Products, and Services section

Biocontrol of *Botrytis*

Botrytis cinerea is one of the most ubiquitous and damaging fungal pathogens in the world, and is a major pest in both container and bareroot nurseries. Because high humidity is such a major predisposing factor, the fungus is particularly destructive in greenhouse nurseries. *Botrytis* can cause damping-off, but it is most damaging as a foliar blight called grey mold, which quickly develops into branch and stem cankers, and can eventually kill the host seedling. Because this fungus thrives at unusually low temperatures, *Botrytis* develops into a devastating storage mold if infected seedlings are not culled during the grading process.

Both chemical and cultural controls are effective against *Botrytis,* especially when incorporated into an IPM program. Aggressive scouting for early detection, followed by roguing of infected seedlings, and careful management of irrigation and ventilation is recommended. A wide variety of fungicides have been used against *Botrytis,* but the fungus has developed resistance to several of the more commonly-used products (Figure 7).

New research, however, has produced several biocontrol agents which show promise against both *Botrytis* foliar blight and storage mold. Greygold™ is a biocontrol for grey mold that is currently undergoing EPA registration, and should be commercially available by this fall. The product is a mixture of three beneficial icororganisms: a filamentous fungus *(Trichoderma hamatum),* a yeast fungus *(Rhodotorula glutinis),* and a bacterium *(Bacillus megaterium).* Greygold™ attacks *Botrytis* in several different ways: 1) with the production of antibiotics that suppress spore germination and growth, 2) by physical competition which reduces sites for *Botrytis* colonization, and 3) by direct parasitism of *Botrytis* mycelia and sclerotia. While it is most effective as a preventative treatment, Greygold™ has also worked as an eradicant to suppress disease outbreaks in conifer seedlings. The easy-to-use formulation mixes well with water, and can be injected through irrigation systems or applied with tank sprayers. And, like most biocontrol products, Greygold™ has a minimal re-entry period, instead of the twelve or more hours required for most chemical fungicides. If you would like more information or want to obtain a sample for your own operational trials, contact:

EDEN Bioscience Corporation
5795 NE Minder Road
Poulsbo, WA 98370 USA
Tel: 800-635-6866
Fax: 360-297-7369

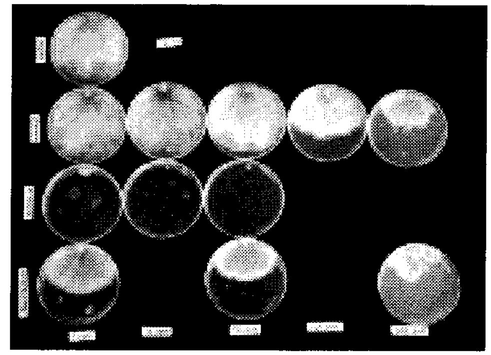


Figure 7. The Botrytis fungus has developed resistance to many of the common fungicides as illustrated by the lack of mycelial growth on these petri dishes.

Gliocladium roseum is a fungus that has shown considerable promise against both the germination of Botrytis spores and elongation of the mycelium. Suspensions of the asexual spores of *Gliocladium,* called conidia, significantly suppressed grey mold infections in container black spruce crops, even under epidemic conditions. At the higher application rates, *Gliocladium* was about twice as effective as the fungicide chlorothalonil in controlling sporulation, and also reduced seedling mortality by as much as 80% (Figure 8).

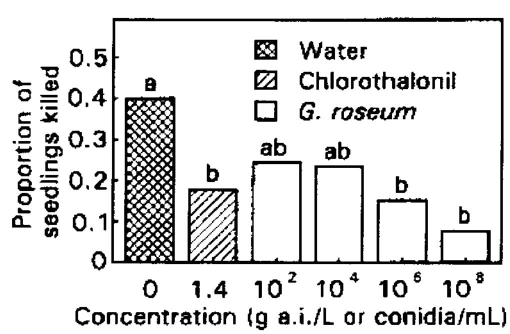


Figure 8. Spores of the biocontrol fungus Gliocladium roseum were shown to reduce the amount of container black spruce mortality due to Botrytis cinerea, and high concentrations even outperformed the fungicide chlorothalonil (Zhang and others 1996).

Researchers at the Horticulture and Food Research Institute in New Zealand have been conducting experiments to control *Botrytis* on stored kiwifruit. They are using an aromatic extract from the *Trichoderma* fungus which is apparently a natural fungicide and prevents *Botrytis* from penetrating plant tissue. The extract, called "6-PAP" (6-pentyl-alpha-pyrone), smells like a combination of coconut and celery. 6-PAP is not a new discovery, but was originally isolated by researchers at the USDA Agriculture Service back in the 1970's, but no more work was done with it until recently. Treated kiwifruit has remained disease-free for as long as 12 months of refrigerated storage, and if this research proves conclusive, there may hope for a way to treat tree seedlings prior to long-term storage.

Source:

Biocontrol for kiwi mold. 1995. Science 270(1): 1443.

McElroy, F. 1996. Personal communication. Poulsbo, WA: Eden Bioscience Corporation.

Zhang, P.G.; Sutton, J.C.; Hopkin, A.A. 1996. Inoculum concentration and time of application *ofGliociadium roseum* in relation to biocontrol *of Botrytis cinerea* in black spruce seedlings. Can. J. For. Res. 26(3): 360-367.

Biocontrol for Fungal Root Pathogens

Bio-Trek 22G™ contains a new strain of a beneficial fungus called *Trichoderma harzianum,* and offers preventative control of common root pathogens, including: *Pythium, Rhizoctonia,* and *Fusarium.* When incorporated into soils or growing media, the Trichoderma fungus quickly colonizes the seedling's root system, and prevents the attack of pathogen through both competition and mycoparasitism. Because it functions as a preventative rather than curative treatment, Bio-Trek 22G™ must be applied early in the growing season, but will grow along with the seedlings as they mature, and even remains effective after transplanting. Because it is compatible with chemical fungicides such as Subdue and Terrachor, Bio-Trek 22G™ is perfect for IPM programs. This EPA-approved biopesticide is safe for workers, animals and the environment, and has one of the shorter re-entry intervals of only 4 hours. In the Pacific Northwest, Bio-Trek 22G™ is being distributed by Wilbur-Ellis Company:

Kurt Spingath
Wilbur-Ellis
PO Box 8838
Portland, OR 97208 USA
Tel: 503-227-3525
Fax: 503-243-7645

Sun Protection

Working outdoors is one of the primary reasons that people like to work in nurseries, and many summer nursery tasks require spending long hours in the sun. Some exposure to sunlight is necessary to good health. For example, sunlight helps the body produce vitamin D, enabling it to utilize calcium and prevent a calcium deficiency disease called rickets. A healthy tan is one of the benefits of working in the sun, but like many things, you can have too much of a good thing.

Sunlight is the common term for electromagnetic radiation that originates from the sun. The light that our eyes see is only a very narrow band of this radiation, but contains the wavelengths that drive photosynthesis, and make all life on earth possible. Wavelengths longer than visible light are harmless, ranging from the infrared rays that we feel as heat, to very long radio and TV signals that pass harmlessly through our bodies. Wavelengths shorter than visible light, ranging from ultraviolet (UV) to cosmic rays, can be hazardous to your health because of their higher relative energy. Specific wavelengths of ultraviolet light are known to affect human health: UVB is considered a primary cause of skin cancer, whereas UVA rays cause premature wrinkling. Fortunately, the earth's atmosphere selectively screens out most of these harmful rays. Ozone molecules high in the atmosphere intercept much of the UV radiation reaching our atmosphere, however, because man-made pollutants are causing a thinning of the ozone layer, this protective effect is diminishing. Correspondingly, there has been a dramatic increase in skin cancer since World War II, especially among people who spend long hours in the sun.

There are three common types of skin cancer: basal-cell carcinoma, squamos-cell carcinoma, and malignant melanoma. While carcinomas can be deadly, malignant melanoma is by far the most serious type of skin cancer, with 80 percent of the cases becoming fatal. Melanocytes are normal skin cells that produce melanin, the dark pigment that causes tanning and helps protect the skin from solar radiation. UVA rays are thought to break the DNA molecules in the melanocytes, turning them into cancerous cells that multiply out of control. Melanoma is a particularly deadly form of cancer, because some of the cancer cells break off and rapidly migrate through the lymph and circulatory systems to other body organs. One of the insidious aspects of this disease, is that the melanoma may not spread for many years, but once it does, the cancer is almost impossible to cure.

Doctors have identified several factors which have linked the incidence of UV light to skin cancer:

1. The predominant occurrence of tumors on exposed areas of the skin

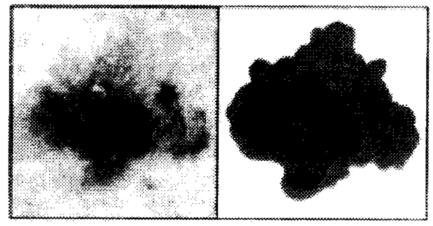
2. The correlation to the amount of time spent in the sun

3. A relationship to the intensity of the sunlight

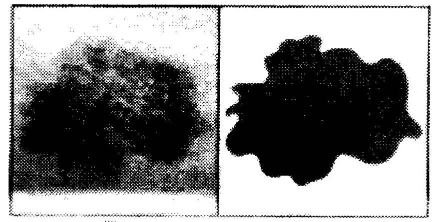
For carcinomas, cumulative lifetime solar exposure is believed to be the primary causative factor. This hypothesis is supported by studies showing a prevalence of skin cancers on those who spend much time outdoors, either recreationally or occupationally. Some people are more at risk than others, and melanoma is rare among people of African or Asian ancestry. High risks factors include a family history of skin cancer, a fair complexion with blue eyes, red hair, or freckles, and skin than tends to burn rather than tan. Regardless of your risk category, everyone should practice the following precautions to reduce their risk of skin cancer:

* Wear light clothing and a hat to protect exposed areas, especially during midday when sunlight is most intense. Remember that UV radiation can penetrate clouds so be cautious even on cloudy days.
* Use sunscreens to block the sun's rays, and re-apply them frequently. Sunscreens are rated by an SPF (sun protection factor) number. For most people, an SPF-15 sunscreen should be sufficient as it blocks out 93% of the UV rays. Lighter-skinned people or those working out in the sun all day should use SPF-30.
* Wear UV-blocking sunglasses. Almost any brand provides a moderate level of protection, but outdoor workers may want to consider special UV-rated glasses that can reflect 99% of UV radiation.
* Practice early detection by examining yourself regularly. Most skin cancers are easily treated and cured if they are detected in time. Look for a change in the size or appearance of a mole or blemish, and become concerned if these areas are sore or start to itch. If any of your moles or pigmented skin spots have any of the following A-B-C-D symptoms (Figure 9), contact your doctor immediately.

A - Asymmetry: One half of the spot is different than the other half.



B - Border is irregular: The spot has a scalloped or poorly defined border.



C - Color or texture is varied: Parts of the spot vary in color or skin texture.

D - Diameter is unusually large: The size of the spot are larger than 6 mm, or the size of a pencil eraser.

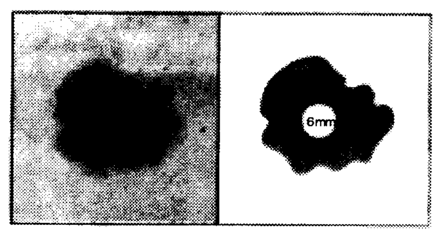


Figure 9. People working outdoors should regularly examine their skin for any suspicious blemishes or moles (Courtesy of the Oregonian).

So, with a little common sense and some simple precautions, nursery workers can reduce their risk of developing health problems, and still enjoy the physical and mental benefits of working outdoors.

Sources:

O'Neill, P. 1996. Save your skin. The Oregonian, May 30, 1996. p. A-19 to A-20.

Sunscreens. 1995. Consumer Reports, May, 1995.

MacKie, R. 1992. Screening for skin cancer. Occupational Health. July, 1992. p. 202-203, 206.

Siegel, M. 1990. Safe in the Sun. New York: Walker and Company

Equipment, Products, and Services

Boom Irrigation

Traveling booms are a relatively recent method to irrigate seedlings in forest and conservation nurseries, and are rapidly becoming the method of choice for several reasons:

1. Uniform water, fertilizer, and pesticide application—The nozzles are evenly spaced along the boom to apply water in a moving vertical plane (Figure 10A), which gives much better coverage than the circular horizontal pattern produced by stationary nozzles (Figure 10B). While this is obviously important for irrigation coverage, soluble fertilizers and pesticides can be applied much more evenly through a boom system than by hand or with stationary sprinklers.

2. Less waste and runoff of water and nutrients—Automated irrigation systems wastes the water that hits the aisles and edges of the propagation area, as well as that which runs down between the containers, and/or leaches through the medium. Although manufacturers advertise that water-use efficiency ranges from 50% to 90% with boom irrigation, recent comparisons found that the actual efficiencies are somewhat lower. Nevertheless, tests indicate that boom systems can be significantly more efficient than fixed overhead irrigation systems or hand watering.

3. Less wind drift—Because water is sprayed down onto the crop instead of up into the air, the water distribution pattern from a boom is not as affected by wind direction as stationary irrigation systems.

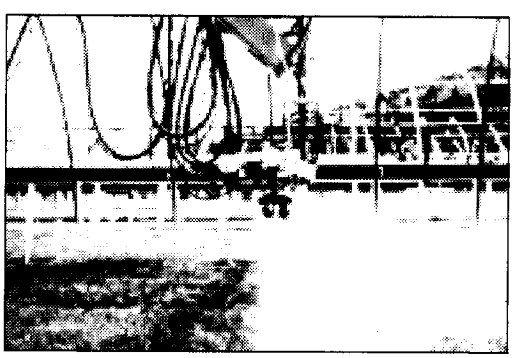
4. Multiple functions—Irrigation booms can be equipped with multiple nozzles that can be switched to perform different functions: regular irrigation and fertigation, misting for humidity control, and pesticide application.

5. **Lower peak irrigation demand**—Because a propagation area can be kept irrigated with fewer total nozzles using boom irrigation, peak water demand is considerably lower under conditions of high evapotranspiration.

6. **More economical**—Compared to hand irrigation, the savings of water, labor, fertilizer, and pesticides can be enough to allow growers to pay off a boom system in as little as one year.

A wide range of irrigation boom systems with many different options are available. The booms can be suspended from greenhouse trusses or designed to travel along bottom rails. Computer-controlled models with variable-speed electric motors allow growers to program a preset series of operations, including: different irrigation rates, skipping sections, as well as automatic start and stop functions. Booms can be designed to cover areas ranging up to 21 m (70 ft) wide and 122 m (400 ft) long, and their height is easily adjusted for different crops. Boom systems also are available for open growing compounds, and are particularly valuable when wind drift is a problem. Some ground-mounted models have the ability to fold and pivot so that the boom trolley can be moved between growing areas-a very economical option. Prices depend on the type of system and features, but can typically cost anywhere from \$10.76 to \$32.38 per m^2

A.



B.

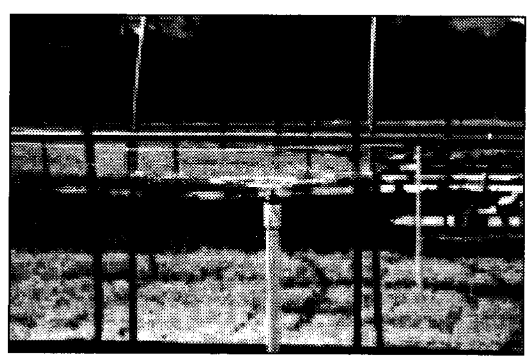


Figure 10. Boom irrigation systems apply water in a continuous linear pattern (A) and are much more efficient than rotary sprinklers which produce a circular distribution pattern (B).

($1.00 to 2.00 per ft2). Contact the following manufacturers for specifics:

Andpro Ltd.
PO Box 399
Waterford, ON
CANADA N0E 1 Y0
Tel: 519-443-4411
Fax: 519-443-8861

Growing Systems, Inc.
2950 N. Weil
Milwaukee, WI 53212
USA
Tel: 414-263-3131
Fax: 414-263-2454

Canaan Industries, Inc.
PO Box 8097
Dothan, AL 36304
USA
Tel: 205-793-9112
Fax: 205-677-0846

ITS % McConkey & Co.
PO Box 1690
Summer, WA 98390
USA
Tel: 206-863-8111
Fax: 206-863-5833

East Coast Designs, Inc.
PO Box K
Alburtis, PA 18011
USA
Tel: 215-965-1127
Fax: 215-965-8910

Transplant Systems
PO Box 983
Kinston, NC 28501
USA
Tel: 919-523-0970
Fax: 919--523-4966

Sources:

Dumroese, R.K.; Page-Dumroese, D.S.; Wenny, D.L. 1992. Managing pesticide and fertilizer leaching and runoff in a container nursery. IN: Landis, T.D. tech. coord. Proceedings, Intermountain Forest Nursery Association' 1991 August 12-16; Park City, UT. Gen. Tech. Rep. RM-21 1. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 27-33.

Greenhouse Manager. 1993. A look at boom irrigation. Greenhouse manager I 1(10): 80-8 1.

Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1994. Nursery Planning, Development, and Management, V of 1, The Container Tree Nursery Manual. Agric. Handbk. 674. Washington, DC: USDA Forest Service. 188p.

Transplant Systems Ltd. 1996. Cost savings with booms. Growth Points 3: 2-3.

Compost Maturity Test

Composts have several uses in both container and bareroot nurseries. They can serve as the organic component in growing media, and research has shown that compost-based media are suppressive to soilborne diseases. Bareroot nurseries can use organic composts as soil amendments to improve tilth, drainage and aeration. They also make ideal mulches for covering seed and protecting young emerging germinants, or for over-wintering older seedlings.

The composting process is explained in detail in the January, 1994 issue of FNN, but here's a quick review. Composting requires a mixture of organic wastes with particles ranging from 1 cm to 5 cm (0.4 to 2.0) in size and with a carbon-to-nitrogen (C:N) ratio between 25:1 to 35:1 (Figure 11). In the case of organics with a high C:N, like sawdust, fertilizer nitrogen is also required. The decomposer micro-organisms require water and oxygen to breakdown the organic matter and reproduce, and then give off heat and carbon dioxide as by-products of their respiration.

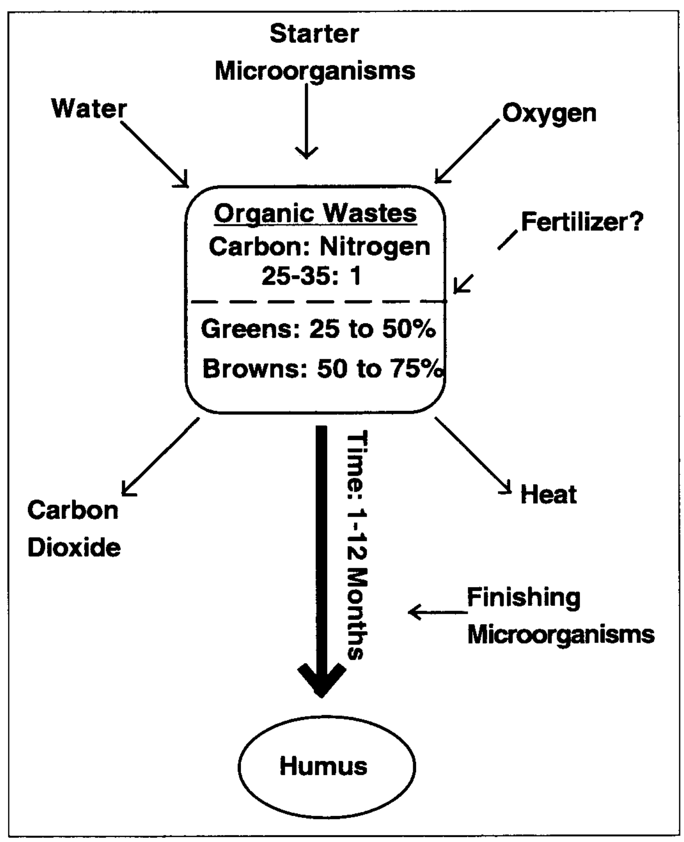


Figure 11. Although composting occurs naturally, nurseries can speed up and improve the quality of the humus by monitoring their compost piles

Up until now, the only way to check the progress of your compost pile was to measure the internal temperature. Recently, however, Woods End Research® has developed a series of field test kits which nursery managers can use to scientifically track the biological progress of their compost:

* The Compost Maturity Test is a colorimetric test that takes only 4 hours, and costs about $14 per sample. The relative color is keyed to a numerical index from 1 to 8 (Table 6), which then describes the compost condition. Cost = $84.00 (does 6 tests)

* The Compost Self-heating Test Kit evaluates the stability of the compost by measuring residual heating ability by monitoring the temperature in a special reusable flask. Cost = $325.00

* The Compost Oxygen Probe is a kit containing a hand vacuum pump with a long probe for taking gas samples from within the compost pile. Cost = $575.00

Woods End Research also performs other more complicated tests that require controlled laboratory facilities. Compost conditions, such as: decomposition rate, volatile organic acids, and phytotoxic compounds can be done on a fee basis. For more information, contact:

Jonathan W.Q. Collinson
Woods End Research Laboratory
Old Rome Road, Rt. 2, Box 1850
Mt. Vernon, ME 04352 USA
Tel: 207-293-2457
Fax: 207-293-2488

Table 6. Relationship between organic compost condition and Solvita® Test Kit results

Stage in Composing Process	Compost Maturity Test	Dewar Self Heating Test	Approximate Oxygen Use (mg/gVS/hr)	Approximate Carbon Dioxide Evolution Rate %C/day
Fresh, raw compost. Extremely high rate of decomposition. High is volatile organic acids and so very odiferous	1 Yellow	I	1.60	2.75
Moderately fresh compost. Very high respiration rate, requiring frequent turning and aeration.	2 Orange-Yellow	II	1.40	2.25
Active compost. High respiration rate still requiring turning and aeration	3 Light Orange	I I I	1.25	2.00
Moderately active compost that is still decomposing	4 Orange	I I I	1.00	1.50
Moderately active compost, but past the active decomposition stage. Beginning to cure.	5 Reddish-Orange	IV	0.75	1.25
Moderately mature compost in curing phase, requiring less aeration and management.	6 Maroon	IV	0.50	0.75
Well-matured and aged compost that is well-cured. **Ready for growing media and soil amendments.**	7 Reddish-Purple	V	0.25	0.50
Highly matured compost that is well aged. **Best for soil amendments.**	8 Purple	V	0.00 to 0.10	0.00 to 0.25

New Disinfectant and Algacide

Naccosan concentrate has recently been registered by the US Environmental Protection Agency for use in container nurseries. While chemically similar to the other alkyl ammonium chlorides, this new product contains four different active ingredients and so is effective at much lower concentrations. As a disinfectant, Naccosan kills fungi, and bacteria on surfaces, tools, and equipment, but can also be used to control algae in evaporative cooling systems. Another attractive feature is that chelating agents chemically immobilize calcium carbonate, so Naccosan remains effective in hard water. To get more information contact:

Dexter Friede
Grow-More, Inc.
15600 New Centry Drive
Gardena, CA 90248 USA
Tel: 310-515-1700
Fax: 310-515-4937

New Root Control Containers

Root form is always a concern with container seedlings, so manufacturers continue to offer new features that will control spiraling, and produce a well-distributed, fibrous root system. Vertical ribs inside the cells were the first revolutionary design feature, and recently the inside of the cells were coated with copper compounds to promote chemical root pruning. Recently, this technology has been applied to polybags. Another new concept features slits in the sides of containers to stimulate lateral air pruning, and several manufacturers are now offering containers with side slits.

Spin Out® Polybags—As we discussed in the July 1995 issue of FNN, root deformation and spiraling are particularly bad in containers made of plastic sheeting. Polybags are one of the most widely-used containers in the world, and are especially popular in developing countries. The Griffith Corporation has just succeeded in developing a process that will treat the surface of polybags with Spin Out®, a copper hydroxide-based root control product which is already registered in several countries. Research trials are already underway with forest species, and results look promising, but the Griffith folks would like to try out the Spin Out® treated polybags with other species and in other climates. So, if you are interested in conducting an operational trial at your nursery, contact Mark Crawford:

Griffith Corporation
PO Box 1847
Valdosta, GA 31603-2571 USA
Tel: 912-249-5271
Fax: 912-244-5978

Side slit containers—Forcing seedlings to airprune their roots at the bottom of the container is a well accepted cultural practice. Now, several manufacturers are offering containers with vertical or horizontal slits in the sides to promote lateral air pruning. The concept is attractive, and several nurseries are now testing these containers. Several different types of side slit containers are now available:

Stuewe and Sons, Inc. offers **the Rigi-pot 25050** container from IPL, Inc. as well as two side slit containers from **Hiko:** the V-50SS and the V-150SS. Both are featured in their full color catalog, so call for a free copy:

Stuewe and Sons, Inc.
2290 SE Kiger Island Drive
Corvallis, OR 97333-9461 USA
Tel: 541-757-7798
Fax: 541-754-6617

The **Winstrip®** tray system features side slit cells interspersed with open vertical columns to further encourage air exchange. These hard plastic containers come in 4 models that feature a range of different cell volumes, depths, and densities. For more information, contact:

Sarah J. Lupfer
Winstrip, Inc.
PO Box 5095
Mills River, NC 28742 USA
Tel: 704-891-6226
Fax: 704-891-8581

RootMaker® Portable Container—These were developed from the research of Carl Whitcomb who pioneered work with side slit containers. Three sizes are available—the propagation size containers are arranged in a 4x4 configuration, the #1 square or round single pot, and the #3 round pot. For prices and more information, contact:

Carl Whitcomb
Lacebark, Inc.
PO Box 2383
Stillwater, OK 74076 USA
Tel: 405-377-3539
Fax: 405-377-0131

The **Lannen Plantek** F side slot tray (Figure 12) comes in 4 sizes of square cells ranging from 50 to 90 cm 3 in volume. Plantek trays were developed in New Zealand, where they are proving a viable option for growing Eucalyptus and Radiata pines. To receive more information, contact:

Hakmet Ltd.
881 Harwood Blvd.
Dorion, PQ J7V 7J5
CANADA
Tel: 514/455-6101
Fax: 514/455-1890

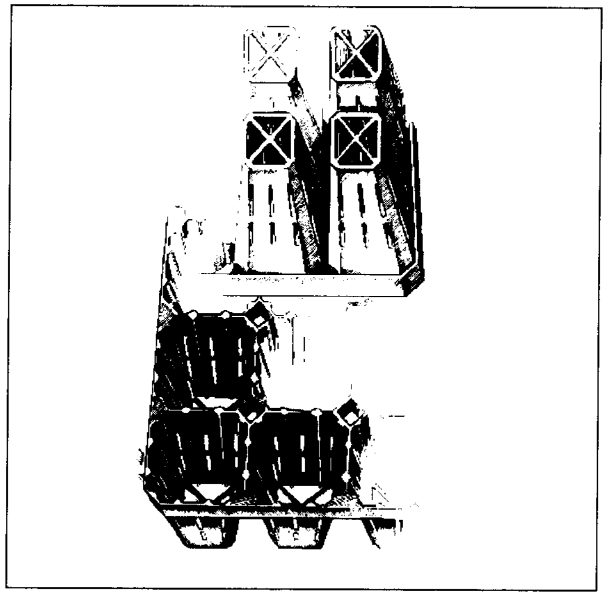


Figure 12. "Side slit" containers, such as this model from Lannen, are the newest type of containers which are specifically-designed to control root spiraling.

Nursery Networks

Cooperatives are an excellent way to network with other growers, and there are a couple of forest nursery cooperatives that are based at universities in the United States. In this issue, we'll discuss the cooperative at Oregon State University, and then talk about the one at Auburn University in the next FNN issue.

The Nursery Technology Cooperative (NTC) is headquartered at the Department of Forest Science of Oregon State University in Corvallis, Oregon. The NTC is run by Project Leader Robin Rose and Associate Director Diane Haase, who are assisted by Caryn Chachulski. The history of the NTC can be traced back to 1979 when a task force noted a lack of research support and educational assistance to the forest industry in the Pacific Northwest. Their report proposed that a nursery technology center be established at Oregon State University to address these needs, and the NTC was officially established in 1982.

Nursery Technology Cooperative

Figure 13. The Nursery Technology Cooperative is headquartered at Oregon State University and serves forest and conservation nurseries throughout the Pacific Northwest

The goal of the NTC is to improve the productivity of Pacific Northwest forests through the use of advanced seedling technology to achieve optimal regeneration. Using an integrated program of coordinated studies, information sharing, and technical assistance, the NTC focuses attention on all aspects of nursery management, especially its consequences on seedling outplanting performance. NTC members include: state, federal, and private nurseries; seedling users; and specialist organizations who provide financial support based on their size. The NTC Leadership Team is advised by a Technical Committee, a Policy Committee, and an Integrated Pest Management (IPM) subcommittee who make decisions concerning program strategy and financial support. They also help plan Cooperative studies by identifying problems and setting priorities.

As you can see from the following list, the NTC is involved in a wide variety of interesting studies:

** Coconut (coir) as a growing media for container seedlings.*

** Microelement nutrient loading in the nursery.*

** The use of controlled-release fertilizer in the field.*

** The effect of copper coating on subsequent field performance of container seedlings.*

** Root culturing technical service studies.*

** Effectiveness of Hot Sauce as an animal repellant for planted conifer seedlings.*

** The effects of Sol-u-Gro, Cytoplex, and SP-11c on Douglas-fir growth in the nursery.*

** Herbicide Screening.*

** Long-term Project on Alternatives to Methyl Bromide.*

** Propagation of PNW Native Plants.*

** Chlorophyll Fluorescence.*

** Effects of fall fertilization on Douglas fir seedling quality.*

For more information on the NTC, contact Robin or Diane visit the Worldwide Web site in the following section:

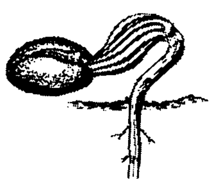
Nursery Technology Cooperative
Oregon State University
Forest Science Lab. 020
Corvallis, OR 97330 USA
Tel: 541-737-6576
Fax: 541-737-5814

FNN Home Page

We have been working to get a Forest and Conservation Nursery Home Page on the World Wide Web. It will be housed at the USDA Forest Service, Northeastern Area site in St. Paul, MN - "http://willow.ncfes.umn.edu". We envision a site that contains a variety of technology transfer services:

> *Directories of forest and conservation nurseries and seed suppliers.
> * A full set of *Forest Nursery Notes,* including back issues.
> * A list of Forest Service nursery and tree improvement publications, and how to order them.
> * Cross-references to other sources of information like the nursery cooperatives.
> * Information on how to contact the Forest Service nursery and tree improvement specialists.

As with everything, however, the project is taking longer than expected but we still hope to have it fully operational in the next couple of months. So, check us out the next time that your are surfing the Net.



Nursery Web Sites

As I started in the last FNN issue, I'm going to accumulate a listing of World Wide Web (WWW) Sites here and will eventually put them on the Forest Service Home Page. Right now, I'm just going to list them in alphabetical order but will eventually workout some more rational organization. If you would like me to list your nursery or company WWW page, send the address to us. We've included an E-mail and WWW address location on the Literature Order Form on the back page.

Colorado State Forest Service Nursery
http://www.colostate.edu/Depts/CSFS/csfsnur
Ft. Collins, CO USA

Forest Nursery Grower Page
http://www.wbm.ca/users/jmatthew/
J. Matthews
Prince Albert, Sask. CANADA

Nursery Technology Cooperative
http://www.fsl.orst.edu/coops/ntc/ntc.htm
Oregon State University Corvallis, OR USA

Pacific Forestry Centre
http://www.pfc.forestry.ca
Canadian Forest Service
Victoria, BC CANADA

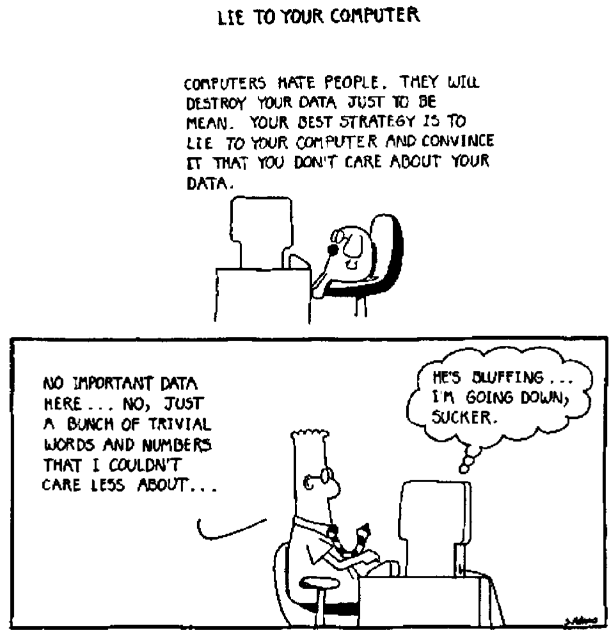
Stuewe & Sons, Inc.
http://www.stuewe.com
Nursery Containers and Equipment
Corvallis, OR USA

Tree of Life Nursery
http://www.prtcl.com/tol/home.htm
San Juan Capistrano, CA USA

Horticultural Humor

Doctors used to consider laughter as only a coping mechanism, but it is now considered a relaxation technique because of its physical health effects. Recent medical studies suggest that physical expressions like laughing and crying contribute to our health and well-being, and many doctors are now prescribing a daily dose of humor to help improve our physical and mental health.

The best type of humor is when we can laugh at ourselves, and in the nursery business, we have plenty of opportunities, because nature has a way of keeping us humble. Best of all, humor is contagious, and can be shared, so here at FNN we're trying to do out part:



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"Excellent work. I look forward to taking credit for it."

Reprinted by permission: Paul Nicoloff.

Gazing up at the night sky with its billions of stars made Tom feel tiny and insignificant by comparison. So he stopped doing it.

Reprinted by permission: Tribune Media Services.

New Nursery Literature

Many of the journals that are listed in *Forest Nursery Notes* are copyrighted, and some charge a copyright fee. So, to comply with copyright laws, there are 3 categories of publications listed in the New Nursery Literature section:

1. Numbered or lettered articles can be ordered using the Literature Order Form on the last page. Subscribers should circle the appropriate number or letter and return the form to us.

2. Items with © are copyrighted and require a fee for each copy, and so only the title page and abstract will be provided through this service. If subscribers desire the entire article, they can order a copy from a private literature service.

3. Special Order (SO) publications are either too long or too expensive for us to provide free copies, but prices and ordering instructions are provided here, or following the individual listings in the "New Nursery Literature" section.

Special Publications

SO. Dey, D.; Buchanan, M. 1995. Red oak ***(Quercus rubra L.)*** acorn **collection, nursery culture and direct seedling:** a literature review. Forest Res. Info. Paper No. 122. Saint Ste. Marie, ON: Ministry of Natural Resources, Ontario Forest Research Institute. 46 p.

This softbound publication does an excellent job of reviewing the literature about the seed propagation of red oak. It contains chapters on seed collection, seed stratification and storage, bareroot culture, container culture, and direct seeding. Best of all, it is well-illustrated with numerous black-and-white photographs, illustrations, and tables.

COST: Free **ORDER FROM:**
Ontario Forest Research Institute
PO Box 969
1235 Queen Street East
Saint Ste. Marie, ON P6ASN5
CANADA
Tel: 705-946-2981
Fax: 705-946-2030
E-mail: ofriin@epo.gov.on.ca

SO. Rose, R.; Haase, D.L.; Boyer, D. 1995. **Organic matter management in forest nurseries: theory and practice.** Corvallis, OR: Oregon State University, Nursery Technology Cooperative. 65 p.

This is a update of an earlier Forest Service publication "Organic amendments in forest nursery management in the Pacific Northwest", and has been reorganized and expanded to reflect the latest published literature. The chapters cover physical, chemical and biological properties of organic matter in soil, decomposition, organic amendments, and green manure crops. It is an excellent overview of the subject.

COST: Free **ORDER FROM:**
Forestry Publications Office
Oregon State University
Forest Research Laboratory
Corvallis, OR 97331-78401 USA
Tel: 541-737-4271
Fax: 541-737-3385

SO. Rose, R.; Chachulski, C.E.; Haase, D.L. 1996. **Propagation of Pacific Northwest Native plants: A manual, Volume One.** Corvallis, OR: Oregon State University, Nursery Technology Cooperative. 66 p.

The demand for native plants continues to increase and so more and more nurseries are being asked to propagate everything from grasses and forbs to rangeland shrubs and noncommercial tree species. This spiral-bound publication is a literature review on the seed and vegetative propagation of 50 different species from the Pacific Northwest of the US. The authors state that this is only a first effort and another more comprehensive will be published in the future.

COST: Free **ORDER FROM:**
Forestry Publications Office
Oregon State University
Forest Research Laboratory
Corvallis, OR 97331-78401 USA
Tel: 541-737-4271
Fax: 541-737-3385

SO. Moulton, R.J.; Lockhart, F.; Snellgrove, J.D. 1996. **Tree Planting in the United States1995.** Washington, DC: USDA Forest Service. State and Private Forestry. 18 p.

This annual report summarizes tree planting and nursery production activities by forest land ownership category and state for 1995. In addition to the tabular statistics, an introductory section discusses trends and prospects for future demand and the output of the various federal cost-share programs. For example, the Southern states continue to lead the nation in tree planting with 1,689,981 acres planted which is almost 70 % of the US total (Figure 13).

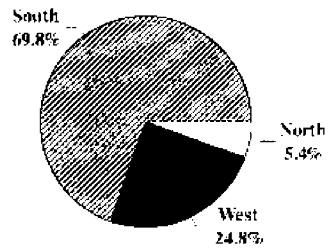

Figure 14. Tree planting statistics for the 3 major regions of the US (Moulton 1996).

COST: Free **ORDER FROM:**
Robert Moulton
USDA Forest Service
Forestry Science Laboratory
PO Box 12254
Research Triangle Park, NC USA
Tel: 919-549-4032
Fax: 919-549-4047

Bareroot Production

1. ***Irrigation for frost protection in forest nurseries: room for improvement.*** Rose, R.; Haase, D. L. Western Journal of Applied Forestry 11(1):16-19. 1996.

SO. ***Top pruning bare-root hardwoods.*** South, D.B. Auburn University, Southern Forest Nursery Management Cooperative, Technical Note 96-1. 12 p. 1996. ORDER FROM: Ken McNabb, School of Forestry, Auburn University, AL 36849-5418. Tel: 334/844-1044 Fax: 334/844-1084

2. ***Smart toolbar: final report.*** Karsky, R. USDA Forest Service, Technology and Development Program, Missoula. 9624-2809-MTDC. 10 p. 1996. ORDER FROM: USDA Forest Service -MTDC, Building 1, Fort Missoula, Missoula, MT 59801. Phone (406) 329-3900. Free.

Business Management

3. ***Common contract and business forms.*** Dunleavy, P. G. Greenhouse Management and Production 14(2):50-51, 55. 1995. How to prepare forms that will meet your business needs.

4. ***Contract rules and regulations.*** Dunleavy, P.G. Greenhouse Management and Production 14(1):60-62. 1995. Information you need to know to protect your business.

5. ***Does your nursery work leave you hurting?*** Appleton, B. L. The Digger 40(3):14-17. 1996.

6. ***Get it in writing.*** Dunleavy, P. G. Greenhouse Grower 14(1):66-68. 1996.

7. ***Getting a grip on catastrophic crop insurance.*** Panczyk, T. D. American Nurseryman 183(9):48-51. 1996. The Federal Crop Insurance Reform Act of 1994 has received mixed reviews, but changes are underway to better protect nursery professionals hit by natural disasters.

8. ***No laughing matter.*** Perry, P. M. American Nurseryman 183(9):58, 60-63. 1996. Ethnic and cultural discrimination in your workplace can result in costly lawsuits and affect your bottom line.

9. ***The power of paper trails.*** Ibarbia, E. A. Greenhouse Grower 14(1):53-54. 1996. Federal pesticide safety rules went into effect about this time last year. How are you doing in keeping up with the paperwork?

10. ***Ride the technology wave.*** Buist, A. L. Greenhouse Grower 14(1):103-104, 106. 1996.

11. ***Stimulating success.*** Perry, P. M. American Nurseryman 183(10):55, 57-61. 1996. High employee morale can lead to increased productivity for your business. Here's how to measure it and increase it.

12. ***Tune into radios.*** Healey, D. Greenhouse Grower 14(3):36, 38. 1996. Walkie talkies can make communication during your busy season a whole lot easier.

Container Production

13. ***Germinant sowing in South Africa.*** South, D. B.; Young, C. Tree Planters' Notes 46(1):7-10. 1995.

14. ***Growth of Coreopsis and Plumbago in plastic and $Cu(OH)_2$-impregnated fiber containers.*** Ruter, J. M. HortTechnology 5(4):300-302. 1995.

15. ***Making DIF work for you.*** Martinez, H. Greenhouse Management and Production 16(2):36-39. 1996. Temperature control can lead to better plant growth, less chemical regulators.

16. ***Propagate and prosper: when propagating oaks, a methodical approach and a natural fungus can yield maximum fibrous roots.*** Krautmann, M. American Nurseryman 183(1):24-26, 28-29. 1996.

17. ***Root and shoot growth of Eucalyptus in response to container configuration and copper carbonate.*** Schuch, U. K.; Pittenger, D. R. HortScience 31(1):165. 1996.

18. ***Why you should consider automated controls.*** Neal, K. Greenhouse Management and Production 16(2):33-35. 1996.

Diverse Species

19. ***Changing your propagation paradigms.*** Borland, J. American Nurseryman 183(5):2429. 1996.

20. ***Gibberellic acid during priming of Echinacea purpurea (L.) Moench seeds improves performance after seed storage.*** Pill, W. G.; Haynes, J. G. Journal of Horticultural Science 71(2):287-295. 1996.

21. ***Improved vegetative propagation of Scouler willow.*** Edson, J. L.; Leege-Brusven, A. D.; Wenny, D. L. Tree Planters' Notes 46(2):5863. 1995.

22. ***© In vitro propagation of Salix tarraconensis Pau ex Font Quer, an endemic and threatened plant.*** Amo-Marco, J. B.; Lledo, M. D. In Vitro Cellular and Developmental Biology -Plant 32(1):42-46. 1996.

SO. ***Propagation of Pacific Northwest native plants: a manual volume 1.*** Rose, R.; Chachulski, C. E.; Haase, D. L. Oregon State University, Nursery Technology Cooperative. 66 p. 1st edition. 1996. ORDER FROM: Forestry Publications Office, Oregon State University, Forest Research Laboratory 227, Corvallis, OR 97331. Free.

Fertilization and Nutrition

23. ***Availability and persistence of macronutrients from lime and preplant nutrient charge fertilizers in peat-based root media.*** Argo, W. R.; Biernbaum, J. A. Journal of the American Society for Horticultural Science 12(3):453460. 1996.

24. ***© Diagnosis of nitrogen deficiency and toxicity of Eucalyptus globulus seedlings by foliar analysis.*** Shedley, E.; Dell, B.; Grove, T. Plant and Soil 177(2):183-189. 1995.

25. ***© The effect of soil desiccation on the nutrient status of Eucalyptus regnans F. Muell seedlings.*** Ashton, D. H.; Kelliher, K. J. Plant and Soil 179(1):45-56. 1996.

26. ***© Effects of N addition rates on the productivity of Picea sitchensis. Thuja plicata, and Tsuga heterophylla seedlings. L Growth rates, biomass allocation and macroelement nutrition.*** Brown, K. R.; Thompson, W. A.; Weetman, G. F. Trees: Structure and Function 10(3):189-197. 1996.

27. ***Feed crops without contaminating nature.*** Cuny, H. Nursery Management and Production 12(3):47-49. 1996. Best management practices help you reduce the risk of fertilizer runoff.

28. ***© Growth, potassium and polyamine concentrations of Scots pine seedlings in relation to potassium availability under controlled growth conditions.*** Sarjala, T. Journal of Plant Physiology 147(5):593-598. 1996.

29. ***Nitrogen fertilization requirements of Douglas-fir container seedlings vary by seed source.*** Thompson, G. Tree Planters' Notes 46(1):15-18. 1995.

30. ***Prime your pH.*** Pawelek, M. A. Greenhouse Grower 14(5):72, 74. 1996. A Texas grower offers time tested techniques for maintaining pH at lower levels.

31. ***Release rates of soluble and controlled-release potassium fertilizers.*** Broschat, T. K. HortTechnology 6(2):128-131. 1996.

32. ***Role of calcium in plant responses to stresses: linking basic research to the solution of practical problems.*** Palta, J. P. HortScience 31(1):51-57. 1996.

33. ***Store fertilizer stock solutions properly.*** Albano, J. P.; Miller, W. B. Greenhouse Management and Production 16(3):47. 1996. Iron chelates in commercial soluble fertilizers are vulnerable to light degradation.

34. ***Sulfur on tap.*** Reddy, S. K. Greenhouse Grower 14(1):5$, 60. 1996. Irrigation water sources across the U.S. rarely provide sufficient sulfur for greenhouse plants.

General and Miscellaneous

35. ***CRP: a wake-up call for agriculture.*** Dukes, D. Journal of Soil and Water Conservation 51(2):140-141. 1996.

36. ***Environmental laws and forest nursery pest management in the United States.*** Campbell, S. J. IN: Diseases and insects in forest nurseries, p. 283-292. R. Perrin and J.R. Sutherland, eds. Institut National de la Recherche Agronomique. 1994. Covers FIFRA, NEPA, Clean Water Act, Safe Drinking Water Act and Endangered Species Act.

SO. ***Red oak (Quercus rubra L.) acorn collection, nursery culture and direct seeding: a literature review.*** Dey, D.; Buchanan, M. Ontario Ministry of Natural Resources, Forest Research Information Paper 122. 46 p. 1995. ORDER FROM: Ontario Ministry of Natural Resources, P.O. Box 969, Sault Ste. Marie, Ontario P6A SNS Canada. Free.

SO. ***Tree planting in the United States 1995.*** Moulton, R. J.; Lockhart, F.; Snellgrove, J.D. USDA Forest Service, State and Private Forestry, Cooperative Forestry. 1996. ORDER FROM: Cooperative Forestry, USDA Forest Service, P.O. Box 96090, Washington, D.C. 20090-6090. Phone: (202) 205-1376. Free.

Genetics and Tree Improvement

37. ***Parental rank changes associated with seed biology and nursery practices in Douglas-fir.*** El-Kassaby, Y. A.; Thomson, A. J. Forest Science 42(2):228-235. 1996.

Mycorrhizae and Beneficial Microorganisms

38. ***© The effect of soil pH on the ability of ectomycorrhizal fungi to increase the growth of Eucalyptus globulus Labill.*** Thomson, B. D.; Grove, T. S.; Malajczuk, N.; Hardy, G. E. SO Plant and Soil 178(2):209-214. 1996.

39. ***© The effect of two ectomycorrhizal fungi, Paxillus involutus and Suillus tomentosus, and of Bacillus subtilis on Fusarium damping-off in jack pine seedlings.*** Hwang, S. F.; Chakravarty, P.; Chang, K. F. Phytoprotection 76(2):57-66. 1995.

40. ***Effects of Boletus edulis. Laccaria laccata~ Pisolithus tinctorius and Rhizopogon luteolus on the growth performance of Pinus kesiya Royle ex. Gordon in north-eastern India.*** Tiwari, S. C.; Mishra, R. R. Indian Journal of Forestry 18(4):293-300. 1995.

41. ***© Effects of the fungicide dithane M-45 on the growth and mycorrhizal formation of Pinus patina seedlings.*** Reddy, M. S.; Natarajan, K. Soil Biology and Biochemistry 27(11):1503-1504. 1995.

42. ***© Fungal biomass in roots and extramatrical mycelium in relation to macronutrients and plant biomass of ectomycorrhizal Pinus sylvestris and Alnus incana.*** Ekblad, A.; Wallander, H.; Carlsson, R.; Huss-Danell, K. New Phytologist 131(4):443-451. 1995.

43. ***© Growth and ectomycorrhizal formation of container-grown Douglas fir seedlings inoculated with Laccaria bicolor under four levels of nitrogen fertilization.*** Gagnon, J.; Langlois, C. G.; Bouchard, D.; Le Tacon, F. Canadian Journal of Forest Research 25(12):1953-1961. 1995.

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45. ***© Hyphal contribution to water uptake in mycorrhizal plants as affected by the fungal species and water status.*** Ruiz-Lozano, J. M.; Azcon, R. Physiologia Plantarum 95(3):472478. 1995.

46. ***Inclusion of arbuscular mycorrhizal fungi in alginate films for experimental studies and plant inoculation.*** Calvet, C.; Camprubi, A.; Rodriguez-Kabana, R. HortScience 31(2):285. 1996.

47. ***© Mycorrhizal relations in trees for agroforestry and land rehabilitation.*** Haselwandter, K.; Bowen, G. D. Forest Ecology and Management 81(1-3):1-17. 1996.

48. ***© Seasonal ectomycorrhizal fungal biomass development on loblolly pine (Pinus taeda L.) seedlings.*** Sung, S. J. S.; White, L. M.; Marx, D. H.; Otrosina, W. J. Mycorrhiza 5(6):439-447. 1995.

49. ***© The survival and development of inoculant ectomycorrhizal fungi on roots of outplanted Eucalyptus globulus Labill.*** Thomson, B. D.; Hardy, G. E. StJ; Malajczuk, N.; Grove, T. S. Plant and Soil 178(2):247-253. 1996.

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50. ***Cooling requirements for screened greenhouses.*** Cuny, H. Greenhouse Management and Production 16(4):30-32. 1996.

51. ***Fertilizer injector check-up.*** Kessler, J. R., Jr. Greenhouse Grower 14(3):40, 42, 44. 1996.

52. ***For safety's sake, comply with today's electrical codes.*** Bartok, J. W., Jr. Greenhouse Management and Production 14(1):90-91. 1995.

53. ***A look at: cooling pads.*** McLean, J. Greenhouse Management and Production 16(4):5960. 1996.

54. ***A look at: exhaust fans.*** McLean, J. Greenhouse Management and Production 16(3):7072. 1996.

55. ***A look at: fogging nozzles.*** Greenhouse Management and Production 16(2):57-58. 1996.

56. ***A look at: horizontal airflow fans.*** Roskens, L. Greenhouse Management and Production 14(2):46-49. 1995.

57. ***A look at pH meters.*** Roskens, L. Greenhouse Management and Production 14(1):92-94, 9698. 1995.

58. ***A look at: structured sheets.*** McLean, J. Greenhouse Management and Production 16(5):58-61. 1996. Polycarbonate and acrylic rigid plastic sheets.

59. ***Make sure you use the right concrete for the job.*** Bartok, J. W., Jr. Greenhouse Management and Production 16(2):55-56. 1996.

60. ***Natural vs. mechanical.*** Martinez, H. Greenhouse Management and Production 14(2):4142, 44-45. 1995. When it comes to ventilation, both systems work - under the right circumstances.

61. ***New product express.*** Greenhouse Grower 14(2):32, 34, 36-38, 40-41. 1996. Includes chemicals, fertilizers, containers, environmental controls, growing media, structures and covers.

62. ***Overinflated tractor tires waste fuel, reduce productivity.*** Lancas, K. P.; Upadhyaya, S. K.; Sime, M.; Shafii, S. California Agriculture 50(2):28-31. 1996.

63. ***Read this before you glaze.*** Cuny, H. Davis ,. T. Greenhouse Management and Production 16(5):30-33. 1996. Tips on 5 glazing options: glass, rigid plastic sheets, polycarbonate, acrylic and polyethylene.

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