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Cover Photo: *Seedling storage and delivery were quick and easy when nurseries were located close to the outplanting site (Bessey Nursery,' Kearney, Nebraska).*

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Thought for the Day...

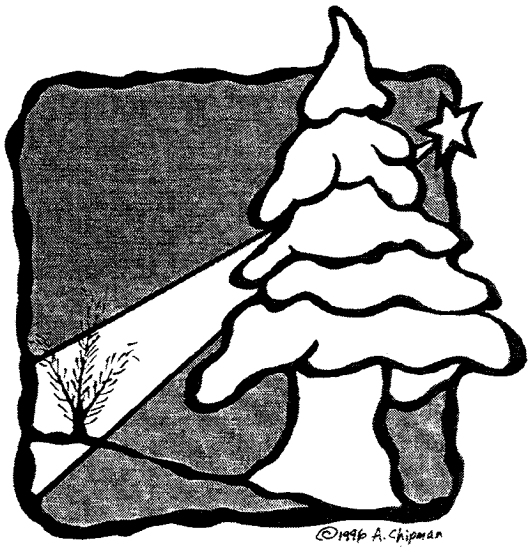
"Reality is When It Happens to You". Personnel downsizing and budget cuts have been increasingly common for the past few years and this trend shows no signs of going away. Tough decisions are being made concerning all government programs in the face of steadily decreasing funds, and no program is exempt. As of the date of this issue, the Forest Service still has no budget for the current fiscal year, and because of a lack of operating funds, we were on a work furlough from the middle of December until early January. *Forest Nursery Notes is* one of those "non-critical programs" that were halted due to the furlough, and we lost almost 3 weeks of time. Therefore, this issue of *FNN* will be several weeks late.

Furlough or no furlough, work continues to pile up-especially technical correspondence. Every day I receive letters, Faxes, E-mail, and telephone calls from around the world asking for technical assistance. I'm sure that some of you think me rude for not answering all your inquiries promptly. I would love to have the time to answer all my correspondence, but this is impossible. I am only able to service my first priority customers—forest and conservation nurseries in the Western United States. Requests from other locations in the US are handled after that, and then come those from foreign countries. It looks like my responsibilities will soon be expanded to a new position as National Nursery Technology Specialist, which will further reduce the time that I have to respond to requests for technical information.

Please be patient and I will try to answer your inquiries as soon as possible, but try and understand if you don't hear back from me. You can make things easier if you will do the following when contacting me:

1. Telephone voice mail is hard to understand sometimes, especially when the caller has an accent. If you leave a voice mail message, please speak slowly and give your full mailing address, phone, and FAX number.
2. Send FAX messages whenever possible, and give your complete name, address, and return FAX number (including country code).
3. E-mail is another good possibility, but our US Government Data General computer is not easy to access from outside the system. So, I have opened up a private account with MCI Mail, and you can send me E-mail messages at the following address: 2061340 @ mcimail.com

To end on a positive note, this unwanted work furlough caused me to stop and think about things. Being out of work gave me the perspective to see the difference between a job and a profession, and made me appreciate how lucky we are to be working in a positive profession that extends beyond our current positions. Nursery and reforestation work takes a special dedication that goes beyond personnel cutbacks, job furloughs and budget crises. I'm sure that you feel the same-we are truly blessed. So, let me take this opportunity to wish all of you and your families the very best of this Special Season, and a happy and prosperous New Year.



Nursery Meetings

The ***Twelfth High Altitude Revegetation Workshop*** is scheduled for ***February 21-23,1996*** at the University Park Holiday Inn in Ft. Collins, Colorado. This meeting is sponsored by the High Altitude Revegetation Committee to promote understanding of reclamation and revegetation techniques. A variety of technical presentations will be presented including one on "Native vs. Native" which will focus on the problems involved with reestablishing native plants in the ecosystem. Field trips to the New World Mine and the Denver Botanic Gardens round out the agenda. A Proceedings will be distributed to all registrants. For more information, contact:

High Altitude Revegetation Workshop
Office of Conference Services
Colorado State University
Ft. Collins, CO 80523-8037 USA
Tel: 970-491-7501
Fax: 970-491-5368

The third meeting of the ***IUFRO Working Party S7.03-04 (Diseases and Insects in Forest Nurseries)*** will be held in Gainesville, FL on ***May 19-24,1996***. The meeting will begin with a field trip to observe some southern pine forests, and also feature tours of forest pathology laboratories, and two or three forest nurseries. This meeting will include technical presentations, posters, and workshops on *Pythium, Phytophthora,* and other pests. For more information, contact:

Ed Barnard
Florida Div. of Forestry
PO Box 147100
Gainesville, FL 32614-7100 USA
Tel: 904-372-3505
Fax:904-955-2301

The ***XIVth Meeting of the North* American *Forest Biology Workshop*** will be held on ***June 16-20,1996*** at Laval University in Quebec City, QC, CANADA. The meeting theme is Forest Management Impacts on Ecosystems Processes. For the latest information, check the World Wide Web site (http://forestgeomat.for.ulaval.ca/) or contact:

Alison Munson
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The **1996 Southern Nursery Association Meeting** will be held at the Park Vista Hotel and Conference Center in Gatlinburg, TN on ***June 24 to June 27, 1996***. In addition to many interesting presentations, the agenda features a wide variety of panel discussions: Integrated Pest Management, Hardwood Seed Quality, Handling Hardwood Fruits and Seeds, Growing Longleaf Pine in Containers, Monitoring Nursery Groundwater and Disposal of Toxic Chemicals. A field trip to the Tennessee State Nursery and a Christmas Tree Farm fill out the schedule. Meeting announcements will be coming out after the first of the year and if you would like to make sure that you are on the mailing list, you can contact:

Mike Sherrill
Tennessee Div. Of Forestry
PO Box 120
Pinson, TN 38366 USA
Tel: 901-988-5221
Fax:901-426-0617

The **1996 Northeastern State, Federal, and Provincial Nursery Association Conference** will be held at the Radisson Inn in New London, Connecticut on ***August 20-22,1996***. Topics will include product and program marketing, biodiversity, native vs. exotic species, and tillage practices. The evening banquet will feature a New England style shoreline clambake and the spouses tour will include a visit to 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: 203-376-5839

The **Western Forest and Conservation Nursery Association** will be meeting In Salem, Oregon on ***August 19-22, 1996*** at the Quality Inn Conference Center. These dates were chosen so that attendees would have the benefit of attending the Far West Show of the Oregon Association of Nurserymen, which will be held at the Portland Convention Center on August 22-25. Our host will be Mark Triebwasser of the Weyerhaeuser Aurora Nursery. The agenda and focus topics are still being developed, but field trips are planned to several local nurseries including the Aurora and Weyerhaeuser Turner Nurseries. We also plan to visit some local ornamental nurseries to see their latest technology. To get on the mailing list for this meeting contact Tom Landis or:

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 College of Forestry at Oregon State University is surveying interest in a **Reforestation Training Course** for the **Summer of 1996**. This manager's level course will focus on the integration of issues such as nursery culture, site preparation, planting, monitoring, logistics, personnel training, and operational trials for both temperate and tropical countries. The 3-week intensive training will consist of discussions, homework, and field trips. A $3,000 attendance fee includes tuition, course materials, living expenses, and transportation. For more details, contact:

Conference Assistant
College of Forestry
Oregon State University
Peavy Hall 202
Corvallis, OR 97331 USA
Tel: 503-737-2329
Fax: 503-737-4966

The 1996 **Forest Nursery Association of British Columbia** will be meeting in Quesnel, which is just south of Prince George, British Columbia on **September 23-26,1996**. The agenda is still being developed, so if you want the latest information, contact:

Mike Van Hahn
Hi-Gro Silva Nursery Ltd.
Box 4366
Quesnel, BC V2J 3JA CANADA
Tel: 604-992-8631
Fax: 604-992-6106

A two-day **Tree Seed Pathology Meeting** will be held in Opocno in the Czech Republic during the ***first 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. A registration fee of $250 to 300 (US) is anticipated and 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:

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or

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VULHM VS
686 02 Uherske Hradiste
CZECH REPUBLIC
FAX: 42-632-549119

The first announcement and a call for papers has been sent out for the **Nursery and Establishment Operations for Difficult Sites** conference which will be held on ***Oct. 6 -12,1996*** in Solan, Himachal Pradesh, India. The meeting will be held at the University of Horticulture and Forestry Campus and will topics include seedling quality and nursery operations. 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: 91-1792-6-2291
Fax:91-1792-6-2242

Cultural Perspectives

Seedling Storage

It's that time of year when nurseries are either harvesting their seedlings and putting them in storage, or are planning to lift and pack their stock during the late winter or early spring for storage until outplanting. So, it seems like a good time to review some basics about seedling storage. In this issue, we'll discuss the different types of storage and storage facilities; in upcoming *FNNissues, we'll* continue with a discussion of storage physiology, and seedling packaging and handling techniques.

Seedling storage wasn't a serious consideration back in the days when all nurseries were built close to the outplanting project. Seedlings were just dug up in the nursery one day and then outplanted the next. Transportation was slow and seedling handling and packaging was rather simple (Figure 1). Reflecting back on those days and knowing what we now do about seedling physiology, it's amazing how well those early plantations performed.

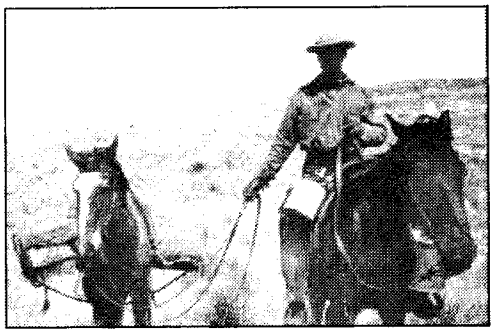

Figure 1. Seedling storage and delivery were quick and easy when nurseries were located close to the outplanting site.

Today, however, we realize that forest and conservation seedlings are a **perishable commodity.** Unlike many other products that can be stored for extended periods without a decrease in quality, nursery crops are living, and therefore have a **very limited shelf life.** Another contributing factor is that today's seedlings typically are grown at considerable distances from the outplanting site-sometimes in different states or even different countries. Therefore, well-designed seedling storage facilities are a necessity at all nurseries, and many large outplanting projects also have their own on-site storage.

There are two basic types of seedling storage: sheltered storage and refrigerated storage.

Sheltered storage.
Traditionally, bareroot nurseries used to store their seedlings outside in "heel-in" beds or in naturally cool structures such as potato cellars, but these techniques are much less common today. Some nurseries still "heel-in" their hardwood seedlings, although the latest research shows that the physiological quality of these seedlings is reduced and their roots are often damaged by pathogenic fungi. If seedlings must be "heeled-in", then mulching the beds with straw or other insulating material reduces injury.

In mild climates, container seedlings are sometimes stored in the propagation area until they are shipped to the outplanting site. The seedlings continue to receive irrigation and are protected from drying winds by shelterbelts. At higher latitudes and elevations where freezing weather is likely, container seedlings are placed directly on the ground for the winter to lessen the possibility of cold injury to the roots. Survival is good when snow covers the seedlings throughout the winter (Figure 2A). A recent study found that outplanting performance of spruce seedlings stored outdoors under a Styrofoam insulation blanket was as good as conventional freezer storage (Figure 2B). Shadehouses have been used as a combination hardening and storage structure for container stock. The typical shadehouse for overwinter storage has shadecloth or snow fencing on both the roof and sides that protects seedlings from adverse weather, including: high winds, intense rains, hail, and heavy snow. Fully-enclosed shadehouses also protect seedlings from large animal pests, such as deer and rabbits. Hoop houses and tunnels are low-cost Quonset structures that have been used to store forest and conservation seedlings in some high-latitude nurseries.

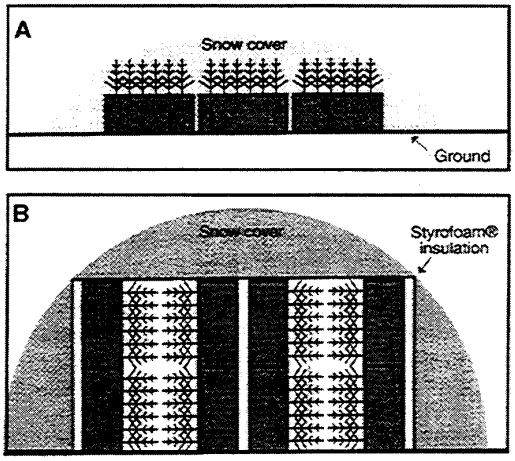

Figure 2. When container seedlings are stored outside over the winter, snow provides a good insulating cover (A). The addition of a Styrofoam blanket helps extend the period of snow cover and protects seedlings in low snow years.

The size of the sheltered storage area that will be needed depends on the type of propagation system, the number of crops produced per season, and the length of the time that the seedlings will have to be stored. Nurseries that produce more than one crop per year will need to carefully calculate the necessary amount of storage space; experience has shown that a storage area of 2 to 3 times the propagation space is often required.

Refrigerated storage.
Bareroot seedlings have been stored under refrigeration for many years, but this practice is relatively new for container nursery stock. When forest and conservation seedlings were first produced in containers, it was assumed that container seedlings could be planted all year, and many nurseries shipped their stock to the outplanting site in the growth container. Then, growers observed that container stock stored in sheltered storage broke dormancy very early, especially the root systems. This often occurred before the planting window opened on many sites, and operational trials revealed that non-dormant container seedlings did not tolerate the stresses of handling very well. So, to minimize storage volume

and maintain the seedlings in a fully dormant condition until the outplanting sites were ready, nurseries began extracting **(pulling)** the seedlings from their containers, grading them, and packing them **(wrapping)** for refrigerated storage.

There are two different types of refrigerated storage used in forest and conservation **nurseries, cooler storage and freezer storage,** which are differentiated by their operational temperatures:

In-box Temperature

Cooler Storage 1 to 2 °C (33 to 36 °F)
Freezer Storage -1 to -4 °C (25 to 30 °F)

Cooler storage is recommended when seedlings are going to be stored for less than 3 months and when seedling shipments occur throughout the storage period. When the storage period is going to be more than 3 months, many nurseries use freezer storage because the lower temperatures suspend seedling metabolic activity and conserve stored carbohydrates. Spruce seedlings in freezer storage have also been shown to develop greater root cold hardiness than those stored outdoors, and they also maintain their hardiness longer. Freezer storage also significantly reduces the incidence of storage molds. Because freezing the seedlings converts all the free water in the storage container to ice, the development of pathogenic fungi such as gray mold *(Botrytis cinerea)* is retarded.

The type and duration of seedling storage depends on the distance to the outplanting site and the outplanting window:

- **Summer outplanting:**

  Seedlings that will be harvested and outplanted during the summer on relatively low stress sites are still actively growing and have little cold hardiness. Because these "hot planted" seedlings must be shipped while still relatively succulent, they should only be held in sheltered storage or cold stored for a few days. Container seedlings can be shipped in the container and held on the outplanting site, and either bareroot or container seedlings can be "jelly-rolled" (Figure 3) and boxed. In either case, the seedlings can still be irrigated if there are delays in outplanting.

- **Fall outplanting:**

  By this time of the year, seedlings have received a moderate amount of cold hardening, but are not fully-dormant when harvested. Nurseries either can ship seedlings in the container, or jelly-roll them as done for summer outplanting. If refrigerated storage is available at the nursery or on the outplanting site, only cold storage is recommended, because freezer storage may damage non-hardy tissue. The storage duration should be limited to a few days or weeks.

- **Winter or spring outplanting:**

  These outplanting windows require fully-hardened seedlings with dormant shoots, and this stock either can be cold-stored (if the storage period is less than 3 months) or freezer-stored (if over 3 months).

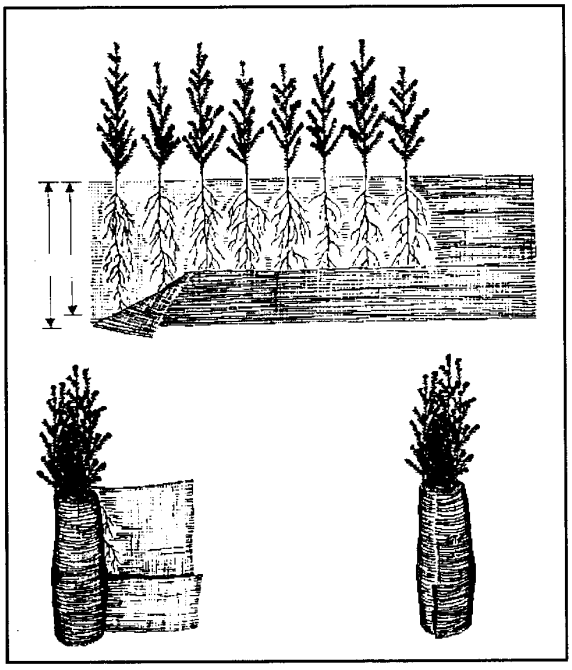

Figure 3. Both bareroot and container seedlings can be "jelly-rolled" in wet cloth wrappings for short-term storage before outplanting.

The seedling storage period is a critical phase in the nursery crop cycle. Nursery managers must design the proper type of storage facility that compliments the condition of the seedlings when they will be harvested, and that will maintain them in top physiological condition until they can be outplanted.

Sources:

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Whaley, R.E.; Buse, L.J. 1994. Overwintering black spruce container stock under a Styrofoam® SM insulating blanket. Tree Planters' Notes 45(2): 47-52.

Secondary Nutrients—Calcium

Conventional fertilization is mainly concerned with the "Big Three" macronutrients-Nitrogen (N), Phosphorus (P), and Potassium (K). This is because together these elements comprise over 75 % of the mineral nutrients found in typical plant tissue (Table 1). The three "secondary" nutrients (Calcium, Magnesium, and Sulfur) are also important to seedling health and vigor, however, since adequate amounts are usually provided by the soil, or incidentally in N-P-K fertilizers, they do not receive as much attention. Beginning with calcium in this issue, we are going to take a more detailed look at these secondary nutrients.

Calcium is seldom in the spotlight in conifer seedling culture because it is found in all but the most acidic soils, and also is commonly present in irrigation water. Another complicating factor is that seedlings of forest and conservation species typically do not display visible calcium deficiency symptoms. This is not the case in horticulture where crops exhibit classic symptoms: tomatoes and peppers develop "blossom end rot, lettuce displays "tipburn" of the leaves, and celery comes down with "blackheart". Although there is no such thing as a true calcium toxicity, excess levels in the soil and water can induce serious deficiencies of other mineral nutrients.

Role in plant nutrition.

The key to understanding calcium-related disorders is knowing its mode of uptake and function within plants. Calcium is primarily found in the cell wall and plasma membrane where it performs a variety of roles in the development and maintenance of overall plant structure and function:

- **Facilitates cell division and elongation.** Calcium forms stable intermolecular linkages needed to build cell walls, so a continuous supply is necessary for normal growth.
- **Strengthens cell walls.** Calcium combines with pectate to form a type of semi-permeable glue called calcium pectate.
- **Helps regulate cell membrane permeability.** Calcium pectate helps control which ions are able to enter and leave the cell.
- **Helps prevent fungal disease infections.** Calcium pectate acts as a physical barrier to fungal hyphae penetration but is degraded by an enzyme called polygalacturonase, which is inhibited by high calcium concentrations. Many fungi, such as *Fusarium* and *Pythium* spp., manufacture this enzyme as a means to invade plant tissue. We don't have any research on forest crops, but in a study on tomato, the severity of Fusarium wilt decreased as the concentration of Ca^{2+} in the nutrient solution increased. In another study, calcium soil amendments reduced Pythium damping-off of cucumber seedlings.

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	0.10 to 0.20	0.10 to 0.20

- **Inhibits potential toxins.** Because it is a divalent cation (Ca^{2+}) calcium is very effective in ameliorating the adverse effects of toxic ions such as sodium. In the absence of adequate calcium levels, sodium ions can disrupt the structure and function of plant membranes.

Availability and uptake.
Calcium uptake is a function of soil solution availability, root system integrity, and seedling transpiration rate. In the soil solution, the type and relative concentration of ions is critical. Being a relatively large divalent cation, calcium can be outcompeted by smaller monovalent cations such as potassium and ammonium-nitrogen or other divalent cations (e.g. Mg^{2+}). Maintaining favorable nutrient ratios in the soil solution is paramount-1:1 for Ca:K and 3:1 for Ca:Mg. Nitrate-nitrogen, because it is an anion, does not suppress calcium uptake, but may actually enhance it. For this reason, calcium nitrate fertilizer [$Ca(N0_3)_2$] is used to correct deficiencies or uptake-related problems, and provides extra calcium during critical times in the crop cycle, such as the Hardening Phase.

The root system needs to be actively growing with a good complement of young root tips which have the greatest absorptive capacity. Anything that compromises root system morphology or physiology reduces calcium uptake. Temperature extremes, excessive moisture or drought, poor aeration, and pathogens all take their toll. After they enter the roots, calcium ions are transported throughout the plant in the xylem. Presence and movement in the phloem is very limited, hence there is little calcium translocation from older to younger tissue if a local deficiency occurs. Xylem sap flows in response to transpirational demand and/or root pressure to its final destination or "sink". Because root pressure is a relatively minor factor, the strength of a particular sink is mainly a function of transpirational demand. Unfortunately, "sink strength" may not correspond to physiological need. Meristems, the very tissues that need calcium the most often lose out to young leaves which transpire water at high rates. Organs with low sink strength have to rely on root pressure, which is only functional at night, for their calcium supply. Therefore, during high transpirational demand, calcium is being carried to places where it is less needed while during periods of lower demand, general calcium uptake is reduced.

Diagnosis of deficiencies/toxicities.
The metabolic functions previously listed explain some typical symptoms of calcium deficiency: disintegration of cell walls, collapse of tissues, root tip mortality, and an increased susceptibility to fungal attack. Minor deficiencies cause membranes to become leaky without any obvious disintegration. This increases the seedling energy requirement to maintain membrane function and reduces the energy available for other metabolic functions, leading to lower growth rates. Since newly-forming cells require a steady supply of calcium, meristematic tissues are the most susceptible to deficiencies. Unfortunately,

calcium deficiencies usually reach severe levels before they are noticed because meristematic tissues are not readily visible-buds are hidden within other tissue, whereas other meristems, such as root tips, are buried in the soil. In the case of root tips, a problem with calcium supply results in a complete cessation of root extension within only a few hours (Figure 4).

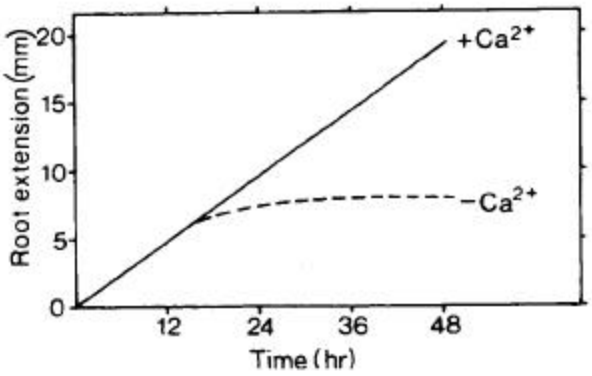

Figure 4. The first evidence of a calcium deficiency is often reduced root growth which is not immediately apparent to the grower. (Marschner and Richter, 1974.)

Monitoring.

Bareroot nursery managers can use annual soil tests to make sure that calcium levels are adequate, and should be particularly careful to maintain the proper pH level. If the pH is too acidic, calcium is leached out of the root zone, whereas at higher pH levels, calcium excesses can induce other nutrient deficiencies, especially iron and phosphorus. With container seedlings, monitoring the leachate will provide the best information about the availability of calcium to the roots.

Plant nutrient analysis only reflects the type of tissue analyzed, and may not give an accurate account of the current calcium status near the meristems. At best, tissue analysis tells us something about past uptake levels and whether or not calcium ions were available in the soil solution.

Calcium management.

So, what does all this mean to the grower? Let's summarize what it takes to insure adequate calcium availability to young, rapidly growing seedlings:

- Analyze your irrigation water, paying particular attention to the calcium, sodium, and total alkalinity levels. This is particularly important for container growers because artificial growing media have inherently low calcium levels unless limestone has been added. Moderately "hard" water (> 40 ppm Ca) provides a steady supply, reducing the need for additional calcium fertilizer. "Soft" water contains high sodium levels relative to calcium, so fertilization may be warranted.
- Monitor pH in the soil or growing medium, keeping it within the 5.5 to 6.5 range. Bareroot nurseries should use dolomitic limestone to raise soil pH, and sulfur amendments to lower it. Note the preference of dolomitic instead of calcic limestone—the former has the proper balance of Ca: Mg. Growing medium pH should not be a problem with most commercial mixes unless irrigation water is alkaline.
- Use fertilizers or amendments containing calcium if needed. Dolomitic limestone is all that is needed in bareroot nurseries, but container seedling growers need to insure a steady supply of soluble calcium. Simply adding dolomite amendments to the growing medium does not insure that young seedlings are getting a steady supply of calcium, hence liquid fertilization is recommended if the irrigation water does not contain enough. Most "complete" container seedling fertilizers do not contain any calcium because of solubility problems in the mixing tank but some newer formulations such as Peters Excel® now do (Figure 5). A concentration of 40 to 80 ppm Cain the "applied fertilizer solution" is a good target, but remember to watch mineral nutrient ratios as well as absolute levels.
- Balance irrigation and transpiration to maintain a moderate level of moisture stress, which keeps calcium moving into the plant and available to all tissues, especially the meristems.
- Maintain adequate calcium levels during all phases of seedling growth from germination though dormancy. During the Hardening Phase, stem meristems are particularly active and cells in foliar tissues are developing thicker

walls. Calcium nitrate is an excellent ingredient in a hardening fertilizer, not only because it is completely soluble, but also because it supplies nitrogen in the proper nitrate form. Be aware that some commercial hardening fertilizers do not contain calcium.

In conclusion, nurseries will benefit from paying more attention to secondary mineral nutrients such as calcium. Understanding the role of calcium in seedling growth and how it is taken up and utilized in plant tissue provides the key to proper management.

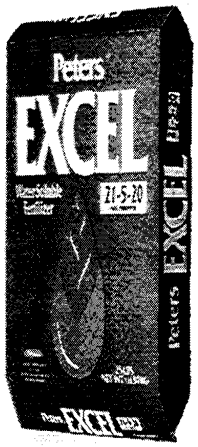

Figure 5. Peters® Excel is one of the few water soluble fertilizer mixes that contains calcium.

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Eric van Steenis of the British Columbia Ministry of Forests collaborated in the conceptualizing and writing of this article, and his assistance is gratefully acknowledged.

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What Is a Soil Management Plan, and Why Would You Want One?—Part III

This is the last of a three part series on how to develop a Soil *Management Plan* and use it in your nursery. The first installment in the January, 1995 issue covered the various parts of a Plan and how to organize the soil survey. The second part, "How to perform the soils survey and interpret the results" was covered in the last FNN issue. Now, we'll wrap up the subject by showing how to assess the production potential of your nursery soil and implement the Soil Management Plan.

Assessing Soil Production Potential.

Continuing with the example from the Colorado State Forest Service (CSFS) nursery that we began in the first two segments of this series, we can now discuss how the potential productivity of nursery blocks can be evaluated. Using the soil survey data (Table 1 from the July, 1995 issue) and the soil productivity targets that we developed (Table 2 from that same issue), we can rank the nursery blocks for their suitability for growing the various crops and stock types that the nursery produces (Table 2).

Although we only discussed two of them in the last *FNN* issue, four criteria were used in the soil productivity ranking at the CSFS nursery: soil depth, texture, pH, and % calcium carbonate ($CaC0_3$) (Figure 6). Like most forest and conservation nurseries, the CSFS nursery grows a wide variety of species that have different soil preferences but we can group

them into 3 general classes. "Conifers" prefer low pH and coarser soils, whereas many shelterbelt species are deciduous trees and shrubs ("Hardwoods") that can tolerate medium texture soils with a neutral pH. Conifer "Transplants", such as plug+one stock, are also more tolerant of the soil conditions in this middle class (Table 2). Soils that did not meet the criteria for either of these productivity classes were assigned to a third "Marginal" soil class which, although they are unsuitable for seedling production, can be used for seed production areas or stool blocks.

Some of these productivity classes are not permanent, and the soils can be improved. If the limiting factor is a physical condition, such as depth or texture, then it is usually not economical to try and fix it. But, if the problem is chemical in nature, then the condition may be corrected with amendments. For example, blocks C-5 and C-6 at the CSFS nursery have deep, fine sandy loam soils that would be suitable for conifer seedlings, but their pH values of 7.2 and 7.3 are slightly too high. High soil pH can slowly be corrected by adding sulfur soil amendments and using acidifying fertilizers which will lower the pH into the acceptable range within a few years.

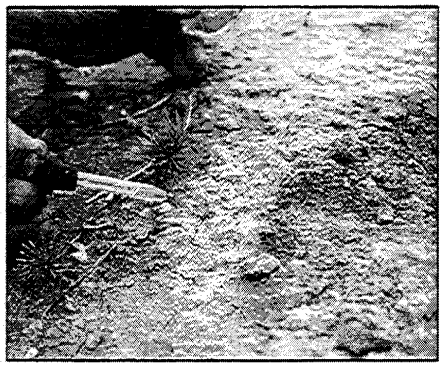

Figure 6. Calcareous soils can be easily identified by putting a drop of dilute acid on the surface—bubbling indicates the presence of calcium carbonate.

Implementing and Updating The Soil Management Plan

Once a Soil Management Plan has been developed, it can be used for many different purposes, such as: determining irrigation applications, scheduling soil amendments (such as sawdust), and prescribing cultural treatments (such as deep ripping). One of the most immediate and practical uses of a Soil Management Plan is to compute fertilizer rates and application schedules. The mineral nutrient tests that were performed during the soil survey can be used to scientifically calculate the types and amount of fertilizer that should be added to a particular nursery block. By comparing the soil test values to target levels, the exact amount of fertilizer to apply to each block can be calculated. The following example shows the calculations for a nursery block with a phosphorus soil test of 18 ppm:

1. Determine how much P is needed to bring the soil up to the target level:

Target Level	*= 35 ppm P*
- Base Soil Level	*= 18,ppm P*
Need to Add	*= 17 ppm P*

2. Convert from parts per million to pounds per acre (or kilograms per hectare)

$$17\ ppm = \frac{17\ parts}{1,000,000\ parts} \quad or \quad \frac{17\ lbs}{1,000,000\ lbs}$$

Table 2. Potential Productivity of Nursery Blocks at the Colorado State Forest Service Nursery Using Limiting Factors from the Soil Survey.

	Soil Productivity Classes		
Evaluation Criteria	Conifers	Hardwoods or Transplants	Marginal
Soil Depth	> 12 inches	> 12 inches	< 12 inches
Soil Texture	Coarse (Sandy)	Medium (Loam)	Heavy (clay)
pH	<7.0	7.Oto8.0	>8.0
%CaC03	< 0.0	< 0.0	> 0.0

Nursery Block Rankings—Listed in Decreasing Order of Acceptability.

Conifer Culture		Hardwood Culture		Marginal Productivity	
Block	Acres	Block	Acres	Block	Acres
A-1	1.7	C-5	1.5	B-1	1.5
B-3	2.2	C-6	2.2	D-3	0.6
A-6	1.0	E-1	2.0	D-7	0.7
C-4	2.4	B-7	3.9	D-2	2.4
B-6	1.2	D-6	1.0	D-1	4.2
C-1	1.7	D-10	0.9	B-5	3.1
C-3	2.4	C-2	1.4	B-2	3.7
B-4	1.4	A-4	1.7	E-8	2.9
A-2	1.6	E-3	3.7		
		E-2	3.7	Total	19.1
Total	15.6	A-3	1.7		
		A-5	1.6		
		E-4	3.4		
		D-5	0.9		
		D-9	0.9		
		E-6	2.9		
		E-5	1.9		
		D-4	2.0		
		D-8	2.0		
		E-7	2.9		
		Total	42.2		

3. One acre-foot of average soil weighs approximately 4,000,000 lbs, so 1 plow slice (9 in. deep) of soil would weigh 3,000,000 lbs per acre. Therefore, the weight of P needed for 1 acre can be determined by solving the following proportion with cross-multiplication:

$$\frac{17 \text{ lbs}}{1,000,000 \text{ lbs}} = \frac{X \text{ lbs}}{3,000,000 \text{ lbs}}$$

X= 51 lbs of P per acre

4. Fertilizers are rated in phosphoric acid (P205) instead of elemental P, however, so we need to add more bulk fertilizer to meet our target:

51 lbs of P/ac x 2.3 = 117.3 lbs. of P_2O_5 / ac.

5. Finally, we need to compute the application rate for a specific fertilizer. For example, concentrated superphosphate has an analysis of 0-46-0, which means that it contains 46% P_2O_5, so:

117.3 = 0.46 = 255 lbs. of 0-46-0 should be added per acre.

Using the soil fertility targets for the other mineral nutrients, and the data from the soil fertility tests, you can use this process to calculate a scientifically-based fertilizer application schedule for your bareroot crops.

Soil Management Plans are not meant to be fixed or inflexible documents, and they do have a limited shelf-life. Most nursery managers find that their Plans must be adjusted at regular intervals as more information on seedling performance is accumulated and soil characteristics become modified with amendments. Storing soils information on computer databases allows easy updating, and CAD programs help visualize the process.

Well, hopefully this discussion will convince you that your nursery could use a well-designed Soil Management Plan. Contact the USDA Natural Resource Conservation Service (formerly Soil Conservation Service), your state university extension service, or other government soils agency for help. There are also consulting soil scientists who can help you develop a Plan on a contract basis.

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Vermiculite Storage

You long-time *FNN* readers may remember that we had this same thing happen a few years ago when they closed a US vermiculite mine due to a scare about the health risks of an asbestos-related material called tremolite (see *FNN* January, 1994; April, 1991 and October, 1991 and 1992).

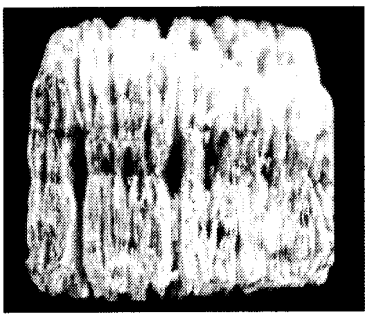

Figure 7. Coarse grade vermiculite particle.

Well, it's happening again. Coarse grade vermiculite, the preferred grade for growing forest and conservation nursery crops, has been in short supply for the last year, and the outlook isn't much better for 1996 (Figure 7). Several factors have contributed to this shortage. Vermiculite ore is screened into several different grades after it is mined and processed (Table 3). The vermiculite mines in the United States are only able to produce fine and medium grades of ore, so suppliers of growing media are having to purchase their coarse grade ore from foreign sources. Currently, most US suppliers are purchasing coarse vermiculite from mines in South Africa. There are additional mines in China and Brazil, but they are not exporting to the US at the present time. The South African mines can meet the demand, but like everything else, politics is getting into the act. Last spring, exporters were diverting coarse grade vermiculite shipments to the European markets where they can get a higher price. This means that US producers must pay for their vermiculite ore in advance of shipment, and even that doesn't guarantee that they will get their shipments on time. This year, the US vermiculite producers have stockpiled raw ore in warehouses so that they can meet the demand, but coarse grade vermiculite will remain in short supply.

The bottom line is that container growers should make sure that they send their vermiculite and growing media orders to suppliers early. Michelle Miller supplied the information for this section, and if you would like more details, she can be reached at:

Black Gold, Inc.
19308 Highway 99E
Hubbard, OR 97032
USA
Tel: 503-981-4406
Fax:503-981-2304

Sources:

Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1990. Containers and Growing Media, Volume Two, The Container Tree Nursery Manual. Agric. Handbk. 674. Washington, DC: USDA Forest Service. 88 p.

Table 3. Physical characteristics of vermiculite grades

Grade	Bulk Density (k /m3)	US Sieve Size	Range of Particle Sizes (mm)	Aeration Porosity (%)	Water Retention (% by weight)	(% by volume).
1	64.1 to 112.1	3/8 to 16	1.2 to 10.0	44.3	297	30.7
2*	64.1 to 128.2	4 to 30	0.6 to 4.7	40.4	412	39.0
3*	80.1 to 144.2	8 to 100	0.1 to 2.4	29.9	530	52.4
4	96.1 to 176.2	16 to 100	0.1 to 1.2	24.5	499	54.4

* = Standard horticultural grades

Methyl Bromide Fumigation

As regular *FNN* readers know, I have had a section on this subject in almost every issue for the past several years. Well, the methyl bromide ban is still making news and so, rather than review the entire socio-political background again, I will refer readers to previous *FNN* issues *and* just cover the newest developments.

The projected phase-out of methyl bromide by the year 2,001 has spawned a wave of new research on the fate of this popular fumigant in the atmosphere, as well as tests of new alternatives. The Methyl Bromide Global Coalition has appropriated almost $14 million for new research and the results of the first trials are now being published.

Methyl bromide is considered to be the most important source of the atmospheric bromine radicals which are partially responsible for destroying the Earth's ozone layer (Figure 8). Current estimates are that soil fumigation accounts for about 80% of synthetic methyl bromide use. There is some doubt, however, as to whether soil applications really escape to the atmosphere at all, and that furthermore, soil may actually be a "sink" for methyl bromide. Recent research has shown that soil bacteria can break down significant amounts of methyl bromide. An article in the respected journal *Nature* presents research that in some soils methyl bromide is rapidly and irreversibly consumed below the levels found in the global atmosphere. If this biological breakdown is expanded to a global scale and combined with the already well documented chemical destruction of methyl bromide in salt water, then its atmospheric lifetime is half what was previously thought and its ozone depletion potential (ODP) is about 30% smaller than the previous estimate. That ODP is still high enough to keep it under the regulation of the Montreal Protocol and the Clean Air Act, however.

This research does not apply to the high methyl bromide concentrations used in soil fumigation, and besides, fumigation kills soil bacteria anyway. What is significant is that we are finally learning more about the chemical fate of methyl bromide in the soil and in

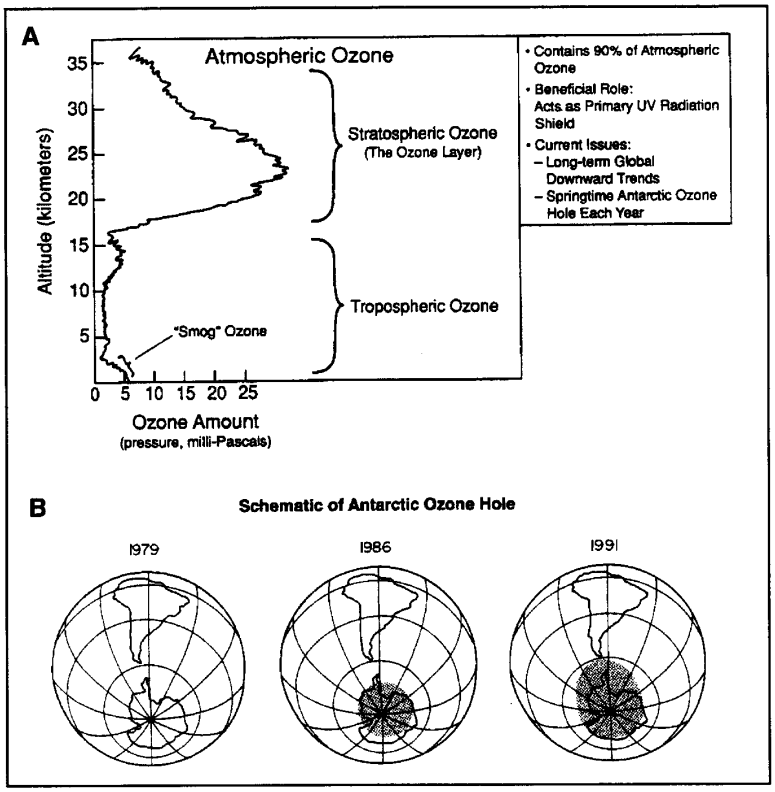

Figure 8. The protective ozone layer in the stratosphere (A) has been decreasing in recent years over the South Pole (B), so bromine and other halogens are facing severe restrictions.

the atmosphere, and we will be able to really determine if it poses a threat to the ozone layer.

On the other side of the coin, the US Environmental Protection Agency (EPA) has just published the ***Scientific Assessment of Ozone Depletion: 1994*** which states that "methyl bromide continues to be viewed as a significant ozone-depleting compound". They cite laboratory studies that confirm the ozone depleting role of methyl bromide, but acknowledge that there are "significant uncertainties in quantifying the oceanic sink for atmospheric methyl bromide". The EPA has also released ***Alternatives to Methyl Bromide,*** which is a summary of information on methyl bromide alternatives, including the Aqua Heat® hot water soil treatment and Basamid® Granular fumigant. Cost comparisons are also provided, one of which estimates application costs of Basamid to be similar to methyl bromide (Table 4).

Obviously, the situation will continue to change as more information becomes available, and the perspective and significance will vary depending on whom you talk to. The EPA continues to stress that methyl bromide will be phased out by the year 2,001 and that nurseries should immediately start switching to alternatives. On the other hand, the Methyl Bromide Working Group contends that the current level of knowledge about the fate of methyl bromide in the atmosphere is incomplete and that further research will show that this fumigant is not as damaging as is currently believed. I will just continue to try to keep you up-to-date. Contact the following sources for the latest information on the methyl bromide fumigation, and note that the issue now has a World Wide Web site!!

Peter G. Sparber
Methyl Bromide Working Group
1319 F Street, NW, Suite 301
Washington, DC 20004
Tel: 202-737-MEBR
Fax: 202-393-4385

Bill Thomas U.S. EPA, Methyl Bromide Program
6205J, 401 M St. SW
Washington, DC 20460
Tel: 202-233-9179
Fax:202-233-9577
E-Mail: thomas.bill@epamail.epa.gov
World Wide Web Home Page: http://www.epa.gov/docs/0zone/mbr/mbrqa.html

Sources:

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Environmental Protection Agency. 1995. Alternatives to methyl bromide, ten case studies: soil, commodity, and structural use. Publication Number EPA430-R-95-009. Washington, DC: US Environmental Protection Agency, Office of Air and Radiation.

National Oceanic and Atmospheric Administration. 1995. Scientific assessment of ozone depletion, 1994: executive summary. Global Ozone Research and Monitoring Project Report No. 37. Washington, DC: National Oceanic and Atmospheric Administration. 36 p.

Table 4. Cost comparison of two soil fumigation alternatives to methyl bromide fumigation.

Cost Factor	Basamid Granular	Methyl bromide/chloropicrin
Application Rate	250 to 350 lbs a.i. per acre	375 lbs a.i per acre
Chemical Price	$2.90 per lb	$1.64 per lb
Chemical Cost	$725 to 1,015 per acre	$615 per acre
Est. Application Cost	$1,800 to $2,000	$1,800 to $2,000

Biocontrols for Fungus Gnats

Fungus gnats (*Bradysia* spp.) are a familiar nuisance to container seedling growers, but it wasn't until fairly recently that their pest status was fully recognized. This is because the adult gnats themselves don't directly attack seeds or seedlings; instead, it is their small larvae that live hidden in the growing media that cause the most damage. Although it was only suspected until recently, the true role of the adult gnats as vectors of fungal pathogens has now been firmly established. A recent article confirmed that fungus gnats are now considered to be the third most destructive greenhouse pest.

As is true for all pests, you should understand the entire pest complex before starting to think about controls.

Hosts.
The larvae feed on various forms of organic matter, including moss and algae, but will also attack fleshy seeds and the fine roots of young tree seedlings and cuttings. All species and age classes of plants are susceptible if they are found in warm, wet environments containing abundant organic matter. Unfortunately, this describes almost all greenhouse crops.

Diagnosis/Damage.
The first evidence of a problem is the presence of the small [2 to 4 mm (0.08 to 0.16 in.)] adults which hover around the crop and fly when disturbed. There are several flies that are common in greenhouses, however, and growers need to be able to distinguish between them to determine if control is warranted. Fungus gnats are small, dark, mosquito-like flies which can be identified by a "Y-shaped" vein at the top of the transparent wing (Figure 9 A). The larvae are around 0.5 mm (0.02 in.) in length, legless, and semitransparent to white in color with black heads (Figure 9 B). I've found a few of the larvae in growing media, but they are extremely difficult to locate, so it's easier to make the identification from the adults. Plant symptoms include seeds that do not germinate, and seedlings or cuttings which wilt and lose vigor. Examine seeds and the tips of the root system with a hand lens. The larvae completely consume fine roots but just the exterior cortical tissue of larger ones, leaving the stripped vascular tissue. These symptoms are very similar to fungal root rot,

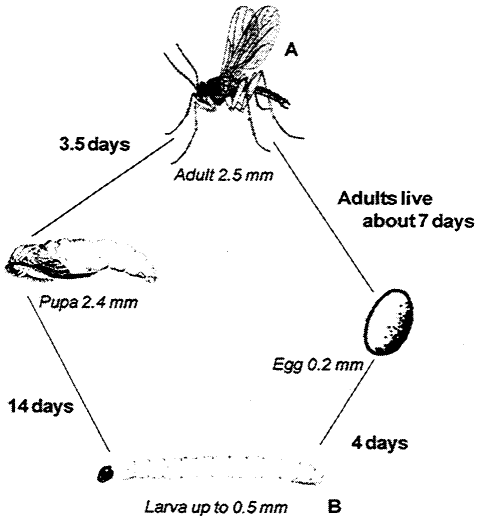

Figure 9 A/B. The life cycle of the fungus gnat only takes a few weeks, so populations can build up rapidly. (Sketch courtesy of J.R. Baker, North Carolina Cooperative Extension Service, Raleigh, NC 27695-7613).

but the presence of the adult gnats is diagnostic. Quick diagnosis is critical because by the time symptoms become common, damage is usually so severe that control is difficult. Instead, the adults should be controlled as soon as they are noticed.

Fungus gnats have been shown to vector several fungal root rots, including *Pythium* and *Fusarium,* and even foliage pathogens like *Botrytis* and *Phoma.* This vectoring of plant pathogens actually may prove to be more damaging than the direct feeding injury of the larvae, and further stresses the need for early treatment.

Life Cycle.
Just how these insects first get into the greenhouse is uncertain, but like *Botrytis cinerea,* fungus gnats seem to appear whenever conditions are favorable. The eggs or pupae survive between crops on moss, algae, and weeds around the nursery, so a source is always present. The adult fungus gnats live only about a week, and then the females lay their eggs on any moist surface that is high in organic matter. They particularly love damp, highly organic peat-

vermiculite growing media, especially when it is kept too wet. The eggs hatch in about 4 days, the larvae feed for a couple of weeks, and then they pupate in the top layers of the growing medium. After a few days, the adults emerge and the entire cycle, which takes less than a month, starts all over again.

New Biocontrols.

Although most common insecticide sprays are effective, it is difficult, if not impossible, to completely control fungus gnats with chemicals alone. Keeping a clean greenhouse is imperative, and cultural controls such as using a well-drained growing medium and being careful not to overwater are crucial to a good integrated pest management program. Now, in just the last couple of years, several new biocontrol options have come on the market (Table 5).

If you decide to try biocontrols, then you should use them in an integrated pest management context: scouting, proper identification, establishing action thresholds, and most importantly, keeping good records. Using the proper release strategy is also important (Table 5). Inoculative releases are made when pest populations are low, so that the biocontrol organisms can establish, reproduce, and suppress the pests before they reach damaging levels. Inundative releases, on the other hand, are more in tune with traditional pesticide mentality because the biocontrol agents are released when gnats become a problem. Both types of biocontrols require time to work. For example, Gnatrol® contains bacterial endospores and toxin crystals that are ingested by the larvae as they feed. Because the adults are not killed, growers must be patient and make several applications before the fungus gnat life cycle is broken and populations of the adults decrease. Pre-emptive applications are the most effective but require good scouting and lower action thresholds than those for chemical pesticides.

So, you can see that biocontrols require some adjustments in your pest management mentality and strategies. They also offer many benefits over traditional pesticides: negligible applicator risk, minimal re-entry intervals, low phytotoxicity, and no problems with pesticide runoff.

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Muckle, E. 1990. Fungus gnats: more than just a greenhouse fly. 21 st Century Gardener. 4(III): 29-31.

Rosetta, R.L. 1996. How to use biological control to manage propagation pests. Proceedings, International Plant Propagators' Society Volume 45. In Press.

Table 5. Types of biocontrol agents for controlling fungus gnats.

Type of Organism		Product Name	Release Strategy	Application Method
Bacteria	*Bacillus thuringiensis* var. *isrealensis*	Gnatrol®	Inundative	Soil Drench through Irrigation System
Mite	*Hypoaspis miles*	Order by Species	Inoculative	Apply to soil surface in vermiculite carrier
Nematodes	*Steinernema feltiae*	*X-Gnat*®	Inundative	Soil Drench through Irrigation System

Federal Nursery Environmental Impact Statements (EIS)

I recently received a copy of the Draft EIS for the USDA Forest Service Placerville Nursery, which reminded me of something that I had been meaning to do. The Forest Service has published an exhaustive EIS document for each of their nurseries across the US. And, while it is true that much of this information is site- and species-specific, some of this could be useful to other state and private nurseries. For example, each EIS contains the latest information on the environmental, economic, and social consequences of using common nursery pesticides (Table 6). In addition to extensive tabular datal, each EIS discusses specific effects, and develops a list of control alternatives. In fact, the entire procedure by which the federal nurseries have developed their EIS's is a good example of how this rather complicated process can be accomplished, and could serve as a model for other nurseries.

So, if you would like a copy of an EIS, contact the federal nursery nearest to you. If you are not sure of their location, let me know and I'll give you their address.

Table 6. Acute Toxicity Classification of Pesticides used at the Placerville Nursery compared to other common chemicals

Toxicity Category*	Pesticide or Other Chemical	Oral LD_{50} for Rates (mg/kg)	Equivalent Human Dose
IV - Very Slight		5.000 to 50.000	> 1 pint
	Sugar	30,000	
	Potassium salts of fatty acids	16,900	
	Ethyl alcohol	13,700	
	Benomyl	> 10, 000	
	Oxyfluorfen	> 5,000	
III - Slight (Caution)		50 to 5.000	1 oz to 1 pint
	Glyphosate	4,320	
	Table Salt	3,750	
	Sethoxydim	2,676	
	Bleach	2,000	
	Aspirin	1,700	
	Acephate	866	
	Thiram	560	
II - Moderate (Warning)		50 to 500	1 tsp. to 1 oz.
	Esfenvelerate	458	
	Malathion	370	
	Dazomet	320	
	Carbaryl	270	
	Diazinon	250	
	Methyl bromide	214	
	Caffeine	200	
	Dimethoate	150	
	DDT	100	
I - Severe (Danger/Poison)		0 to 50	< 1 tsp.
	Nicotine	50	
	Chloropicrin	37.5	

*Categories, signal words and LD_{50} ranges based on EPA labeling system

Biocontrols for Canada Thistle

Nursery managers have been fighting weeds with physical controls, pesticides, and even fire, but some particularly ornery weeds like Canada thistle (*Cirsium arvense) are* tough to handle, both literally and figuratively. Recently, however, biocontrol researchers at the University of Minnesota have identified a bacterium *(Pseudomonas syringea* pv. *tagetis*) that helps control Canada thistle plants. Heavily infected plants have been killed outright, evenly and mildly infected plants did not flower or produce viable seed. The bacteria also attack other common weeds such as common ragweed (*Ambrosia artemsiifolia*) and giant ragweed (A. *tirfida*), and horseweed (*Conyza canadensis*). Up to five applications were necessary to achieve adequate results, but the treatment was effective across extremes of temperature and humidity.

Source:

North Dakota State University. 1995. North Dakota Pesticide Quarterly 13 (4). Fargo, ND: North Dakota Extension Service.

National Pesticide Telecommunications Network

The National Pesticide Telecommunications Network provides information on all aspects of pesticide use, including: pesticide products, poisoning recognition and management, toxicology and symptomatic reviews, health and environmental effects, and cleanup and disposal procedures. The network is accessible from 6:30 AM to 4:30 PM, (Pacific Standard Time) Monday through Friday by the following toll-free telephone numbers, and will soon be available over the Internet:

General Public	1-800-858-7378
Medical Professional and Government Agencies.	1-800-858-7377

Health and Safety

In the last *FNN* issue, we looked at a couple of health problems associated with nursery work: the fungal disease sporotrichosis, and repetitive motion injuries like carpal tunnel syndrome. Because there was so much interest, we decided to feature these two ailments at last summer's meeting of the Western Forest and Conservation Nursery Association meeting. I've summarized the highlights of those presentations in the following sections. If you would like to order the entire articles, I've included their FNN order number after the citation at the end of this section.

The Latest on Sporotrichosis

This rather rare skin disease is caused by a fungus *Sporothrix schenckii* which is found in many types of organic materials. The most common cause of nursery-related infections, however, is Sphagnum peat moss. Nursery workers are exposed when raw Sphagnum moss is used as a moisture-holding medium around the roots of bareroot seedlings during lifting and packing, container nursery workers use Sphagnum-based growing media, and tree planters are also exposed during outplanting.

The fungus.

S. schenckii is worldwide in distribution and has been found in both temperate and tropical climates. It has been isolated from soil, humus, organic fertilizer, mushrooms, hay, bark, wood, and from many types of plants including roses, carnations, and even cacti. From a mycological standpoint, this fungus is interesting because it is dimorphic. In nature it grows as a typical mycelial fungus and produces conidia, just like

Botrytis spp. In animal tissue, however, it behaves like a yeast and reproduces by budding.

The disease.
The fungus invades the skin through puncture wounds and causes small lesions which do not respond to normal treatment (Figure 10). Left untreated, secondary lesions develop along the lymph system and can persist for years. Sporotrichosis outbreaks have occurred in the southern, eastern, and midwestern states. In 1988, the largest North American epidemic involved 84 cases in 15 states and resulted from handling and planting pine seedlings which were packed in *Sphagnum* moss and distributed from a nursery in Pennsylvania. Although the fungus has been isolated from peat-vermiculite growing media, there have been no cases of sporotrichosis associated with container nursery culture.

Prevention.
The possibility of contracting sporotrichosis can be greatly reduced by some rather simple precautions:

- Supplies of *Sphagnum* moss should be stored indoors and kept dry because warm, wet conditions encourages the proliferation of the fungus. Do not store *Sphagnum* moss from year to year.
- Disinfect the peat moss storage area, containers, and utensils after the packing season.
- Nursery workers and tree planters, especially those handling *Sphagnum* moss, should protect their hands and arms by wearing long-sleeved shirts and gloves.
- At breaks, and especially at the end of the day, workers should wash their hands and other exposed areas of the body thoroughly with a bacterial soap to prevent infection.
- Any cuts or puncture wounds should be thoroughly cleaned, treated with a disinfectant such as tincture of iodine, and bandaged. Workers should report any wounds which do not heal within a few days to their supervisor.

Figure 10. The first symptom of sporotrichosis is a small skin lesion that does not respond to normal treatment.

Diagnosis.
A positive diagnosis of sporotrichosis can be made by:

1. Direct examination. The yeast cells can be stained and identified in biopsy tissue
2. Isolation in culture. *S. schenckii* can be isolated on special media and the diagnosis is confirmed by the conversion from the mycelial form to the yeast form at 37 °C (98 °F).
3. Serology. Serological tests from skin lesions can provide a quick diagnosis of sporotrichosis but are not as useful for determining the prognosis of the disease.

Treatment.
Skin lesions respond well to orally administered potassium iodide, but its bitter taste and a variety of side effects make the treatment unpleasant. The response is also slow, and a treatment period of 6 to 12 weeks is typical. Immersing lesions in hot water or heating the infected area with pads or pocket warmers can help speed up the healing process.

Some other interesting tidbits:

- The latest outbreak of sporotrichosis was at Disney World in Florida in 1994 where workers became infected while they were constructing topiary figures made of chicken wire and covered with *Sphagnum* moss. The

combination of small puncture wounds from working with the wire and the continual contact with warm, wet peat moss provided the ideal conditions for infection.

- In Uruguay, half the known cases of sporotrichosis resulted from hunting the nine-banded armadillo (*Dasypus nevemcinctus)* which were found to be systemically infected. (The obvious take-home lesson here-the next time that you're fondling an armadillo, remember to wash your hands afterwards!)

Conclusions.

Sporotrichosis should be considered a normal occupational hazard of nursery work, and should not be used as a reason to eliminate the use of *Sphagnum* peat moss. Raw *Sphagnum* moss is an ideal packing material, and peat-vermiculite growing media will continue to be the most popular type of artificial growing media. With proper education and early treatment, sporotrichosis does not have to be a major concern in forest and conservation nurseries.

Sources:

Kenyon, E.M.; Russell, L.H.; McMurray, D.N. 1984. Isolation of *Sporothrix schenckii* from potting soil. Mycopathologia 87:128.

Padhye, A.A. 1995. Sporotrichosis - an occupational mycosis. IN: Landis, T.D.; Cregg, B. tech. coords. National proceedings, Forest and Conservation Nursery Associations. Gen. Tech. Rep. PNW-GTR-365. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 1-7.

(Order #20 on the Literature Order Form)

Coping with Repetetive Motion Injuries

Repetitive motion injuries (RMIs), also known as cumulative trauma disorders, have become epidemic in recent years. The Bureau of Labor Statistics estimates that RMIs account for about 60% of all workplace injuries, and the Occupational Safety and Health Administration (OSHA) reports that they cause more that one-third of all Workers' Compensation Costs. Many common nursery tasks, such as the pulling and wrapping of container seedlings and grading of bareroot seedlings, have resulted in such a high number of Worker's Compensation Claims that some nursery managers have decided to contract all such work.

Although carpal tunnel syndrome is the one you hear about the most, there are other RMI conditions which also cause work-related injuries. Here is a brief sketch of some common ones that develop from nursery work:

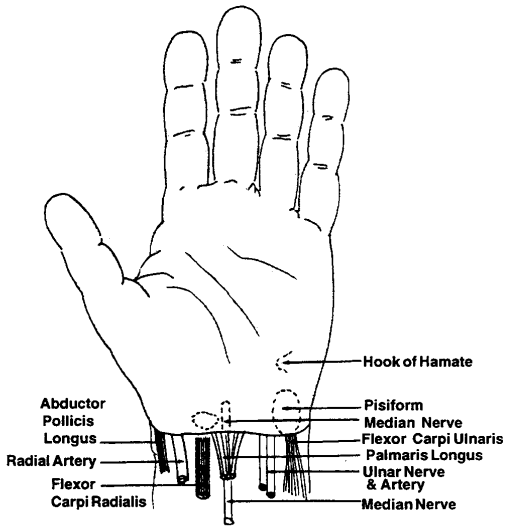


Figure 11. Carpal tunnel syndrome is a repetitive motion injury that results when the median nerve is constricted where it passes through the wrist, resulting in numbness and pain in the hand.

Carpal tunnel syndrome—an RMI that is associated with compression of the median nerve that passes through the narrow carpal tunnel in the wrist (Figure 11).

De Quervain's tendonitis—a condition involving the three tendons that move the thumb.

Lateral epicondylitis—this RMI, more commonly known as "tennis elbow", involves the tendons near the elbow.

Flexor tenosynovitis—this condition is called "trigger finger", and is caused by repeated use of the index finger.

Diagnosis.

The first step in treating RMIs is an accurate diagnosis, which requires a combination of symptoms, patient history, and diagnostic testing. Many carpal tunnel syndrome cases have been misdiagnosed in the past but there are some simple tests that can tell you if this RMI should be suspected. For example, Tinel's test involves tapping on the wrist to see if numbness radiates into the first three digits of the hand. Nerve conduction studies called electromyography can detect a slowing in the sensory conduction through the median nerve, and are widely considered to be the definitive diagnosis for carpal tunnel syndrome.

Diagnosis of RMI conditions is particularly critical because symptoms become worse with time when they remain untreated. If you are having trouble finding a doctor that is familiar with these disorders, there are several medical centers that specialize in them. For example, the Portland Hand Surgery and Rehabilitation Center (Tel: 503-227-1636 or Fax: 503-227-5722) specializes in treatment of carpal tunnel syndrome.

Prevention.

Some people are more susceptible to RMI's than others. For example, some personal characteristics such as age, wrist size, obesity, and type of off-work activities have been related to susceptibility to carpal tunnel syndrome. You can't do much about the first two, but the incidence of RMI's is much less for people who keep in good physical shape. Some specific actions that can prevent or at least lessen the incidence of RMI's include:

- Train all workers on proper technique before starting a new task, and spend extra time showing new employees how to do it properly.
- Schedule warm-up exercises each morning (Figure 12), and emphasize those that build-up shoulder, arm, and wrist muscles. Encourage workers to join fitness programs off the job.
- Rotate jobs or work stations whenever possible. For example, rotate workers through the "pulling" station when processing container seedlings, or avoid using vibrating equipment such as electric shears, for more than 2 hours at a time.

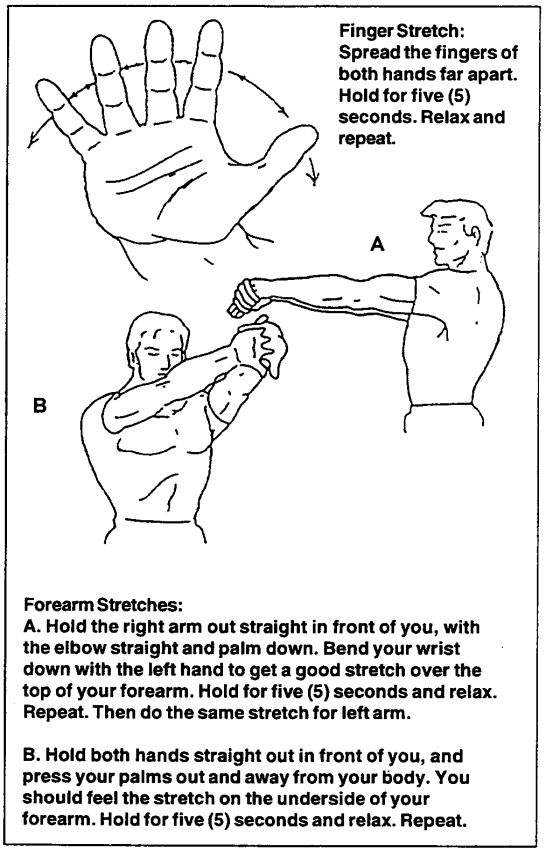


Figure 12. Nursery workers who keep in good physical shape and limber up with exercises before starting work each morning have less chance of suffering from repetitive motion injuries.

- Tell workers to stop at the first sign of chronic pain and inform their supervisor. Some workers just may not be able to do certain tasks.
- Emphasize correct posture and technique and vary physical position when performing repetitive tasks. Try to grasp rather than pinch and keep the thumb in the neutral position. When using tools, wrap the thumb around the handle instead of holding it lengthwise along it.
- Switch to new ergonomically-designed tools that conform to the hand. Tool handles are being redesigned relative to their diameter, attachment angles, and many feature anti-slip coatings, finger grips, and cushioned coverings.
- Dress warmly and use gloves in cold work areas such as packing sheds because cold conditions are known to aggravate RMI's.

Conclusions.

Repetitive motion injuries are a hazard of nursery work, but their incidence and impact can be significantly decreased with a few simple precautions. Create awareness at nursery safety meetings and promote prevention by regular training sessions.

Sources:

Appleton, B.L. 1995. Horticulture or Horticulture? Nursery Management & Production 11(7): 57-60,62-63. **(Order #11 on the Literature Order Form).**

Mowry, D. 1995. Current developments in the prevention and treatment of repetitive motion injuries of the Upper Extremity. IN: Landis, T.D.; Cregg, B. tech. coords. National proceedings, Forest and Conservation Nursery Associations. Gen. Tech. Rep. PNW-GTR-365. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 8-12. **(Order #6 on the Literature Order Form)**

Personal Protective Equipment

According to the EPA's Worker Protection Standard that became effective in 1995, pesticide handlers, applicators, and early entry workers are required to wear some type of personal protective equipment (PPE). The type of required PPE varies with the pesticide and the type of job; the specifics are given on the pesticide label. OSHA recently released a booklet on PPE which provides practical information such as the five conditions under which respirators must be used and the factors to be considered for selecting gloves. A single free copy of the booklet may be obtained by sending a self-addressed label to:

U.S. Department of Labor, OSHA
OSHA Publications P.O. Box
37535 Washington, DC
20013-7535 USA Tel:
202-219-4667
Fax:202-219-9266

Equipment, Products and Services

All trade names mentioned in this section are used for the information and convenience of the reader, and do not imply endorsement or preferential treatment by the author or the USDA Forest Service.

Soluble Fertilizers with Calcium and Magnesium

As any of you know who have ever tried to custom-mix soluble fertilizer solutions for liquid injection, materials containing calcium and magnesium can cause solubility problems in the mix tank (Figure 13). This problem is especially common in nurseries with very pure water which do not contain a base level of these important nutrients (see pages 9-11 for more on calcium nutrition). Recently, however, Scotts Horticultural Products has introduced a line of water soluble fertilizers that contain both calcium and magnesium, as well as micronutrients (Table 7). Their new patented process has made it possible to mix a complete fertilizer solution in one tank, which eliminates the need for two-head injectors, and makes the mixing instructions much simpler.

In addition, the new Osmocote Plus? controlled-release-fertilizers also contain 6 micronutrients and magnesium, but not calcium, for those incorporating slow-release fertilizers into their growing media. Several N-P-K formulations are available that will last from 3 months to as long as 1.5 years at 21 °C (70 °F), which is much longer than earlier slow-release fertilizers. For this reason, they are being applied at the time of outplanting to provide supplemental mineral nutrition during that critical period of establishment.

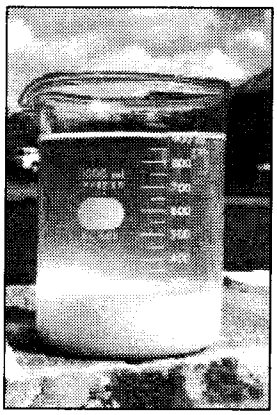


Figure 13. It is difficult to add calcium to most concentrated soluble fertilizer mixes because chemical incompatibilities result in heavy precipitates.

Growing Media Containing Sawdust

Although sawdust has been used as a growing media component in horticulture for many years, this has not been the case in forest and conservation nurseries where peat-vermiculite media have been the norm. About five years ago, Steve Pelton of Pelton Reforestation in British Columbia began experimenting with a medium containing sawdust, and after good initial results, other Pacific Northwest growers followed suit. Now, Black Gold is offering a new "Forestry Mix #3" which contains 30% fresh Douglas-fir sawdust and 70% *Spagnum* peat moss. Since fresh sawdust requires supplemental nitrogen during decomposition, this mix contains 0.75 lb of urea form fertilizer (38-0-0) per cubic yard to allow for this demand.

Table 7. The Peters line of Excel? fertilizers contain calcium and magnesium

Product Name	Formulation (N-P_2O_5-K_2O)	Available Nutrients in 100 ppm N Solution					
		N	P	K	Ca	Mg	S+Micros
EXCEL Cal-Lite	15 - 0 - 0	100	0	0	120	0	Yes
EXCEL Cal-Mag	15 - 5 -15	100	15	83	33	13	Yes
EXCEL Magnitrate	10 - 0 - 0	100	0	0	0	90	Yes

Growing media containing uncomposted sawdust offers one valuable attribute that other commercial media lack-the gradual creation of more macropores during the growing season. This shrinkage due to decomposition was originally thought to be detrimental because it caused the media to pull away from the side of the container, allowing irrigation to run through without wetting the media. If this decrease in volume could be controlled, however, then the growing media would gradually create more aeration porosity, and places for roots to expand throughout the growing season. Good growers have been concerned about the tendency of roots to fill all the available cavities in the medium, which decreases the air porosity and creates saturated conditions in the root zone (Figure 14). This condition is particularly prevalent later in the growing season when root growth reaches its peak. As the peat moss-sawdust mix gradually decomposes, however, the additional porosity provides better aeration in the rhizosphere and places for the roots to grow.

The rate of decomposition must be carefully controlled. The type and condition of the sawdust, and the amount and form of supplemental nitrogen fertilizer are critical. The quality of sawdust varies considerably depending on tree species, age, and how it is handled and stored. Black Gold has developed a steady source of Douglas-fir sawdust of uniform quality and has the expertise and mixing equipment that is necessary to properly incorporate the fertilizer. They also have the ability to sample the media and maintain a uniform quality which is most important. As with any change in growing media, irrigation and fertilization will have to be adjusted, so the Forest Research Nursery at the University of Idaho will be conducting a series of tests with this peat moss-sawdust media during the upcoming season. Several other growers will also initiate small- scale trials, so we should know more about this exciting new growing media by later this fall. If you would like more information in the meantime, then call or FAX Michelle at Black Gold:

Michelle Miller
Black Gold, Inc.
19308 Highway 99E
Hubbard, OR 97032
USA
Tel: 503-981-4406
Fax:503-981-2304

Figure 14. Waterlogged roots often develop "cauliflower-like" growths around the lenticels.

Source:

Handreck, K.A.; Black, N.D. 1994. Growing media for ornamental plants and turf. Randwick, NSW, Australia: University of New South Wales. 448 p.

Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1990. Containers and Growing Media, Volume Two, The Container Tree Nursery Manual. Agric. Handbk. 674. Washington, DC: USDA Forest Service. 88 p.

Seed Upgrading Equipment

Nursery managers that purchase seed should expect clean, pure seed of high quality, but those that collect and process their own seed may need to upgrade certain seedlots. While it cannot directly improve the quality of individual seeds, upgrading improves the potential performance of a seedlot by removing empty, damaged, weak, and immature seed. Nurseries often upgrade seed lots that will be single sown, especially if precision seeders will be used.

A promising new technique for upgrading Pinus and Picea seed lots is the IDS (Incubation-Drying-Separation) method which separates filled, nonviable seeds from filled, viable ones. First, the seeds are soaked in water at 15 °C (59 °F) to obtain full

imbibition, then dried at 25 °C (77 °F) to create differences in seed moisture content. During drying, viable seeds will retain more moisture than nonviable ones, and this difference in weight can be used to separate the two fractions by flotation in water. The principle is that heavier filled seeds will sink and the lighter empty or damaged seeds will float. This procedure needs to carefully checked with a cut test, however, as some filled seeds will float if water bubbles are trapped on the seed coat, or empty seeds may sink if they are dirty.

Several types of upgrading equipment can also be used to upgrade seed, but air column separators are perhaps the best option because they can be precisely adjusted to separate seeds by three physical properties: size, shape, and density. Richard Felden of Seed Tech Systems has developed a couple of new precision air seed separators. The STS-WM3 is a wall-mounted model that was specifically designed for upgrading seedlots based on the weight of the individual seed in relation to its air resistance (Figure 15). The rate at which seed is fed into the air columns can be precisely adjusted so that each seed reacts individually, and an air valve slide adjustment controls the volume or velocity of air moving up through the separating columns. The STS-WM3 has been shown to successfully reclaim seed that would have been discarded from screen separators or gravity tables. The STS-MACS is a multiple air chamber system which feeds seed into multiple enclosed chambers which have precisely calibrated air streams. The air flow is calibrated by a digitized LED variable frequency computer to allow very precise air adjustments in each column, and thus achieves in a single-step process, the same separation that would require several other machines in sequence. For more specific details, you can call Rich at:

Richard W. Felden
Seed Tech Systems
PO Box 980243
West Sacramento, CA
95798
Tel: 916-684-1196
Fax: 916-684-7675

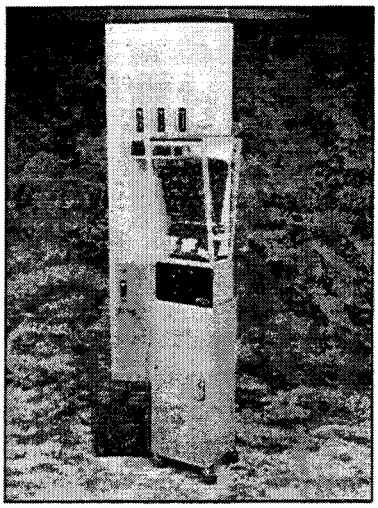


Figure 15. Air column separators are one of the best and easiest ways of upgrading seedlots by removing empty or partially filled seeds. (Courtesy of Seed Tech Systems.)

Source:
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.

MycorTree Root Dip Inoculant

Mycorrhizal fungal inoculants have been around for decades (see article in *FNN* January, 1993), but this new product incorporates two important concepts:

1) use of a mixture of fungi, and
2) proper timing of inoculation.

MycorTree is a root dip that is used to inoculate either bareroot or container seedlings prior to outplanting. One of the limitations of previous mycorrhizal inoculants is that they were composed of only one fungus that was specifically suited to a limited number of plant species. MycorTree? , on the other hand, contains five specially selected

species of both vesicular-arbuscular (VA) and ectomycorrhizal fungi that can colonize the roots of most plant species under a broad range of growing conditions. The VA "cocktail" includes spores of several species of *Glomus* spp. as well as *Entrephospora columbiana*, along with spores of the well-known ectomycorrhizal fungus, *Pisolithus tinctorius*. Actually, I would prefer a few more ectomycorrhizal fungi in the mix, but I still like the concept. For ease of application, the spores have been mixed with Terra-Sorb? super absorbent gel to reduce root drying and enhance drought resistance, and natural organic extracts to promote fast root regeneration.

The other thing that I like about this product is the fact that the seedlings are being inoculated at the right time. One of the problems that I've had with other mycorrhizal inoculants is that they are added either as a seed treatment, mixed into the growing medium prior to sowing, or sprayed on young seedlings in the nursery. These types of applications mean that the grower often must modify irrigation and fertilization practices to encourage the development of the mycorrhizae, usually at the expense of seedling growth. I've always contended that the time to inoculate is during the Hardening Phase when fertilization and irrigation are being reduced anyway. Dipping the seedling roots right before outplanting is a good idea that allows nursery managers to treat their crops without sacrificing growth. MycorTree? Root Dip is added to water in a bucket and mixed for 3 to 5 minutes until it becomes a slurry with the consistency of a heavy gravy. Seedlings are treated by dipping the roots into the slurry until it completely coats the root system. Although it is best to plant them immediately, treated seedlings can be stored for a reasonable amount of time without loss of effectiveness. For more information, contact:

Don Mans or Ed Cordell
Plant Health Care, Inc.
440 William Pitt Way
Pittsburgh, PA 15238 USA
Tel: 412-826-5488 or 800-421-9051
Fax: 412-826-5445

New Rooting Compound

This new root growth stimulant is called Rootall? or "P-ITB" because of its chemical composition (phenyl indole-3-thiolobutyrate) and is used just like indole-3-butyric acid (IBA). Comparative trials with IBA conducted on a wide range of ornamental woody plants showed similar effectiveness, but the toxicity profile for P-ITB is much lower. Rootall has just been registered with the US Environmental Protection Agency but it was a long and expensive process. Therefore, the company is conducting a marketing analysis and would like to hear from potential users. If you would like more information including a Material Safety Data sheet on this product, contact one of the following people:

Thomas Zeller or Greg
Brekken Gro/Tech, Inc. PO
Box 725 Rapid City, SD
57709 USA Tel:
605-394-6440

Temperature/Humidity Sensors

Rotronic Instrument Corporation is marketing a line of instruments that should have several applications in forest and conservation nurseries. The AZ model is a battery operated portable instrument with a long probe (Figure 16) that measures both ambient temperature and relative humidity (RH) and displays

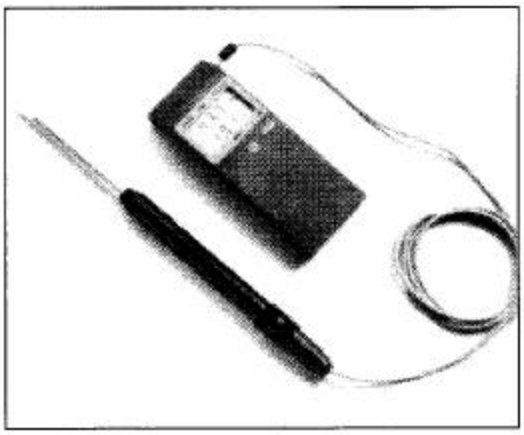


Figure 16. The A_2 is a portable instrument with a long probe that can measure relative humidity and temperature, and also can compute the dew-point. (Photo courtesy of Trotronic Instrument Corp.)

them on an LCD screen. Temperature measurements have never been much of a problem but measuring RH, especially in high humidity environments like greenhouses or seedling storage buildings, has been more of a challenge. Accuracy of RH measurements is advertised at +/- 2% in the range of 5 to 100% RH. The company also sells humidity/temperature transmitters that are ideal for remote control applications. For more information, contact:

Gary L. Moliver
Rotronic Instrument Corp.
160 E. Main St.
Huntington, NY 11743 USA
Tel: 516-427-3898
Fax: 516-427-3902

Nursery Networks

As you know, the electronic mail (E-Mail) age is upon us, so I thought that I'd use this forum to let you know about new nursery newsletters, World Wide Web (WWW) pages, and other network connections. Several people have asked why we don't put *FNN* on the WWW, and I really don't have any good answer except that the US government is always slow to adopt new technology. We'll continue to work on it—if we ever get a budged!

The Genetic Forest

The first edition of this new newsletter (Volume I, No. 1, 1995) has just been distributed (Figure 17). This new publishing venture is co-sponsored by State and Private Forestry, USDA Forest Service and the Oregon Department of Forestry, with the objective of covering news and perspectives of forest genetics in the western US. The focus will be on the application of scientific principles, concepts, and technological developments to further forest management goals and to protect and conserve the

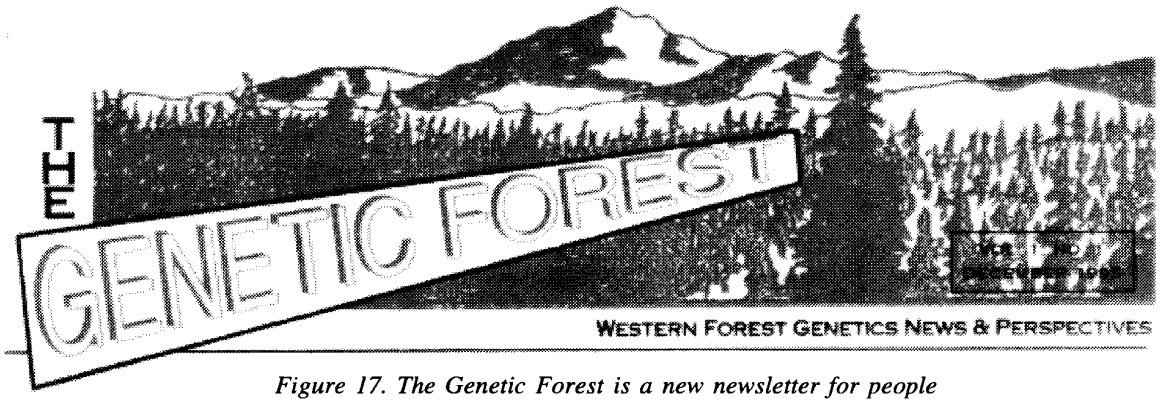


Figure 17. The Genetic Forest is a new newsletter for people interested in forest genetics in the western US.

basic genetic resource. This newsletter will be published semi-annually and distributed to geneticists, tree improvement workers, silviculturists, extension specialists, nursery managers, and other professionals. If you would like to receive a copy of the first issue and be added to the mailing list, contact:

The Genetic Forest c/o
Daniels & Associates, Inc.
4530 SE 47th Ave.
Portland, OR 97206 USA
Tel: 503-788-0366 E-mail:
dodo 104@aol.com

World Wide Web

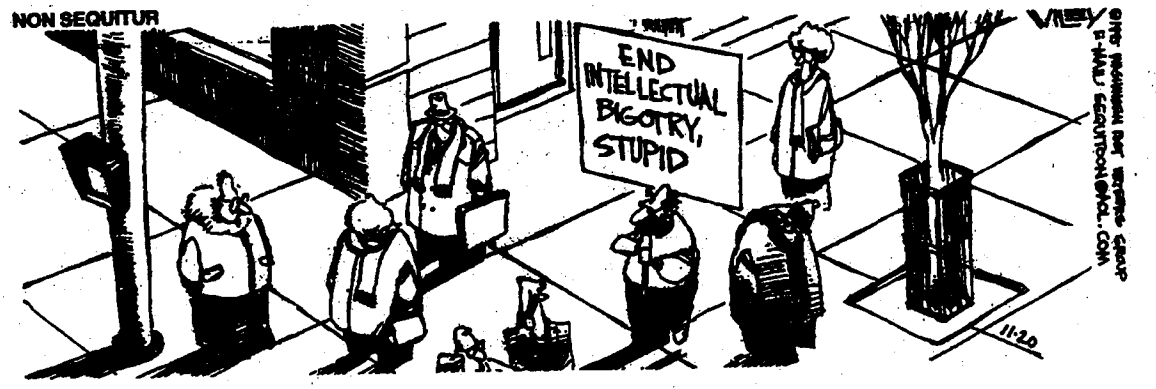
Several people have begun sending me the addresses for their World Wide Web (WWW) sites, and so I am passing them on to those of you who are interested. If any of you would like to list your nursery or company WWW page, send the address to me and we'll start a directory.

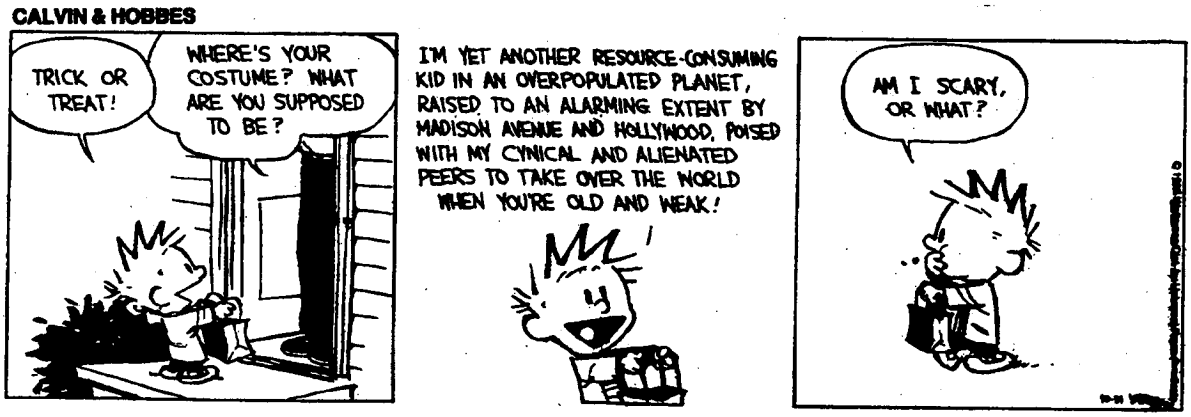
Nursery Technology Cooperative, Oregon State University, Corvallis, OR
http://www.fsl.orst.edu/coops/ntc/htm

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

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

Horticultural Humor





MOTHER GOOSE & GRIMM

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MIXED MEDIA

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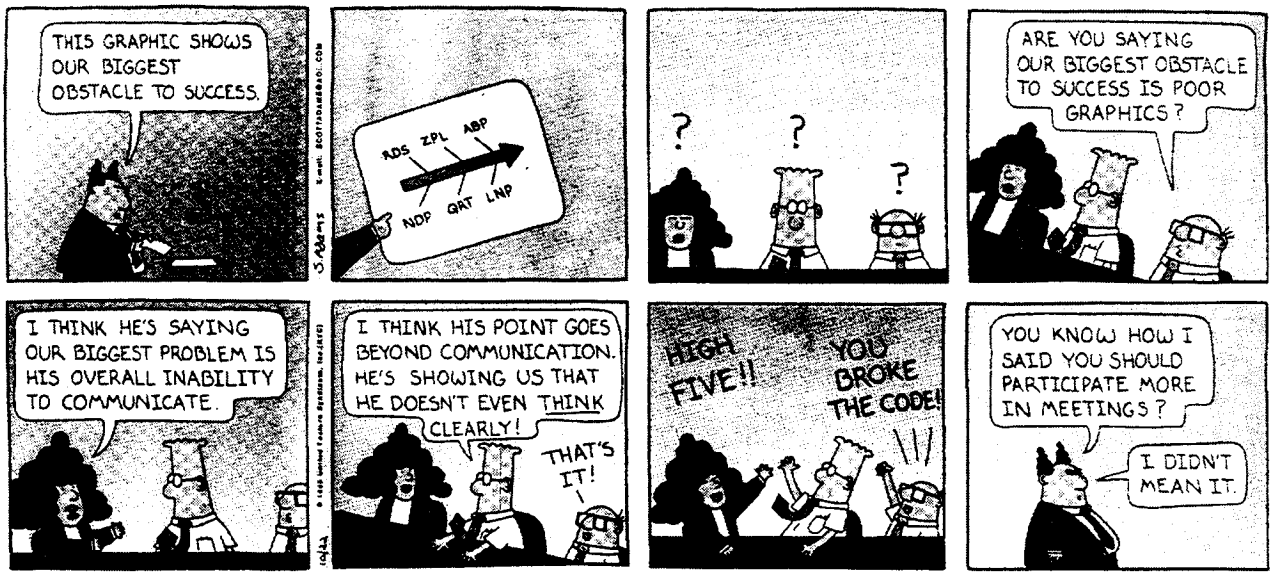

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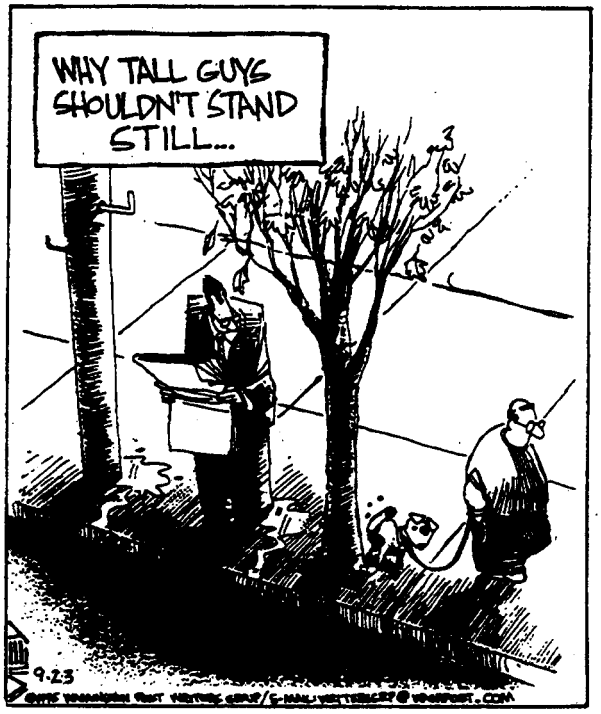
"That's strange. Since when did the government list the blue-footed booby as an indentured species?"



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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 three 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 circle the appropriate number or letter and return the form to me.

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 Order Publications

SO. Handreck, K.A.; Black, N.D. 1994. Growing media for ornamental plants and turf. Randwick, NSW, Australia: University of New South Wales Press. 448 p.

The first edition of this very handy reference was published back in 1984, and was a primary reference when I wrote *Volume Two: Containers and Growing Media* on the Container Tree Nursery Manual series. The authors do a fine job of explaining the basic concepts of managing native soils and container growing media in a practical, common sense way. Numerous tables, drawings, graphs, photos, and photomicrographs add greatly to the readability (Figure 18). The major additions to this new edition include sections on composting, air-filled porosity, minimizing water use and fertilizer runoff, and a "self-help chapter". It can be purchased in the US from:

COST: $39.95 **Order From:**
ISBS, Inc.
5804 NE Hassalo St.
Portland, OR 97213-3644 USA
Tel: 503-287-3093
Fax: 503-280-8832

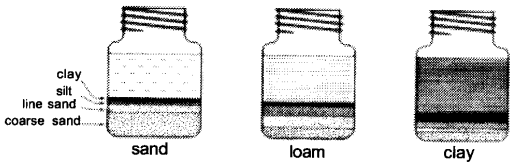

Figure 18. ***Growing Media for Ornamental Plants and Turf*** *contains many excellent illustrations, such as this simple water suspension procedure for demonstrating soil texture.*

SO. Landis, T.D.; Cregg, B. tech. coords. 1995. National proceedings, Forest and Conservation Nursery Associations. Gen. Tech. Rep. PNW-GTR-365. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 155 p.

This is the annual compilation of technical papers presented at the regional meetings of the forest and conservation nursery associations in the United States in 1995. The Western Forest and Conservation Nursery Association was held in Kearney, NE on August 7-11 and the Northeastern Forest Nursery Association Conference was held on August 14-17 in Mitchell, IN. The 23 papers deal with subjects ranging from seed collection and processing through nursery cultural practices to harvesting, storage, and outplanting.

Cost: Free **Order From:**
Circle **"A"** on Literature Order Form for the entire proceedings, or individual papers are listed in the New Nursery Literature Section.

SO. USDA Forest Service. 1995. Commercial suppliers of tree and shrub seed in the United States. Misc. Rep. R8-MR 33. Atlanta, GA: USDA Forest Service, Southern Region. 97 p.

Professionals in both the public and private sectors in the fields of forestry, horticulture, resource conservation and land management can use the directory to locate seed from over 2000 species. The directory is broken down into five sections. The first section covers guidelines for buying seed. The second section lists the names, addresses and phone numbers of 58 tree and shrub seed dealers located in the US. The third section covers vendor services. For example, does the vendor keep seeds in inventory, or can they make special collections, etc. The fourth section is the actual list of species sold by these seed dealers. The species list is cross-referenced with the vendor list in section two. Section five is an index of some common plant names.

Cost: Free **Order From:**
Circle **"B"** on Literature Order Form.

SO. Okholm, D. 1996. Pacific Northwest Nursery Directory and Report. Pub. # R6-CP-TP-13-95. Portland, OR: USDA Forest Service, Cooperative Programs. 58 p.

This is the principal directory of forest and conservation nurseries in the Pacific Northwest region of the US, and was developed from survey information. Nurseries are listed by state, along with addresses, ownership information and statistics on seedling production and distribution. This publication serves as a valuable networking tool serving foresters, nursery professionals, and natural resource managers, and others engaged in reforestation and conservation activities.

Cost: Free **Order From:**
Circle "C" on Literature Order Form.

SO. Solomon, J.D. 1995. **Guide to insect borers in North American broadleaf trees and shrubs.** Agric. Hndbk. 706. Stoneville, MS: USDA Forest Service, Southern Forest Experiment Station. Southern Hardwoods Laboratory. 735 p.

This is the definitive work on insect borers of hardwoods in the US and includes the important nursery pests.

Cost: Free

Order From:
USDA Forest Service
Attn: Eula Emanuel
PAO, 2/CEN
PO Box 96090
Washington, DC 20090-6090 USA
TEL: 202-205-0819
FAX: 202-205-0885

SO. Addendum: Diseases and Insects in British Columbia Forest Seedling Nurseries. This pamphlet supplements the original volume and contains chapters on Meria needle cast of larch and Keithia blight of western redcedar. Copies are available from:

Cost: Free

Order From:
Publications Section
Pacific Forestry Centre
506 W. Burnside
Victoria, BC V8Z 1M5
CANADA
Tel: 604-363-0600
Fax: 604-3 63-6006

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D. Ostry, M.E.; Wilson, L.F.; Mc Nabb, H.S., Jr.; Moore, L.M. 1988. **A guide to insect, disease, and animal pests of poplars.** Agric. Handbk. 677. Washington, DC: U.S. Department ofAgriculture. 118 p.

This spiral bound book contains identification keys and sections on the major pests of poplars in the US, and is well illustrated with good color photographs. Each section provides specific information on the identification, biology and control of a particular pest group.

New Nursery Literature

Please obtain these articles from your local forestry library or literature service if at all possible. Numbered articles can also be ordered directly, using the Literature Order Form on the last page - just circle the appropriate number and return form to me. These free copies are a technology transfer service of USDA Forest Service, State and Private Forestry. Items marked with © are copyrighted and require a fee for each copy, so you will only be sent the title page and abstract. If you desire the entire article, follow the ordering instructions that follow the abstract.

Special Order (SO) articles or publications must be ordered directly from the publisher. Prices and ordering instructions follow each listing.

Bareroot Production

1. ***Culturing 1-0 western larch seedlings at J. Herbert Stone Nursery.*** Steinfeld, D.; Feigner, S. IN: Ecology and management of Larix forests: a look ahead, proceedings of an international symposium, p. 501-502. USDA Forest Service, Intermountain Research Station, General Technical Report INT-319. 1995.

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5. ***Comparing productivity in greenhouse tasks of individuals with and without mental disabilities.*** Eddy, R. T.; Belfiore, P. J. HortTechnology 5(2):134-137. 1995.

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10. ***Get the word out.*** Healey, D. Greenhouse Grower 13(13):40,42. 1995. How to receive some extra publicity for your greenhouse operation.

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