United States
Department of
Agriculture

Forest Service

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Northwest
Region

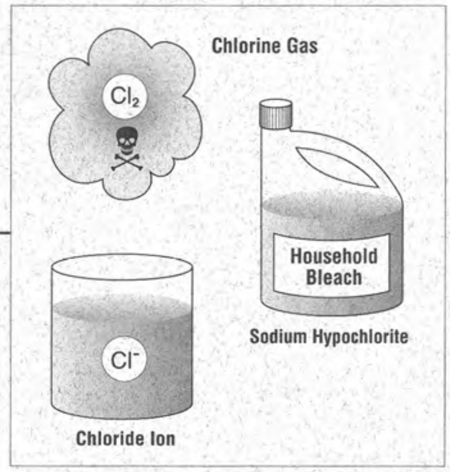
State and Private
Forestry

Cooperative
Programs

R6-CP-TP-01-03

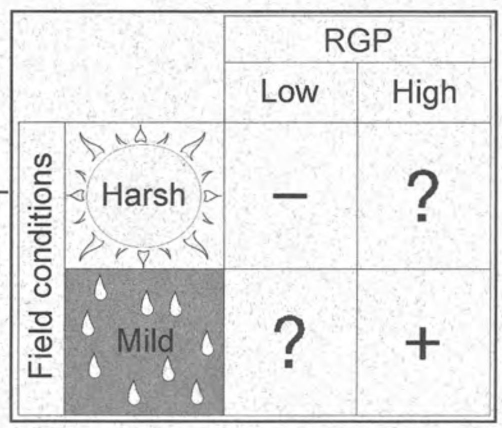
Forest Nursery Notes

Winter 2003



Cultural Perspectives
Micronutrient - Chlorine

Equipment, Products, and Services
Frost Protection Fabrics



Cultural Perspectives
Seedling Quality Tests: Root Growth Potential

Forest Nursery Notes
Winter 2003

Please Update Your Address: The FNN mailing list is always out-of-date so we would like to make sure that we have your latest address. Please take the time to check the mailing label and note any additions or corrections on the Literature Order Form at the back of this issue. In particular, check your telephone and FAX numbers because area codes keep changing. Supply the country code if you are a foreign subscriber. Also list your E-mail and website addresses if you have them.

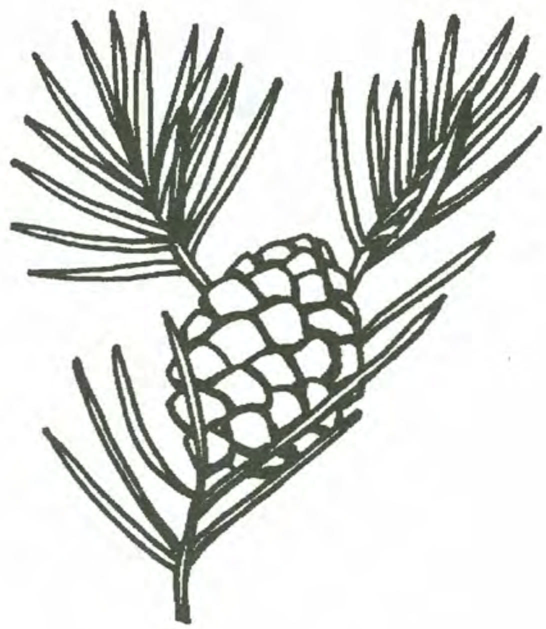
Technical Requests. Every day we receive letters, telephone calls, Faxes, and E-mail messages from around the world requesting publications or asking for technical assistance. Our technology transfer team prides itself on responding to all inquiries as soon as possible but we do have to set some priorities. Forest and conservation nurseries in the United States receive first priority and then we handle requests from foreign countries. Our contact information is listed on the inside cover of this issue. If Tom is not around, then contact David or Rae and we'll get back to you as soon as possible. You can make things easier if you will remember a few things when contacting us:

- ♦ Telephone calls are 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, FAX, and E-mail numbers.

- ♦ FAX messages are easy to process but be sure to give your complete name, address, and return FAX number *including country code.*

- ♦ E-mail is the best option because it is non-invasive and accessible around the clock. If you are requesting publications, be sure and give us your full mailing address.

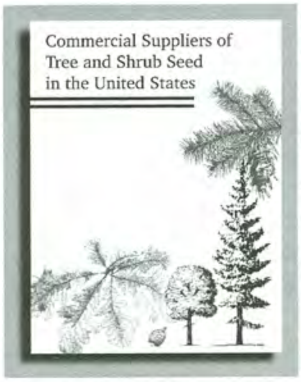
New E-mail and Website Addresses: Tom has a new "official" E-mail address (tdlandis@fs.fed.us), so please note it in your address book, and our website has also changed to: <http://www.rngr.fs.fed.us>



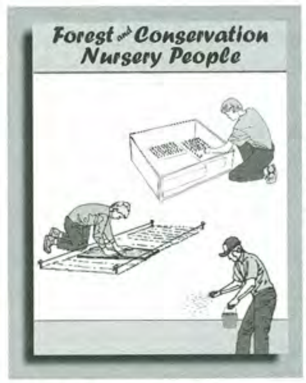
Nursery Networks

Directories on the Reforestation, Nurseries, and Genetic Resources (RNGR) home page - One of the objectives of Forest Nursery Notes is to promote networking and so we maintain several different directories on our website. ***Note the new address:***

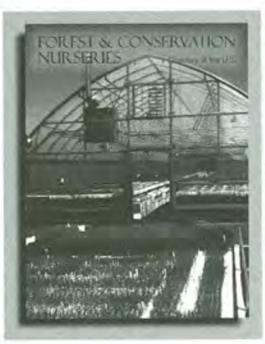
<http://www.rngr.fs.fed.us>



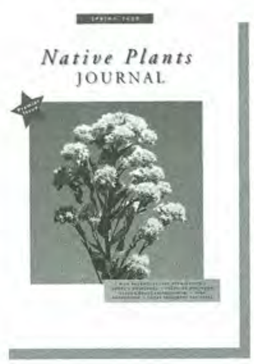
Commercial Suppliers of Tree and Shrub Seed in the United States – This directory provides a list of vendors of tree and shrub seed for the US. The directory starts with some basic information on seed quality and then is followed by addresses, telephone and fax numbers. Services supplied by each vendor are also included along with an alphabetical list of all the tree and shrub seed sold in the US and common plant names. Again, much of this information is already out-of-date so please let us know if there are changes or additions.



Forest and Conservation Nursery People – This is an MS Excel spreadsheet of people who work in the forest and conservation nursery field from around the world. It is composed of the mailing list for FNN so, if you'd like to be added to the directory or update your listing just fill out and return the Literature Order Form in the back of this issue.



Directory of Forest and Conservation Nurseries – This directory is organized by state and contains the latest addresses and production information for forest and conservation nurseries on a state-by-state basis. For those nurseries that have them, links to E-mail addresses and WWW home pages are also provided. Ownership category, type of nursery (container or bareroot), and current and potential seedling distribution are included. We are continuing to update this directory so contact us if your listing needs to be corrected.



Native Plants Network - A list of propagation protocols for a wide variety of native plants and past issues of the Native Plants Journal can be accessed at: http:// www.nativeplantnetwork.org/. We are in the final stages of completing a Directory of Native Plant Nurseries and it should be on-line in the next few months.

Nursery Meetings

This section lists upcoming meetings and conferences that would be of interest to nursery, reforestation, and restoration personnel. Please send us any additions or corrections as soon as possible and we will get them into the next issue.

A joint meeting of the ***Society for Ecological Restoration, Northwest Chapter*** and the ***Pacific Northwest Chapter of the Society of Wetland Scientists*** will be held ***March 24-28, 2003*** at the Oregon Convention Center in Portland, OR. The restoration toolbox is the general theme and both technical sessions and field trips are planned. Nursery folks will be particularly interested in the session on Plant Materials. For the latest information and registration information, check out the website:

<http://216.119.67.178/2003conf/Index.htm>

The fifth meeting of the **IUFRO WP S7.03.04:Diseases and Insects in Forest Nurseries** meeting will be held at Kerala Forest Research Institute, Kerala, India during **May 6-8, 2003.** For details on the meeting please contact:

Dr. C. Mohanan
E-mail: mohanan@kfri.org

New date for the 2003 WFCNA meeting. Because of conflicts with fall transplanting, we have decided to try a June date for the annual Western Forest and Conservation Nursery Association meeting. Therefore, this year's meeting will be hosted by the USDA Forest Service Coeur d' Alene nursery on ***June 9-12, 2003*** in ***Coeur d' Alene, ID.*** We are currently working on the agenda which will consist of morning technical sessions followed by afternoon field trips. We will have a focus topic on seedling processing and storage, fertilizers and nutrition, blackout, as well as a general topics session. Please let us know if you would like to present a paper.

For local arrangements, contact:

Marlis Beyer
Coeur d' Alene Nursery
USDA Forest Service
3600 Nursery Road
Coeur d'Alene, ID 83814
TEL: 208.765.7390
FAX: 208.765.7474
E-MAIL: mbeyer@fs.fed.us

For information on the agenda, contact:

Tom D. Landis
USDA-Forest Service
J.H. Stone Nursery
2606 Old Stage Road
Central Point, OR 97502
TEL: 541.858.6166
FAX: 541.858.6110
E-MAIL: tdlandis@fs.fed.us

Again this year, the ***Intertribal Nursery Council*** will hold its annual meeting in conjunction with the 2003 WFCNA meeting described above. The INC meeting will be held at the Coeur d' Alene Indian Reservation on **Monday, June 9, 2003** and all American Indians and people working with tribes are encouraged to attend. The Forest Service will provide the funds for travel and per diem for Indian people attending these sessions on a first-come, first served basis. If you would like more information, contact:

Jeremy Pinto
USDA Forest Service
Rocky Mountain Station
1221 South Main Street
Moscow, ID 83843
TEL: 208.883.2300
FAX: 208.883.2318
E-MAIL: jpinto@fs.fed.us

Tom D. Landis
USDA-Forest Service
J.H. Stone Nursery
2606 Old Stage Road
Central Point, OR 97502
TEL: 541.858.6166
FAX: 541.858.6110
E-MAIL: tdlandis@fs.fed.us

The 2003 ***Northeastern Forest and Conservation Nursery Association*** meeting is being planned for the week of ***July 14, 2003***, in ***Springfield, Illinois***. In addition to the technical sessions, a field trip will visit the Mason State Tree Nursery. If you would like to give a paper or just want the latest information, please contact:

David Horvath, Nursery Manager
Mason State Tree Nursery
Illinois Division Of Forestry Resources
17855 N. County Road 2400e
Topeka, IL 61567
TEL: 309.535.2185
FAX: 309.535.3286
E-MAIL: dhorvath@dnrmail.state.il.us

The **International Union of Forestry Research Organizations [IUFRO], Seed Physiology and Technology Research Group [RG 2.09.00]** will hold their annual symposium **August 10 through 14, 2003**, at the University of Georgia, **Athens, Georgia, USA**. All interested people are requested to contact Gary Johnson. Pre-registration forms and information about the symposium are posted on the web page: ntsl.fs.fed.us.

Gary Johnson
National Tree Seed Laboratory
5675 Riggins Mill Road
Dry Branch, GA 31020
TEL: 478.751.3555
FAX: 478.751.4135
E-MAIL: wjohnson03@fs.fed.us

The **ISTA Forest Tree Seed and Shrub Seed Committee and the Forestry and Game Management Research Institute** of the Czech Republic will host this workshop from **October 20-22, 2003**, in **Prague, Czech Republic**. The workshop will deal with practical problems of broadleaf and conifer seeds such as: purity, defining germination, tetrazolium tests, health testing and referee tests. Following the Prague meeting there will be an optional, 3-day long (October 23-25) field trip (seed testing facilities and extraction plants, plus wine cellars) to eastern Czech Republic (Moravia) and the Republic of Slovakia. A preliminary registration form is available at <http//www.seedtest.org> or contact:

Dr. Zdenka Prochazkova,
FGMRI RS Uherske Hradiste
686 04 Kunivice
CZECH REPUBLIC
E-MAIL: prochazkova@vulhmuh.cz

Health and Safety

Seasonal Affective Disorder

What is SAD?

Seasonal affective disorder (SAD) is a form of depression occurring mostly in the fall or winter, when days shorten and daylight decreases. It is an extreme case of the "winter blues" that is relieved during the spring and summer months. There are rare cases of people experiencing SAD in the summer, although this is usually related to severe heat rather than light. Nightshift workers or people who work or live in poorly or badly lit places can also suffer from SAD, even during the summer.

Young people and women are at the highest risk for this disorder, but it can affect anyone. It is estimated that 25 percent of the population suffers from a mild winter SAD and about 5 percent suffer form a more sever form of the disorder.

Melatonin is a sleep-related hormone produced by the pineal gland in the brain. This hormone is believed to cause symptoms of depression and is reduced at increased levels in the dark. So when days are shorter and darker, the production of the hormone increases.

What are the symptoms?

- Feeling tired, depressed or sad
- Increased appetite
- Craving for carbohydrates and starchy foods
- Weight gain
- Sleeping more than usual
- Social withdrawal
- Lack of interest in usual activities
- Inability to concentrate, to focus
- Inability to meet deadlines
- Decreased libido
- Body aches and pains (several people have the feeling that they have a cold all winter long)

Treatment

People don't need to wait for spring to overcome SAD. If symptoms are mild and they don't interfere too much with daily living, spending time outside during the day or arranging homes and workplaces to receive more sunlight may be helpful. Regular exercise outdoors can also help relieve depression. According to one study, a one hour walk in winter sunlight was as effective as two and a half hours under bright artificial light.

For more severe symptoms phototherapy may help. Phototherapy has been shown to suppress the brain's secretion of melatonin. This treatment consists of sitting in front of a light box that emits very bright light, most commonly a full spectrum fluorescent light. Normal activities such as working, eating or reading can be carried out while stationary in front of the light box. In a 1986 study, 80 percent of 112 patients improved significantly with light therapy.

Anyone who thinks they may have SAD should discuss their symptoms with a qualified health professional.

Sources

National Mental Health Association, <http://www.nmha.org>
National Alliance for the Mentally Ill, <http://www.nami.org>
Northern Light Technologies, <http://www.northernlight-tech.com
Rosenthal NE. 1989 Seasons of the Mind, Why You Get the Winter Blues & What You Can Do About It. 278 p.

Cultural Perspectives

Seedling Quality Testing Services

By Thomas D. Landis

Introduction. Since the early 1900's, foresters and nursery managers have attempted to measure the quality of conifer seedlings by morphological characteristics (Figure 1). These measurements evolved into nursery grading standards such as shoot height and stem diameter, ovendry weight, and size ratios such as the shoot:root ratio. Of the various morphological attributes that have been tested, stem diameter is consistently the best predictor of outplanting survival while shoot height is related to growth (1). Attempts to characterize quality by seedling morphology continue to this day, as evidenced by the recent research on root volume (2). While morphological grading standards for conifer seedlings have been around for over a century, it's interesting to note that there are no accepted standards for most hardwood tree seedlings or native plants.

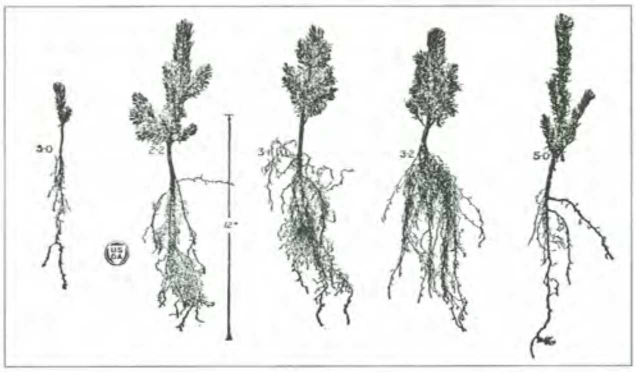


Figure 1 - Establishing seedling grades and stock types was the first attempt to categorize seedling quality

Development of Seedling Quality tests. In the 1940's, a visionary Forest Service scientist named Phil Wakeley was the first to realize that, while seedling "morphological grades" were useful, they often fell short in their ability to predict seedling quality (3). Wakeley proposed a system of seedling quality testing by observing survival and growth after outplanting. The first person to develop an actual seedling testing procedure was Edward Stone who pioneered the root growth capacity test in the 1950's. Interestingly enough, Stone first presented the idea of seedling quality testing to a western forest nursery association meeting (4). He observed that the ability to grow new roots was somehow related to seedling quality and the current root growth capacity test is the result (see following article).

In the 1970's and 1980's, there was a tremendous increase in the amount of research on seedling physiology. The first comprehensive discussion of the concept of seedling quality testing was the Evaluating Seedling Quality workshop organized by Mary Duryea and the Nursery Technology Cooperative at Oregon State University. The Proceedings from this workshop have become one of the primary references for seedling quality testing (5). One of the revolutionary insights of this meeting was that seedling quality discussions must involve seedling users as well as nursery workers.

Types of Seedling Quality Tests. Several different tests have been developed over the past 25 years. Some tests, like plant moisture stress, only measure one aspect of seedling quality and therefore will not be considered here. Others, like electrical impedance, are no longer used although they have an interesting history. A number of research papers in the late 1960's and early 1970's investigated the possibility of electrically measuring seedling quality, (Figure 2) and this research culminated in the development of the Dormancy Meter (6). Operational testing showed that, although the "black box" approach was intriguing, there probably never will be a single test that can give a comprehensive evaluation of seedling quality.

Figure 2 - The concept behind the Dormancy Meter was that seedling dormancy was somehow related to the electrical impedance of the tissue

Starting with root growth capacity in this issue, we are going to take a look at the seedling quality tests that are currently available. Our emphasis will be on the practical, operational aspects of the tests and how they can be used by nursery managers and reforestation and restoration specialists. In upcoming issues, we will look at cold hardiness and chlorophyll fluorescence.

Seedling Quality Testing Facilities. This is the best information that I currently can find for the US and CANADA, but would like to know if there are others out there.

Company	Address	Types of Tests Offered			
		Morphology	Root Growth Capacity	Cold Hardiness	Others
Roseburg Forest Products	34937 Tennessee Rd. Lebanon, OR 97355 TEL: 541.259.2651 FAX: 541.259.3661 E-mail: mjalbrecht@msn.com	X	X	X	X
Nursery Technology Cooperative	Seedling Quality Evaluation Services OSU Dept. of Forest Science 321 Richardson Hall 3015 SW Western Ave. Corvallis, OR 97331 TEL: 541.737.6576 FAX: 541.737.1393 E-mail:SQES@orst.edu	X		X	
KBM Forestry Consultants	SQA Coordinator 349 Mooney Avenue Thunder Bay, ON CANADA P7B 5L5 TEL: 807.345.5445 ex. 34 E-mail: sgelleert@kbm.on.ca	X	X	X	X

Selected References

1. Mexal JG, Landis, TD. 1990. Target seedling concepts: height and diameter. In: Rose, R, Campbell SJ, Landis TD. eds. Target Seedling Symposium: proceedings, combined meeting of the western forest nursery associations; 1990 Aug 13-17; Roseburg, OR. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Gen. Tech. Rep. RM-200.: 37-51.

2. Rose R, Haase D L, Kroiher F, Sabin, T. 1997. Root volume and growth of ponderosa pine and Douglas-fir seedlings: a summary of eight growing seasons. Western Journal of Applied Forestry 12(3):69-73.

3. Wakeley PC 1954. Planting the Southern Pines. Agricultural Monograph No. 18. Washington, DC: USDA-Forest Service. 233 p.

4. Stone EC. 1954. Poor survival and the physiological condition of planting stock. In: Proceedings of the Forest Tree Nurserymen's Meetings. Placerville, CA: USDA Forest Service, Institute of Forest Genetics: 2-6.

5. Duryea ML. ed. 1985. Evaluating seedling quality: principles, procedures, and predictive abilities of major tests; 1984, October 16-18. Corvallis: Oregon State University, Forest Research Laboratory. 143 p.

6. Ferguson RB, Ryker RA, Ballard ED. 1975. Portable oscilloscope technique for detecting dormancy in nursery stock. General Technical Report INT-26. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 16 p.

Seedling Quality Tests: Root Growth Potential

by Gary A. Ritchie and Thomas D. Landis

History. The first published account of the relationship between new root growth and seedling quality can be found in the writings of Philip Wakeley. In the classic "Planting the Southern Pines" (1), he states that physiological seedling quality is related to "observations and measurements of new roots formed by seedlings during the first few weeks after planting". The person who originated the concept of the root growth potential test, however, was Edward Stone of the University of California at Berkeley. He potted nursery seedlings in one-gallon (3.8 l) cans and placed them in a greenhouse environment that promoted root growth. After 60 and 120 days, he washed the soil off the roots "to observe their root development". The seedlings were not rated for the number or length of new roots but were placed in two categories: seedlings that produced new roots or those that did not (2). Stone believed that this ability, later called the "root regenerating potential", was a robust indicator of seedling physiological quality.

Based on Stone's original research, other workers began developing and using this method of seedling assessment (3, 4). The first publication that ignited widespread interest in root growth potential as a seedling quality test was presented by Ritchie and Dunlap at an IUFRO meeting held in New Zealand in 1980 (5). A couple of years later, the newly-formed Nursery Technology Cooperative at Oregon State University sponsored a nursery workshop. The resultant proceedings (6) featured a chapter on Assessing Seedling Quality which contained a discussion and strong endorsement of the "Root Growth Potential" (RGP) test (7). Subsequently, the RGP test has been reviewed at least three more times (8, 9, 10) and has become the most popular and well-known test of seedling quality. It has been employed worldwide and its application and practical usefulness has been the subject of much discussion (11, 12), and even debate (13).

RGP Test Procedure. First, a 25- or 30-tree sample is drawn from a population of seedlings. These are then placed into an environment that promotes rapid root growth. After either 14 or 28 days the seedlings are removed and the root system is evaluated to determine the quantity of new roots produced. The result is then interpreted. Lets have at look at each step.

1. Sampling - Proper sampling is critical to effective RGP testing. If the sample is biased, the test results will also be biased. With nursery stock, the crop in question should first be divided into environmentally distinct units (*e.g.*, wet area, low area, heavy soil area, sandy area, etc) and a random sample then drawn from each unit. This is called "stratified random sampling". These samples can be pooled to obtain a crop "average". With seedlings in storage, sampling becomes more difficult. In theory, storage boxes should be randomly sampled, then seedlings randomly sampled from within the boxes. This can pose challenges, however, especially in large cooler or freezer units.

2. Test environment - This is particularly important because it must provide conditions that are near "optimum" for root growth (14). The temperature should be 66 to 68 °F (19°C to 20°C). The rooting medium should be well aerated, and there should be adequate light and long days. Because these factors will strongly affect test results it is important to maintain consistent conditions across tests.

Three types of test environments have been used for RGP testing:

1. Pot in Greenhouse. Most seedling quality testing facilities use this method in which seedlings are potted in one- or two- gallon (3.8 or 7.6 l) plastic pots filled with a well-drained artificial growing medium comprised of peat and perlite. The pots are kept well irrigated in a greenhouse for the duration of the testing period (9, 15).
2. Hydroponic. Seedlings are suspended with their roots in warm, aerated water. This method is no longer used because of poor aeration and algae growth.
3. Aeroponic. Seedlings are suspended in a closed chamber with warm water periodically misting the roots. USDA Forest Service nurseries still use this technique with good results. One benefit is that a rack of seedlings can be removed from the misting chamber during the test to monitor root development.

Evaluation. Once the test has been completed, new root growth must be quantified. Researchers have attempted to short-cut this tedious process using photography, dyes, volumetrics, and other approaches (9). Despite this, the tried-and-true "root count" technique has prevailed. This involves visually estimating the number of new roots greater than 0.4 in. (1.0 cm) long on the seedling. An experienced technician can do this in a few minutes. This count can be reported as a raw number (*e.g.*, 120 roots/seedling) or transformed into an index such as reported by Burdett (4) or Tanaka et al. (15) (Table 1). Root numbers and total root length are usually well correlated.

Table 1 - Root growth Index (RGI) scale developed by Tanaka and co workers (15) to quantify root growth in an RGP test.

Root Growth Index	Number of New Roots 1 cm or longer
0	No new roots
1	Some new roots
2	1-3
3	4-10
4	11-30
5	31-100
6	101-300
7	More than 300

Interpretation of the results of RGP tests remains challenging. A common mistake has been to assume that RGP results directly predict field performance. In other words, high RGP ensures high survival, while low RGP ensures low survival. This assumption is flawed because the outplanting environment has an overriding influence on performance (11, 12, 13, 14) (Figure 1). A more realistic view is that RGP testing is analogous to seed testing, which provides only a snapshot of the physiological viability of seeds at the time they are tested (10). No one would expect seed that had 95% germination in a seed test always to give 95%

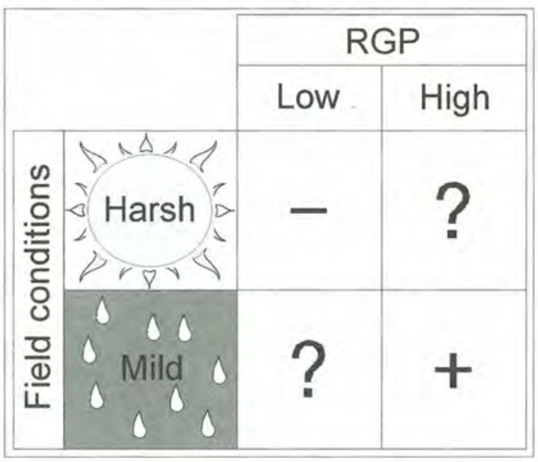


Figure 1. The failure of RGP to predict field performance consistently can be attributed to the interaction of RGP with field conditions. Performance of low-RGP stock planted on a harsh site, or high-RGP stock on a mild site is generally predictable. However, performance of high-RGP stock on harsh sites or low-RGP stock on mild sites is not (9).

emergence in the nursery. But if the test gave an abnormally low value it would indicate poor seed viability. This is the model to use when interpreting RGP test results. The RGP test is a "red flag" test that identifies stock lots that, for whatever reason, are not up to par.

The discovery that conifer seedlings, especially Douglas-fir, require mainly current photosynthate for new root growth (16, 17) has provided a rationale for the interpretation of RGP test results (Figure 2). In order for a seedling to grow new roots, the foliage must be photosynthesizing. Therefore, the stomata must be open and the leaves must be healthy. The phloem pathway to the roots must be intact and functioning properly, and the roots themselves must be metabolizing normally. If any of these systems has been compromised by, say, cold damage, water stress, disease, photodamage, or other agents, it will result in a depression of RGP. Therefore, RGP is a powerful integrator of many critical plant processes. When viewed in that light, despite its many shortcomings, RGP remains a robust, straight-forward and useful test of seedling viability.

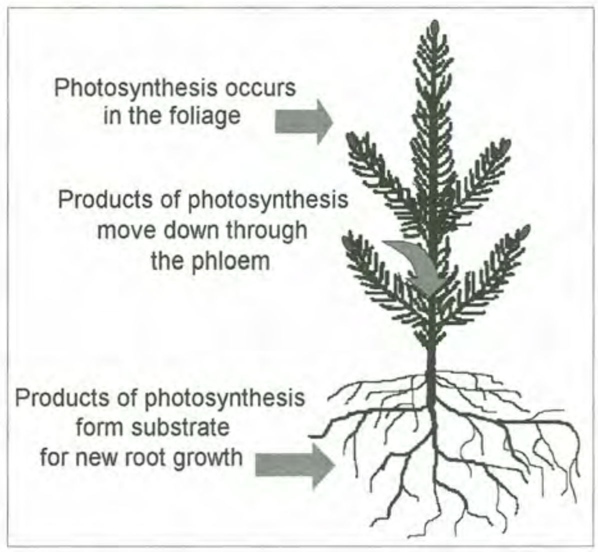


Figure 2. Root growth in many conifers depends on a supply of current photosynthate (16,17). Any factors that can depress photosynthesis or impede the flow of photosynthate from leaves to roots will result in reduced RGP.

Conclusions and Recommendations. RGP has been the most popular seedling quality test because it is intuitive, visual, and simple. Like any test, however, RGP has its uses and limitations:

1. RGP tests are a valuable test of *viability* - that is, are the seedlings alive at the time of the test?

2. RGP tests are a *relative* test of outplanting performance, as more roots are better than fewer roots. However, the numerical ratings used in standard RGP tests should not be interpreted as absolute values. There is no linear relationship between RGP ratings and outplanting perfomance. At best, a threshold numerical rating may be used to separate "good" from "bad" seedlings (15).

3. RGP tests are a "snapshot in time" because seedling quality will change right up until the stock is outplanted. Tests taken during lifting may not correlate with those taken at the time of shipping.

4. Handling after shipping and conditions on the outplanting site have an overriding effect on seedling performance. Poor seedlings may survive and grow just fine during a wet season but even good seedlings will die during a drought (Figure 2).

Selected References

1. Wakeley PC 1954. Planting the Southern Pines. Agricultural Monograph No. 18. Washington, DC: USDA-Forest Service. 233 p.

2. Stone EC 1955. Poor survival and the physiological condition of planting stock. Forest Science 1:90-94.

3. Jenkinson JL. 1975. Seasonal patterns of root growth capacity in western yellow pines. Washington, DC: Proceedings of Society of American Foresters. 75th National Convention. 9 p.

4. Burdett AN. 1979. New methods for measuring root growth capacity: their value in assessing lodgepole pine stock quality. Canadian Journal of Forest Research 9:63-67.

4. Ritchie GA, Dunlap JR. 1980. Root growth potential: its development and expression in forest tree seedlings. New Zeal. J. For. Sci. 10:218-248.

6. Duryea ML, Landis TD. eds. 1984. Forest Nursery Manual: Production of Bareroot Seedlings. Hingham, MA: Kluwer Academic Publishers. 384 p.

7. Ritchie GA. 1984. Assessing seedling quality. In Duryea ML, Landis TD. eds. Forest Nursery Manual: production of Bareroot Seedlings. Hingham, MA: Kluwer Academic Publishers: 243-259

8. Duryea ML. 1985. Evaluating Seedling Quality: principles, procedures and predictive abilities of major tests. For. Res. Lab., Oregon State Univ., Corvallis. 143 p.

9. Ritchie GA. 1985. Root growth potential: principles, procedures and predictive ability. In: Duryea, ML, ed. Evaluating seedling quality: principles, procedures and predictive ability of major tests. Corvallis, OR: Oregon State University: 93-104.

10. Ritchie GA, Tanaka Y. 1990. Root growth potential and the target seedling. In: Rose R, Campbell SJ, Landis TD. eds. Target Seedling Symposium: proceedings, combined meeting of the western forest nursery associations; 1990 /Aug 13-17; Roseburg, OR. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Gen. Tech. Rep. RM-200.: 37-51.

11. Binder WD, Skagel RK, Krumlik GK. 1988. Root growth potential: facts, myths, value? In: Landis, TD, ed. Proceedings, Combined Meeting of the Western Forest Nursery Associations; 1988, August 8-11; Vernon, BC. Ft. Collins, CO: Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-167: 111-118.

12. Sutton RF. 1983. Root growth capacity: relationship with field root growth and performance in outplanted jack pine and black spruce. Plant and Soil 71:111-122.

13. Simpson DG, Ritchie GA. 1997. Does RGP predict field performance? A Debate. New Forests 13:253-277.

14. Landis TD, Skakel SG. 1988. Root growth potential as an indicator of outplanting performance: problems and perspectives. In: Landis TD, ed. Proceedings, Combined Meeting of the Western Forest Nursery Associations; 1988, August 8-11; Vernon, BC. Ft. Collins, CO: Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-167:106-110.

15. Tanaka Y, Brotherton P, Hostetter S, Chapman D, Dyce S, Belanger J, Johnson B, Duke S. 1997. The operational planting stock quality testing program at Weyerhaeuser. New Forests 13:423-437.

16. van den Driessche R. 1987. Importance of current photosynthate to new root growth in planted conifer seedlings. Canadian Journal of Forest Research 17:776-782.

17. van den Driessche R. 1991. New root growth of Douglas-fir seedlings at low carbon dioxide concentration. Tree Physiology 8:289-295.

Micronutrients - Chlorine

By Thomas D. Landis and Eric van Steenis

Chlorine is the last of the micronutrients in our series, (Table1) and the most recent to be proven essential. It is an unusual element for several different reasons. Plant nutritionists can't agree on whether to use "chlorine" or "chloride" but, in most references, chlorine is the preferred usage. Chlorine has some very unusual properties. Although it can exist as a very toxic gas (Cl_2), chlorine is most commonly found in the combined state, such as common table salt (NaCl), or dissolved in water as the chloride ion (Cl^-). In container nurseries, the most common occurrence of Cl is the household bleach (sodium hypochlorite) used for sterilization (Figure 1).

Because Cl is ubiquitous in nature and easily taken up by plants, the original experiments to determine which elements were critical for plant growth required scientists to filter the water and even the air to remove the natural Cl. In fact, several plants have proven capable of obtaining their total Cl requirement from aerial deposition on their leaves. Chorine toxicity is actually a much more serious problem than deficiency under agricultural conditions.

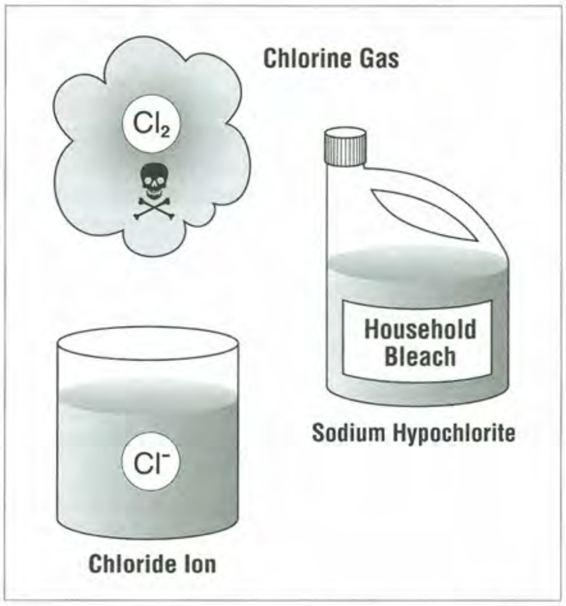


Figure 1 – Although chlorine exists as a toxic gas, the most common forms in the nursery environment are the chloride anion in irrigation water and fertilizer solutions and bleach (sodium hypochlorite).

Role in Plant Nutrition

In normal plant tissue, Cl concentrations can be in the range of most macronutrients but the amount actually required for growth is much less (Table 1). All the physiological functions of chlorine are still not clear but one that has been proven is its involvement in photosynthetic oxygen evolution. Its importance is inferred by the fact that Cl concentrations inside chloroplasts are almost 10 times higher than those

Table 1 - The seven essential micronutrients and their typical concentrations in seedling tissue

Element	Symbol	Average Concentration in Plant Tissue (%)	Adequate Range in Seedling Tissue (ppm)		Where and When Published
			Bareroot	Container	
Iron	Fe	0.01	50 to 100	40 to 200	Forest Nursery Notes: July, 1997
Manganese	Mn	0.005	100 to 5,000	100 to 250	Forest Nursery Notes: January, 1998
Zinc	Zn	0.002	10 to 125	30 to 150	Forest Nursery Notes: July, 1998
Copper	Cu	0.0006	4 to 12	4 to 20	Tree Planters' Notes: 49 (3)
Molybdenum	Mo	0.0001	0.05 to 0.25	0.25 to 5.00	Forest Nursery Notes: Winter 2001
Boron	B	0.002	10 to 100	20 to 100	Forest Nursery Notes: Summer 2001
Chlorine	**Cl**	**0.01**	**10 to 3,000**	**NA**	**This Issue**

measured in the rest of the leaf, and that photosynthesis is impacted negatively if chlorine is withheld.

Chlorine is involved in osmosis (the movement of water or solutes in and between cells). Because it is a common anion, Cl maintains the ionic balance necessary for plants to take up the many cationic mineral elements such as K^+, Ca^{++} and Mg^{++}. It also is important in maintaining turgor; for example, Cl^- regulates the stomates through the management of guard cell turgidity. In addition, Cl acts specifically as the accompanying anion with potassium during osmoregulation.

Chlorine also functions in nitrogen metabolism and disease suppression. It aids in the formation and conversion of certain amino acids and amides used for long distance nitrogen transport. Because it replaces NO_3^- as an osmotically active solute in root vacuoles, Cl facilitates nitrogen transport from the root to shoot. In this way, and by reducing NO_3^- uptake through direct competition, it has been shown to suppress numerous diseases of agricultural crops. This is because plants with low root nitrogen levels are less susceptible to high sugar pathogens such as certain root diseases.

Availability and Uptake

Chlorine in the earth's crust ranges from 0.02 to 0.05% and is found in many types of rocks. Most of the Cl in agricultural soils exists as soluble salts including NaCl, $CaCl_2$, and $MgCl_2$. Chlorine is found in many soil types and in most surface water because it is carried inland from the oceans and deposited in rain and snow (Figure 2). Annual Cl deposition ranges from 12 to 35 lbs/acre (13.5 to 39.2 kg/ha) and can exceed 100 lbs/acre (112 kg/ha) in coastal areas.

Chlorine ions will accumulate in soils wherever drainage is restricted or evapotranspiration exceeds precipitation. Excess Cl becomes a problem in soils irrigated with saline water and Cl is the principal anion extracted from saline soils. Cl toxicity can also become a problem when chloride salts are used for road deicing, from water softener effluent, and runoff from feedlots.

Being an anion, Cl is readily leached from soils and so is common in most groundwater. An analysis of the irrigation water of forest and conservation nurseries from the Intermountain Area of the Western US found that significant chlorine was found in the majority of locations (Table 2).

Chlorine is absorbed by plants as the Cl^- ion through roots and/or leaves, and is easily translocated through the plant. Most plants accumulate Cl in their tissues at levels much greater than the physiological requirement (Table 1).

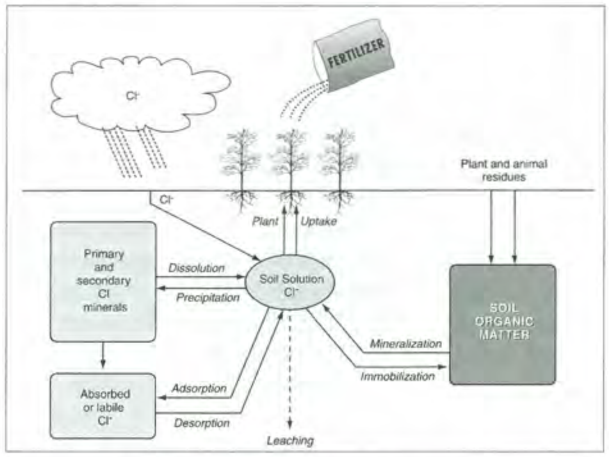


Figure 2 – Chlorine deficiency is rarely a problem in nurseries because it is a contaminant in rainfall and is also found in common soil minerals and multinutrient fertilizers.

Diagnosis of Deficiencies and Toxicities

Deficiency symptoms - There is no published information on Cl deficiency in forest and conservation plants. In agricultural and horticultural crops, symptoms include wilting of leaves, especially leaf margins, restriction of root elongation (stubby roots), chlorosis (yellowing) and bronzing.

Toxicity symptoms - Recognition of salt (sodium chloride) toxicity was made thousands of years before the discovery that chlorine was an essential mineral nutrient. Symptoms of Cl toxicity are more common in the literature than deficiency and include burning and rolling of leaf tips and margins, bronzing, premature leaf abscission and chlorosis. The most consistent symptom is reduced leaf size and stunting although this general symptom is of limited diagnostic value. Another thing that complicates diagnosis is that both sodium and chloride ions of common salt can induce toxic reactions. With citrus crops, it has been difficult to distinguish between the symptoms of sodium and chloride toxicity.

Chlorine Management

In forest and conservation nurseries, chlorine deficiency should not be a problem. Theoretically, it can only occur when the supply from the atmosphere and fertilizers is less than the amount lost through leaching and crop removal. Sandy soils irrigated with very pure water and located far inland are most vulnerable. Chlorine toxicity can be more of a problem in semi-arid environments where high evapotranspiration leads to salt buildup in the soil.

Table 2 - Chloride level in irrigation water of Intermountain Area nurseries

Nursery	Location	Chloride (Cl^-) in ppm*
Albuquerque	Albuquerque, NM	0.2
Bessey	Halsey, NE	0.0
Big Sioux	Watertown, SD	0.2
Colorado State	Ft. Collins, CO	0.1
Lincoln-Oakes	Bismarck, ND	1.3
Lincoln-Oakes	Oakes, ND	0.3
Mountain Valley	Lincoln, NM	1.2
Mt. Sopris	Carbondale, CO	0.0
Nevada State	Tule Springs, NV	0.1
Nevada State	Washoe Valley, NV	0.2
Oklahoma State	Norman, OK	0.2
Towner	Towner, ND	0.1
Utah State	Draper, UT	0.5
*The toxicity threshold for chloride is 70 ppm		
Source: Landis, 1982		

Monitoring - Chlorine levels can be requested as part of normal soil testing. The interest is probably more about toxic levels rather than concern about a deficiency. When testing irrigation water, chloride should always be requested, as it is one of the three toxic ions. The generally accepted toxicity level for chloride is around 70 ppm (Table 2).

As far as tissue testing goes, chloride concentrations of 0.5 to 2.0% can begin to cause growth reductions in sensitive species. Tissue levels in tolerant plants can reach 4.0 % or more without obvious symptoms, although subtle growth reductions probably occur before this point. Most commercial conifers are very susceptible to all salt ions but native plants from arid environments can be expected to be much more tolerant.

Fertilization - Chlorine is so common in the air, soil, and water that fertilization is almost never required. Besides, Cl is a common contaminant in many blended multi-nutrient fertilizers, usually from potassium chloride.

Toxicity - Because it is available to the plant from so many sources, there is more concern about Cl toxicity than deficiency. Excessive Cl can be harmful to most forest and conservation species but plants from arid zones will display much more tolerance. Nurseries in arid or semiarid climates should be most vigilant and have their irrigation water tested. If the irrigation water is not high in Cl, then toxicity will not occur in container nurseries. Bareroot nurseries using saline irrigation water should employ periodic leaching of the soil profile to prevent salt buildup on the surface. This is particularly important with the raised beds used in bareroot nurseries because salts can wick to the surface and cause crusts. In addition to the possibility of direct Cl toxicity, there is more danger from osmotic desiccation from high salinity of the soil water.

Conclusions and Recommendations

Chlorine is an interesting and essential mineral nutrient. In nurseries, chlorine deficiency should not be a problem and could only occur when the supply from the atmosphere is less than that lost through leaching and crop removal. Sandy soils irrigated with very pure water and located far inland are most vulnerable. Chlorine toxicity can be more of a problem in semi-arid environments where high evapotranspiration leads to salt buildup in the soil. Irrigation water should also be tested to make certain that high salts and Cl are not a problem. In general, forest and conservation nurseries need not worry about supplying Cl to their crops. If the irrigation water is not high in Cl, then toxicity will not occur in container nurseries but bareroot nurseries in arid or semiarid regions should be aware about the possibility of salt buildup in their soils.

Sources:

Chapman HD. 1966. Chlorine. In: Chapman HD ed. Diagnostic criteria for plants and soils. Riverside, CA: Homer Chapman, 830 South University Drive: 98-135.

Epstein E. 1972. Mineral nutrition of plants: principles and perspectives. New York: John Wiley and Sons. 412 p.

Havlin JL, Beaton JD, Tisdale SL; Nelson WL. 1999. Soil Fertility and Fertilizers: An Introduction to Nutrient Management. 6th Edition. Upper Saddle River, NJ: Prentice Hall. 499 p.

Landis TD. 1982. IN: Huber RF comp. Proceedings of the 1981 Intermountain Nurserymen's Association meeting. Information Report NOR-X-241. Edmonton, AL: Canadian Forestry Service, Northern Forest Research Centre: 60-67.

Marschner H. 1986. Mineral Nutrition of Higher Plants. San Diego, CA: Academic Press, Inc. 674 p.

Stout PR. 1972. Introduction. IN: Micronutrients in Agriculture. Madison, WI: Soil Science Society of America: 1-5.

Large Containers - Strategies for Growing Large Seedlings for Native Plant Restoration, Part II

By David Steinfeld and Thomas D. Landis

In the Summer, 2002 issue of FNN we began a discussion of how to grow large seedlings for native plant restoration by talking about propagation environments, choosing the right container, and designing growing schedules. In this issue, we will discuss the cultural aspects of growing forest and conservation plants in large containers. By our definition, large containers are those with volumes greater than 30 in^3 (492 cc) and going up to 5 gal (18.9 l). Complete propagation protocols for growing a variety of trees and shrubs in large containers are available on the Native Plant Network (http://www.nativeplantnetwork.org/network/search.asp, select Company/Nursery Name, such as J. Herbert Stone).

Large containers have several characteristics that make them different from the typical small volume container stock. First of all, most large containers are propagated by transplanting rather than by direct sowing. Typically, smaller 4 to 10 in^3 (66 to 164 cm^3) container seedlings are hand transplanted into the larger container. Transplants, by their very nature, are hardier than young seedlings and consequently require less care. Also, by their sheer volume of growing media, large containers have a reservoir of water and mineral nutrients and their roots are buffered against extreme temperatures (Figure 1). Although these factors make growing large container stock less demanding, there are some different cultural requirements that we will discuss in this section. Forest nurseries have traditionally not had much in common with ornamental container nurseries but the advent of large container production makes their technology more applicable.

Filling Large Containers. Since seedlings must remain in large containers for one to three years, the types of growing media and the methods of filling and handling containers become important considerations.

All sizes of containers require artificial growing media and soil should never be considered. Although peat moss, vermiculite, and perlite are standard components for smaller containers, larger sizes require a different type of growing media. The amount of aeration porosity is particularly important. Materials such as vermiculite can compress and uncomposted sawdust and bark can shrink over time, reducing the amount of aeration porosity. In addition, the vigorous roots of large seedlings grow into macropores further reducing the porosity. Due to the large volumes of growing media required to fill a crop of large containers, cost also becomes a more serious consideration.

***Figure 1** The large volume of growing media in this 2 liter container buffers the seedling from extreme stresses.*

Because of the different physical, chemical, and biological characteristics of organic and inorganic components, growing media should be a mixture of organics and inorganics. Stable materials, such as composted sawdust, bark, perlite, and pumice are popular components for larger containers. The nursery literature is full of reports of composted organic matter for growing media. "Compost" does not have a standard definition or quality specifications, however, and can vary considerably from batch to batch. Therefore, growers should always test any new growing media component before using it operationally. The J.H. Stone Nursery uses a growing media composed of 40% pine-fir bark: 35% *Sphagnum* peat moss: 25% pumice for all tree and shrub species they grow. The bark and pumice are both screened to "3/8 inch minus" (>0.95 cm) size.

Filling containers can either be done mechanically or by hand. There are several automated pot fillers available but their high cost limit their use to large production nurseries. At the J.H. Stone Nursery, all sizes of large containers are filled by hand which allows easy control of the amount per container and degree of compaction. A stock tank or other large storage bin is an ideal working area because you can store a supply of media and fill containers with minimal waste and contamination. Each container is filled to the top and them tamped lightly several times to assure that there are no large air pockets. The media should not be compressed excessively or aeration porosity will be severely reduced.

Fertilization Methods. Large container stock can be fertilized in several ways:

1. Soluble fertilizer injected through the irrigation system (fertigation)
2. Controlled-release fertilizer incorporated in the growing media
3. Controlled-release fertilizer applied as a top-dressing

Although fertigation through fixed overhead or traveling boom irrigation systems is an easy way to ensure uniform fertilizer application to small containers, more than half of the soluble fertilizer can be lost between larger containers. The resultant runoff can lead to serious pollution of surface runoff and groundwater, and lately, this is an increasingly serious environmental concern in nurseries. Therefore, fertilization by incorporation and top dressing are usually recommended.

Incorporation of fertilizers into the growing media is increasingly popular because it ensures that a base level of mineral nutrients will be available when the seedlings start to grow. It is also very cost effective because no application equipment is needed. Most commercial growing media suppliers will custom mix any fertilizer formulation and they have the specialized incorporation equipment to assure that each container receives an equal amount of fertilizer. The large volume of media per container is a real advantage in this respect because this facilitates uniform distribution.

The other fertilization option is to top dress each container with fertilizer after seedling emergence or transplanting. This is the preferred technique at J.H. Stone Nursery and large containers are top dressed once per season with a commercial fertilizer that is a mixture of fast and slow release nutrients. The rate of fertilization in large containers will vary on many factors, such as species, cation-exchange-capacity of the media, and rate of irrigation.

Top-dressed fertilizers must have a constant supply of irrigation water to move the released nutrients into the media. Well maintained and designed fixed or boom irrigation systems will deliver fertilizer uniformly to the root system. Single emitter drip systems do not work well but drip stick emitters disperse water over the media surface and help overcome this problem. Top-dressing in a subirrigation system is ineffective because water only moves up through capillary action.

Types of Fertilizers. The typical commercial fertilizer for container stock provides mineral nutrients in readily soluble forms. As mentioned before, fertigation is less practical for large stock and so different fertilizers are needed.

There are a wide variety of new "slow-release" (SRF) and "controlled release" fertilizers (CRF) that are ideal for large containers (Figure 2). Controlled-release fertilizers are the most recent innovation and are characterized by coatings (acrylic resins, polyethylene, waxes and sulfur) that gradually release nutrients over time. In addition to the elemental analysis of the

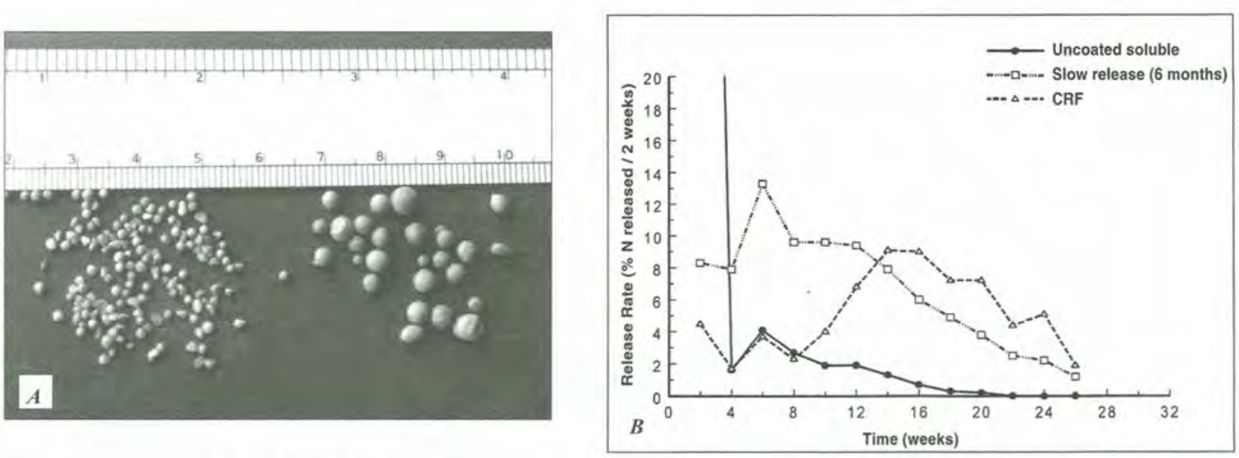


Figure 2 – Many brands and formulations of controlled release fertilizers (CRF) are available (A), and are preferred for large containers because of their extended release pattern (B).

fertilizer, SRF and CRF bags generally indicate a period of nutrient release. In general, temperature, moisture, coating type and thickness are the main factors affecting nutrient release of CRF, whereas SRF are more affected by fertilizer particle size, moisture, and microorganisms present in the medium.

One drawback to the use of SRF or CRF is that monitoring becomes more difficult than with fertigation. Fertilizer salts will build up in any fertilization system and must be flushed from the containers before salts levels become toxic to the seedlings. The most critical periods are during the warm periods of the year, when higher rates of fertilizer salts are being released from CRF. Deep irrigations will lower salt concentrations to acceptable levels. Determining when to flush the containers can be accomplished by periodically testing the salt levels of container leachate using a conductivity meter. Conductivity readings of greater than 4.0 mS/cm (mcmhos/cm) are an indication that flushing with plain water is required.

Irrigation. There are four basic irrigation systems used in large container production - 1) fixed overhead , 2) traveling boom, 3) drip, and 4) ebb and flow. Each system has its advantages and disadvantages as displayed in Table 1.

Fixed Overhead Irrigation - Fixed overhead irrigation systems are composed of a set of elevated sprinkler heads spaced in a pattern to obtain a uniform water distribution. The overall advantage of this system is that it is inexpensive to set up and simple to operate. Its drawbacks are the high amount of wasted water (over 50% of the water can fall between the containers), the higher potential for leaf diseases, and the potential for poor irrigation water distribution from container to container and within container (see article on Testing Irrigation System Uniformity in the Summer 2002 issue of FNN).

Traveling Boom - The traveling boom is composed of a set of nozzles spaced evenly across an irrigation supply line. The line is motorized and moves back and forth on a track as it irrigates. This system has a greater uniformity in the distribution of water than the fixed system but a considerable amount of water is still wasted between containers. The disadvantages to this system are the purchase price of the booms, higher maintenance costs and the potential for leaf disease.

Drip Irrigation - This irrigation method is impractical with smaller containers but becomes more feasible with the larger sizes. The drip irrigation system delivers water to each container through a small emitter attached to flexible tubing. The system conserves water since only the container is irrigated and not the foliage or the spaces between containers. Soluble fertilizers can be injected into the system for greater flexibility. The downside to drip irrigation is the large number of small parts to purchase and maintain. The emitters must be checked frequently (up to twice a month) and cleaned or replaced if they are not functioning properly. Water distribution within the container can also be a problem if the size of the container opening is large and the media is very well drained. Using spray stick emitters can help solve this problem.

Table 1 - Comparison between irrigation systems

	Irrigation Systems			
Criterion	***Fixed***	***Drip***	***Boom***	***Subirrigation***
Frost Protection	++	NA	NA	NA
Water Distribution	-	+	+	++
Leaf Disease	- -	++	- -	++
Temperature Control	++	NA	++	NA
Water efficiency	- -	++	-	+
Flexibility	++	-	+	+
Setup Costs	++	-	- -	- -
Maintenance Costs	+	-	-	+
++ Good, + Fair, - Poor, - - Very Poor				

Subirrigation - Again, subirrigation is rarely used in conventional container facilities but has application with larger stock types. This category includes all irrigation systems where water is applied to the base of the containers. In ebb-and-flow systems, containers are placed in a confined area with an impermeable floor and perimeter and water is periodically flooded into the compound. Mat irrigation consists of containers sitting on a permeable fabric, which is supplied with water. In all types of subirrigation, water is drawn up through the media by capillarity until the media is thoroughly moistened. One of the primary benefits of subirrigation is the very high uniformity in water distribution between containers. The potential for foliar diseases is also much less. One drawback is that irrigation water quality must be very good or salts will begin to accumulate in the growing media. Although subirrigation will probably never be used for routine container culture, it has good potential for riparian species like willows and cottonwoods that require large quantities of water and are very susceptible to foliar diseases under nursery conditions.

Irrigation Schedules - Frequency of irrigation will depend on climate, size of the container, seedling age and species requirements. Grouping containers by their water requirements reduces the potential that certain seedlots will be over or under irrigated. Daily monitoring of evaporative demand and weighing containers will help determine the frequency of irrigations. The duration of irrigations should be sufficient enough to allow some water to drain through the bottom of the containers. This will assure that the media is thoroughly moistened and will reduce the buildup of salts. Observing water coming out of the drain holes, weighing containers and examining the wetting front in select container are methods to determine if the length of irrigations are sufficient. Buildup of salts can occur during the growing season around the drain holes of the containers and is another indicator that irrigations have not been long enough to remove salts from the containers.

Conclusions and Recommendations. The demand for larger stock types is creating a market for growing plants in large containers. Due to their large volume of growing media, large container stock are less culturally demanding than conventional container seedlings. Growing media must be more stable and designed to promote drainage and aeration. Fertilization and irrigation will be different for large containers and growers must consider the unique requirements and be innovative in their management. Many cultural procedures can be adopted and modified from ornamental nurseries so growers should visit local facilities and attend regional nursery meetings and trade shows.

Sources

Appleton, B. Past and future – container now provide more functions than holding media and roots. NM Pro 17(10): 71-76.

Cabrera RI. Using Slow- and Controlled-release Fertilizers in Container Nursery Crops. URL: http://aesop.rutgers.edu/~Floriculture/publications/florpub.htm (Accessed 01-02-2002).

Jacobs DF, Rose R, Haase DL. In Press. Incorporating controlled-release fertilizer technology into outplanting. In: Riley LE, Dumroese RK, Landis TD, technical coordinators. National Proceedings: Forest and Conservation Nursery Associations—2002. Ogden (UT): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P. 8 p.

Landis TD, Tinus RW, McDonald SE, Barnett JP. 1989. The Container Tree Nursery Manual, Volume 4: Seedling Nutrition and Irrigation. Agric. Handbk. 674. Washington, DC: USDA Forest Service. 119 p.

Landis TD, Tinus RW, McDonald SE, Barnett JP. 1990. The Container Tree Nursery Manual, Volume 2: Containers and Growing Media. Agric. Handbk. 674. Washington, DC: USDA Forest Service. 88 p

Whitcomb, CE. Plant production in containers. 1984. Stillwater, OK: Lacebark Publications. 633 p.

Equipment, Products, and Services

Frost Protection Fabrics - An Alternative to Overhead Irrigation

By David E. Steinfeld

Figure 1. Frost protection blanket on 2+0 seedling beds at Stone Nursery

The most common way to protect seedlings from unseasonably cold weather events is the use of overhead irrigation. Because heat is released when water freezes, seedling tissue is protected as long as water is being applied. Although sprinkler protection is effective and relatively inexpensive, there are several drawbacks. The most important is that, if the irrigation rate is inadequate or parts of the system fail (sprinkler nozzles freeze), then the damage incurred can be greater than having provided no protection at all. Another drawback is that several consecutive nights of frost protection will create saturated soils, nutrient leaching, and surface runoff. Last, but perhaps the most important drawback, is the impact on nursery workers. If you've never had the pleasure of spending your nights running through the dark to keep the sprinklers from freezing up, this can be very tiring and potentially hazardous. If you'd like more information, an article on "Frost Protection with Irrigation" can be found in the October 1988 issue of FNN.

There are other options for protecting succulent seedlings from cold injury. One alternative is the use of frost protection fabrics, sometimes referred to as frost blankets or frost cloth. Although frost fabrics have been employed in the fruit and vegetable industries for years, they have not been used extensively in the forest and conservation nurseries. The basic principal is that the coverings block radiant heat loss from seedlings and soil surface, thereby protecting crops from freezing temperatures. During November, 2002, the J.H. Stone Nursery evaluated how well two types of frost protection fabrics succeeded in keeping seedling beds warmer than ambient air temperatures on cold evenings.

The Study. We selected a 2+0 Douglas-fir seedling lot and tested two weights of fabric: medium (4 oz/yd^3 = 149 g/m^3) and heavy (6 oz/yd^3 = 224 g/m^3). For each plot, a 15' by 20' (4.6 to 6.1 m) section of fabric was placed over two seedling beds and pinned into the soil (Figure 1). Prior to installing the cover, iButtons (small recording thermometers - see FNN Winter 2001 issue) were positioned at three locations in the seedling bed of the two treatments and control: in the center of the bed at 12" (30.5 cm) height, on the north side of the bed at

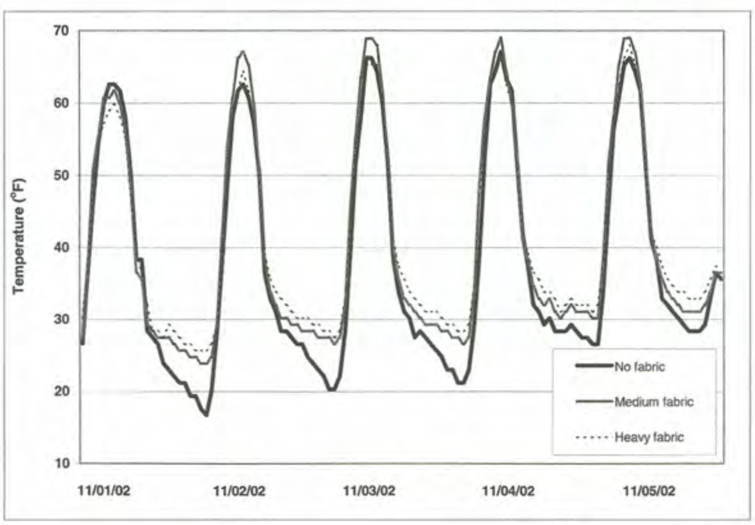


Figure 2. Temperatures measured at 6" (15.2 cm) height in 2+0 Douglas-fir seedling beds under two weights of frost protection fabrics

6" (15.2 cm) height, and in the middle of the bed on the soil surface. The frost protection fabric was applied at the beginning of November 2002 and removed at the end of the month at which time the iButtons were removed and downloaded.

Results. We were fortunate to have installed the administrative study at the beginning of a rare cold event for that time of year. Figure 2 shows diurnal temperatures over the cold five-day period. On all nights, the medium and heavy weight protection fabric retained heat longer than seedling beds without fabric covering. As the ambient air temperature dropped through the evening and into the early morning, temperature differences between covered seedlings and non-covered seedlings widen. On the coldest nights, the differences were as much as 8 °F (4.4 °C) as compared to temperatures in uncovered seedling beds. This pattern also showed up on another cold snap later in November.

The frost protection fabrics tested in this study could have given protection to non-hardy seedlings. Fortunately, the majority of the 2+0 seedlots at Stone Nursery were already hardy to temperatures below 20 °F (- 6.6 °C) and even the control seedlings in this study were not injured. The nursery did attempt to frost protect the 1+0 and 1+1 Douglas-fir stock types, which were known to be less hardy. After the first evening, however, the sprinkler irrigation was discontinued because of the difficulty of keeping the nozzles ice-free, the saturated soil conditions, and the heavy ice buildup on the seedlings. The use of frost protection fabrics, on these seedlots, would have been an effective substitution to frost irrigation.

Costs. The primary expense in using frost protection fabric is the initial cost of the materials and the labor of installation and removal. The fabric costs around \$0.06 per ft^2 (\$0.0056/m^2) for the medium weight fabric. Most brands of fabric are UV treated and expected to last from three to five years. Averaged over two crops, the material would cost about \$1.50 per thousand seedlings. The labor costs for applying and removing the fabric depend on how the material is handled. The Colorado State Nursery has developed a mechanized handling system to efficiently and economically apply and remove fabric to bareroot seedbeds (Figure 3).

These fabrics have other uses besides fall and spring frost protection. They can also be used to cover fall-sown seed, to protect from bird predation or lengthen the growing season. Species such as sugar pine and western white pine need long stratification periods and if sown in the fall and covered with frost protection fabric the seed would meet these chilling requirements naturally. In the spring, seedlings would be protected from bird predation, which is a common problem for both species. For nurseries looking to produce larger 1+0 seedlings, covering seedbeds with fabric will allow nurseries to sow earlier, thereby lengthening the growing season.

Photo courtesy Randy Moench

***Figure 3:** Removing frost protection fabric from 1+0 seedling beds at Colorado State Nursery*

The following companies supply frost protection fabrics:

Name: Dewitt Company
Website: www.dewittcompany.com
TEL: 800.888.9669

Name: Synthetic Industries
Website: www.sind.com/tech.html
TEL: 800.635.2308

Name: Arthur Enterprises
Website: www.harrisind.com/fpfab.htm
TEL: 714.898.1311

Sources

Morgan D. 1997. Seedling survival. Nursery Management and Protection 13(10): 37-39.

Perry KB. 1998. Basics of frost and freeze protection of horticultural crops. HorTechnology 8(1): 10-15.

Moench RD. 1994. Use of frost fabric as a seedbed mulch and frost protection method. In: Landis TD, Dumroese RK. tech. cords. National Proceedings, Forest and Conservation Nursery Associations. Gen. Tech. Rep. RM-257. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station:166 – 169.

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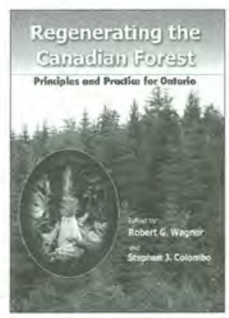
Picks of the Litter - Highlighting Noteworthy Publications

In past issues of FNN, I have tried to point out noteworthy books or articles as Special Orders (SO) in the New Nursery Literature section. SO publications were either too large or too expensive for us to provide free copies so ordering instructions were provided. This listing seemed to generate more confusion than anything, however, so I'm taking a different approach. Starting with this issue, I'm going to create a separate section called "Picks of the Litter". (For you lovers of puns, "litter" refers to the published "literature"). Ordering information will be provided following each listing so please don't write and ask for free copies.

Regenerating the Canadian Forest: Principles and Practice for Ontario
R.G. Wagner and S.J. Colombo, editors.
Fitzhenry & Whiteside Limited, Markham, Ontario, CANADA



This book is intended as a guide for nursery managers, foresters, biologists, students, and others who need a reference that covers the broad field of reforestation. Although it is oriented to Eastern Canada, this book contains basic information that would be useful to nursery managers and reforestation specialists anywhere. Of particular interest to nursery managers are chapters covering bareroot seedling production, container stock production, seed biology and management, seedling quality assessment, and stock handling and planting. For nursery managers interested in how their tree seedlings fit into the bigger picture of reforestation this book also provides information on topics such as stand management, site preparation, vegetation control, and natural regeneration.

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Conifer Cold Hardiness
Edited by Francine J. Bigras and Stephen J. Colombo
Kluwer Academic Publishers

While I'm pitching Steve's books, I might as well mention another new one that is already a classic. "Conifer Cold Hardiness" is a compilation of articles on all aspects of the subject. Sections include Ecology and Physiology, Acclimation and Deacclimation, Seedling Production and Reforestation, Impacts of Biotic and Abiotic Factors, Methods and Analysis of Cold Hardiness, and Species Examples. Chapter 9 on "Influence of nursery cultural practices on cold hardiness of coniferous forest tree seedlings" is an excellent review. Other chapters discuss the specifics of Scots pine (*Pinus sylvestris*), red spruce (*Picea rubens*), yellow-cedar (*Chamaecyparis nootkatensis*), and radiata pine (*Pinus radiata*).

Price: $235 (U.S.)

Order From: Any book seller

Bareroot Production

1. Early spring frost protection for fall-sown maple seedlings. Buzzo, R. International Plant Propagators' Society, combined proceedings 2001, 51:271. 2002.

Business Management

2. How's the weather? Rafter, D. Digger 46(9):41, 42, 44. 2002. More than a conversation starter, forecasting services help nurseries get a jump on the weather and protect crops.

3. Safety first Mauschbaugh, A. J. American Nurseryman 196(6):35-37. 2002. An insurance professional offers adivce on how to help protect your employees and operation from harm.

4. Weaving your web. Shew, M. A. American Nurseryman 196(6):42-45. 2002. A well-designed Web site can be one of your hardest working employees and it's available 24 hours a day, 7 days a week.

Container Production

5. Applying accelerated growth production practices to American chestnut (*Castanea dentata*). Harpster, T. L., Sellmer, J. C., and Kuhns, L. J. International Plant Propagators' Society, combined proceedings 2001, 51:523-525. 2002.

6. Automatic controlled water table irrigation for container production. Buxton, J. W. and McNiel, R. E. International Plant Propagators' Society, combined proceedings 2001, 51:495-499. 2002.

7. Bracing for a cold one. Nelson, J. Digger 46(9):36, 39-40. 2002.

8. BundleUP: using appropriate irrigation techniques and protective coverings can save plants during a long or hard freeze. Bilderback, T. American Nurseryman 196(7):59-61. 2002.

9. Container production innovations. Haman, D. Z., Irmak, S., and Yeager, T. H. American Nurseryman 196 (7):54-56. 2002. A new multipot box production system for container plants may decrease the time it takes to grow a plant, as well as use less water. It collects water that falls between containers and makes it available whenever plants need it.

10. © Copper coated polybags improve seedling morphology for two nursery-grown Mexican pine species. Aldrete, A., Mexal, J. G., Phillips, R., and

Vallotton, A. D. Forest Ecology and Management 163 (1-3):197-204. 2002.

11. © Effect of CCC and daminozide on growth of silver birch container seedlings during three years after spraying. Luoranen, J., Rikala, R., and Aphalo, P. J. New Forests 23(1):71-80. 2002.

12. Hydroponic systems. Steyn, J. M. and de Plessis, H. F. International Plant Propagators' Society, combined proceedings 2001, 51:49-50. 2002.

13. Incident irradiance and cupric hydroxide container treatment effects on early growth and development of container-grown pawpaw seedlings. Pomper, K. W., Layne, D. R., and Jones, S. C. Journal of the American Society for Horticultural Science 127 (1):13-19. 2002.

14. Programmed Plants(TM): a new approach to the production of cell-grown (containerised) tree seedlings. Thompson, S. International Plant Propagators' Society, combined proceedings 2001, 51:247-250. 2002.

15. Seedling development: the critical first days. Whitcomb, C. International Plant Propagators' Society, combined proceedings 2001, 51:610-614. 2002.

16. Survey of container nursery irrigation practices in Georgia. Garber, M. P., Ruter, J. M., Midcap, J. T., and Bondari, K. HortTechnology 12(4):727-731. 2002.

17. Using water reservoir containers to produce plants for wetlands sites. Svenson, S. E. International Plant Propagators' Society, combined proceedings 2001, 51:287-291. 2002.

SO. Growing longleaf pine in containers - proceedings of workshops 1999 and 2001. Barnett, J. P., Dumroese, R. K., and Moorhead, D. J. USDA Forest Service, Southern Research Station, General Technical Report SRS-56. 63 p. 2002. ORDER FROM: USDA Forest Service, Southern Research Station, P.O. Box 2680, Asheville, NC 28802. Free.

Diverse Species

18. © Co-limitation of first year Fremont cottonwood seedlings by nitrogen and water. Adair, E. C. and Binkley, D. Wetlands 22(2):425-429. 2002.

19. Colorado Native Plant Survey -- voices of the green industry. Potts, L. E., Roll, M. J., and Wallner, S. J. Native Plants Journal 3(2):121-125. 2002.

20. Commercial production of American ginseng (*Panax quinquefolius* L.). Hsu, P. C. Native Plants Journal 3(2):106-108. 2002.

21. Conservation of species by protective marking. Corbin, J. E. Native Plants Journal 3(2):98-99. 2002.

22. Cutting requirements for propagation of the endangered species, *Clematic socialis*. Bruner, L. L., Eakes, D. J., Sibley, J. L., Morton, C. M., Knight, P. R., and Cain, J. J. International Plant Propagators' Society, combined proceedings 2001, 51:629-633. 2002.

23. Effect of gibberellic acid and standard seed treatments on mountain snowberry germination. Rosner, L. S., Harrington, J. T., Dreesen, D. R., and Murray, L. Native Plants Journal 3(2):155-162. 2002.

24. Effect of seeding date on establishment of native grasses. Meyer, M. H. and Gaynor, V. A. Native Plants Journal 3(2):132-138. 2002.

25. © Enhancing the early performance of the leguminous shrub *Retama sphaerocarpa* (L.) Boiss.: fertilisation versus *Rhizobium* inoculation. Valladares, F., Villar-Salvador, P., Dominguez, S., Fernandez-Pascual, M., Penuelas, J. L., and Pugnaire, F. I. Plant and Soil 240:253-262. 2002.

26. From seed to seed: producing native grass and wildflower seed for the National Park Service. Kujawski, J. L. International Plant Propagators' Society, combined proceedings 2001, 51:381-382. 2002.

27. © Germination and establishment of halophytes on brine-affected soils. Keiffer, C. H. and Ungar, I. A. Journal of Applied Ecology 39(3):402-415. 2002.

28. Home grown: a California grower makes an effort to restore the state to its original splendor by growing only California natives. Flahardy, C. American Nurseryman 196(7):36-38, 40, 42. 2002.

29. Improving seed germination of *Salicornia rubra* (Chenopodiaceae) under saline conditions using germination-regulating chemicals. Khan, M. A., Gul, B., and Weber, D. J. Western North American Naturalist 62(1):101-105. 2002.

30. Mountain lady's slipper (*Cypripedium montanum*): establishment from seeds in forest openings. Huber, A. G. Native Plants Journal 3(2):151-154. 2002.

31. Native grass seed germination. Dawson, I. and Winder, S. International Plant Propagators' Society, combined proceedings 2001, 51:138-141. 2002.

32. The Native Plants website: an on-line source of propagation information. Landis, T. D. and Dumroese, R. K. International Plant Propagators' Society, combined proceedings 2001, 51:261-264. 2002.

33. Palms of northeastern Mexico. Schoenfeld, C. M. Native Plants Journal 3(2):126-131. 2002.

34. © Physical dormancy in *Geraniaceae* seeds. Meisert, A. Seed Science Research 12(2):121-128. 2002.

35. Propagation of 4 Florida coastal dune species. Thetford, M. and Miller, D. Native Plants Journal 3 (2):112-120. 2002.

36. Propagation of four Florida coastal dune species by stem cuttings. Thetford, M. and Miller, D. International Plant Propagators' Society, combined proceedings 2001, 51:634-638. 2002.

37. Propagation of jojoba (*Simmondsia chinensis* Schneid.) by tip cuttings. Ollerenshaw, P. J. and Dunstone, R. L. International Plant Propagators' Society, combined proceedings 2001, 51:153-155. 2002.

38. Propagation of the endangered legume *Amorpha nitens* and the common shrub *Amorpha fruticosa*. Navarrete-Tindall, N. E., Van Sambeek, J. W., Coggeshall, M. V., and McGraw, R. L. International Plant Propagators' Society, combined proceedings 2001, 51:424-429. 2002.

39. Regeneration of triangle-leaf bursage (*Ambrosia deltoidea*: Asteraceae): germination behavior and persistent seed bank. Bowers, J. E. Southwestern Naturalist 47(3):449-453. 2002.

40. Relationship between thermal shock and germination in five Mediterranean shrubs. Valbuena, L., Luis-Calabuig, E., and Tarrega, R. IN: Fire and biological processes, p. 93-98. L. Trabaud and R. Prodon, eds. Backhuys Publishers. 2002.

41. Rescuing the near dead: propagation for conservation. Staniforth, M. International Plant Propagators' Society, combined proceedings 2001, 51:206-212. 2002.

42. © Responses of dormant heather (*Calluna vulgaris*) seeds to light, temperature, chemical and advancement treatments. Thomas, T. H. and Davies, I. Plant Growth Regulation 37(1):23-29. 2002.

43. Role of warm stratification in promoting germination of seeds of *Empetrum hermaphroditum* (Empetraceae), a circumboreal species with a stony endocarp. Baskin, C. C., Zackrisson, O., and Baskin, J. M. American Journal of Botany 89(3):486-493. 2002.

44. Seed cleaning. Truscott, M. International Plant Propagators' Society, combined proceedings 2001, 51:267. 2002. Of Sambucus.

45. © Seed germination and dormancy in eastern gamagrass. Springer, T. L., Dewald, C. L., and Aiken, G. E. Crop Science 41(6):1906-1910. 2001.

46. © Seed germination in the Great Basin halophyta *Salsola iberica*. Khan, M. A., Gul, B., and Weber, D. J. Canadian Journal of Botany 80(7):650-655. 2002.

47. © Stratification in switchgrass seeds is reversed and hastened by drying. Shen, Z.-X., Parrish, D. J., Wolf, D. D., and Welbaum, G. E. Crop Science 41 (6):1546-1551. 2001.

48. Stratification of American ginseng seeds -- problems and solutions. Li, T. S. C. Native Plants Journal 3(2):109-111. 2002.

49. © Switchcane: propagation and establishment in the southeastern United States. Platt, S. G. and Brantley, C. G. Restoration and Management Notes 11 (2):134-137. 1993.

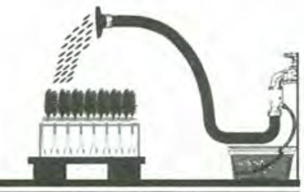
50. Tassel ferns and clubmosses. McAuliffe, J. International Plant Propagators' Society, combined proceedings 2001, 51:174-176. 2002.

51. © Tissue culture of goldenseal (*Hydrastis*

canadensis **L.)** Hall, K. C. and Camper, N. D. In Vitro Cellular and Developmental Biology - Plant 38(3):293-295. 2002.

52. Wild American ginseng. Anderson, R. C., Anderson, M. R., and Houseman, G. Native Plants Journal 3(2):93-97, 100-105. 2002.

Fertilization and Nutrition



53. Aqua-Hort. de Lasson, A. and Buhr, W. International Plant Propagators' Society, combined proceedings 2001, 51:347-349. 2002. Aqua-Hort implements a copper nutrition and electromagnetic treatment of the nutrient solution.

54. © Comparison of physiological responses of peach and almond seedlings to iron deficiency. Gharsalli, M. and Hajji, M. Journal of Plant Nutrition 25 (5):1139-1154. 2002.

55. Do plants need silicon? Muir, S., Khoo, C., Offord, C., Summerell, B., McCabe, B., Brien, J., Dann, E., Terras, M. A., and Tesoriero, L. International Plant Propagators' Society, combined proceedings 2001, 51:131-135. 2002.

56. © Effect of root-plug incorporated controlled-release fertilizer on two-year growth and survival of planted ponderosa pine seedlings. Moore, J. A., Fan, Z., and Shafii, B. Western Journal of Applied Forestry 17(4):216-219. 2002.

57. How to fertilizer plugs. Vetanovetz, R., Jacques, D., Walden, R., and Thomas, M. Greenhouse Management and Production 22(12):42-44, 46-50. 2002.

58. Late-season fertilization of *Picea mariana* seedlings under greenhouse culture: biomass and nutrient dynamics. Boivin, J. R., Miller, B. D., and Timmer, V. R. Annals of Forest Science 59(3):255-264. 2002.

59. © Reactivity of synthetic Fe chelates with soils and soil components. Alvarez-Fernandez, A., Sierra, M. A., and Lucena, J. J. Plant and Soil 241(1):129-137. 2002.

General and Miscellaneous

60. © The Canada - United States softwood lumber dispute. Forestry Chronicle 78(4):555-557. 2002.

61. © Chestnut: history and ecology of a transformed species. Paillet, F. L. Journal of Biogeography 29(10-11):1517-1530. 2002.

62. Did a green revolution restore the forests of the American South? Rudel, T. K. IN: Agricultural technologies and tropical deforestation, p. 53-68. A. Angelsen and D. Kaimowitz, eds. CAB International. 2001.

63. © Hydrological impacts of reafforestation with eucalypts and indigenous species: a case study in southern China. Zhou, G. Y., Morris, J. D., Yan, J. H., Yu, Z. Y., and Peng, S. L. Forest Ecology and Management 167(1-3):209-222. 2002.

64. Land use changes, natural regeneration patterns, and restoration practices after a large wildfire in NE Spain: challenges for fire ecology and landscape restoration. Espelta, J. M., Rodrigo, A., Habrouk, A., Meghelli, N., Ordonez, J. L., and Retana, J. IN: Fire and biological processes, p. 315-324. L. Trabaud and R. Prodon, eds. Backhuys Publishers. 2002.

65. © Mississippi's proposed reforestation investment program. Gunter, J. E., Idassi, J. O., and Granskog, J. E. Proceedings of the Society of American Foresters 2000 National Convention:159-171. 2000.

66. © Planning and management of the afforestation process in northern Israel. Ginsberg, P. New Forests 24(1):27-38. 2002.

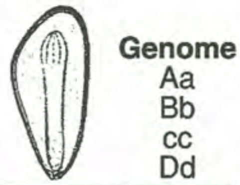
67. Plants found in my backyard... and yours. Hayman, M. International Plant Propagators' Society, combined proceedings 2001, 51:470-475. 2002.

68. © A results-based system for regulating reforestation obligations. Martin, P. J., Browne-Clayton, S., and McWilliams, E. Forestry Chronicle 78 (4):492-498. 2002.

69. The transition from deforestation to reforestation in Europe. Mather, A. IN: Agricultural technologies and tropical deforestation, p. 35-52. A. Angelsen and D. Kaimowitz, eds. CAB International. 2001.

70. What future for plant propagators? Moreau, P. M. International Plant Propagators' Society, combined proceedings 2001, 51:217-221. 2002.

Genetics and Tree Improvement



71. Genetic engineering: is perception reality? Bezar, H. J. International Plant Propagators' Society, combined proceedings 2001, 51:73-79. 2002.

72. © Genetic variation among and within provenances and families of *Eucalyptus grandis* W. Hill and *E. globulus* Labill. subsp. *globulus* seedlings in response to salinity and waterlogging. Marcar, N. E., Crawford, D. F., Saunders, A., Matheson, A. C., and Arnold, R. A. Forest Ecology and Management 162(2-3):231-249. 2002.

73. © Landscape genetic structure of *Pinus banksiana*: seedling traits. Saenz-Romero, C. and Guries, R. P. Silvae Genetica 51(1):26-35. 2002.

74. Plant biotechnology: a global overview of problems and potentials. McCown, B. International Plant Propagators' Society, combined proceedings 2001, 51:80-84. 2002.

Mycorrhizae & Beneficial Microorganisms

75. Silver bullet or silver slug? Appleton, B. American Nurseryman 196(9):49-50, 52, 54-55. 2002. Learn what mycorrhizae can and can't do before inoculating the rhizosphere.

Nursery Structures & Equipment

76. 10 reasons to mechanize. Bartok, J. W., Jr. Greenhouse Management and Production 22(9):63-64. 2002.

77. Design an efficient head house. Bartok, J. W., Jr. Greenhouse Management and Production 23(1):86-87. 2003.

78. Design of a propagation unit that independently controls atmospheric and medium moisture. Saha, S., Kester, S., Wilkerson, E., Buxton, J., and Geneve, R. International Plant Propagators' Society, combined proceedings 2001, 51:518-520. 2002.

79. Energy costs floor growers. Henne, L. Greenhouse Grower 20(14):26, 28, 32, 34-36. 2002. In-floor radiant heating technology is becoming a popular, cost-saving option.

80. Greenhouse floor heating. Both, A. J., Mears, D. R., Reiss, E., and Roberts, W. J. Greenhouse Management and Production 22(8):60-63. 2002. The advantages of floor-heating systems are well worth the installation expense.

81. Greenhouse site assessment helps avoid future problems. Rigazio, A. Greenhouse Management and Production 22(9):67-68, 70. 2002. Determining a location's Exposure Category can make obtaining a building permit a lot simpler.

82. A heavy duty leaf vacuum for greenhouse use. McConnell, J. International Plant Propagators' Society, combined proceedings 2001, 51:266. 2002.

83. Hoop house designs help ease snow loads. Bartok, J. W., Jr. Greenhouse Management and Production 22 (8):75-76. 2002.

84. Junior: a robot for outdoor container nurseries. Schempf, H. and Graham, T. IN: Proceedings of the 2002 IEE/RSJ International Conference on Intelligent Robots and Systems, p. 750-755. 2002.

85. Keep energy costs under control. Swanekamp, J. Greenhouse Grower 20(13):26, 28, 30. 2002.

86. Leave nothing to chance. Calkins, B. Greenhouse

Grower 20(8):74, 76, 78. 2002. Improved technology and a desire for efficiency in water usage and labor is increasing demand for boom irrigation.

87. Make film removal easier. Bartok, J. W., Jr. Greenhouse Management and Production 22(9):87-88. 2002. Describes use of a Tiger Baler to remove plastic films.

88. Respect farm equipment and save a life. Digger 46 (9):20-23. 2002.

89. Technology for greenhouse heating and cooling. Martins, V. International Plant Propagators' Society, combined proceedings 2001, 51:45-46. 2002.

90. Tips for improving seed planting efficiency. Dumroese, R. K., Wenny, D. L., and Morrison, S. J. Native Plants Journal 3(2)140-141. 2002.

91. Upgrade your electrical system for efficiency. Bartok, J. W., Jr. Greenhouse Management and Production 22(12):61-62. 2002.

92. The use of suction cup lysimeters for monitoring EC, pH, and nutrients in large containers. Wright, R. D., Stanley, M., and Harris, R. International Plant Propagators' Society, combined proceedings 2001, 51:572-574. 2002.

Outplanting Performance

93. Afforestation of burnt forests using mycorrhized *Pinus halepensis* and *P. pinaster* saplings. de las Heras, J., Gonzalez-Ochoa, A. I., and Torres, P. IN: Fire and biological processes, p. 253-263. L. Trabaud and R. Prodon, eds. Backhuys Publishers. 2002.

94. Competitive capacity of *Quercus rubra* L. planted in Arkansas' Boston Mountains. Spetich, M. A., Dey, D. C., Johnson, P. S., and Graney, D. L. Forest Science 48(3):504-517. 2002.

95. © Effect of drought on growth and mortality of actively growing Norway spruce container seedlings planted in summer. Helenius, P., Luoranen, J., Rikala, R., and Leinonen, K. Scandinavian Journal of Forest Research 17(3):218-224. 2002.

96. © Effect of nursery conditioning treatments and fall fertilization on survival and early growth of *Pinus taeda* seedlings in Alabama, U.S.A. South, D. B. and Donald, D. G. M. Canadian Journal of Forest Research 32(7):1171-1179. 2002.

97. © Effects of early release on natural versus container loblolly pines 12 years after field establishment. Cain, M. D. and Barnett, J. P. Southern Journal of Applied Forestry 26(4):173-180. 2002.

98. © Effects of nursery characteristics on field survival and growth of loblolly pine rooted cuttings. Frampton, J., Isik, F., and Goldfarb, B. Southern Journal of Applied Forestry 26(4):207-213. 2002.

99. Field performance of pine stock types: two-year results of a trial on interior lodgepole pine seedlings grown in Styroblocks, Copperblocks, or AirBlocks. Jones, M. D., Kiiskila, S., and Flanagan, A. B.C. Journal of Ecosystems and Management 2(1):1-12. 2002. Available online at: www.forrex.org/jem/2002/vol2/no1/art5.pdf.

100. © Planting frozen conifer seedlings: warming trends and effects on seedling performance. Kooistra, C. M. and Bakker, J. D. New Forests 23(3):225-237. 2002.

101. © The regeneration of a highly disturbed ecosystem: a mined peatland in southern Quebec. Girard, M., Lavoie, C., and Theriault, M. Ecosystems 5 (3):274-288. 2002.

102. © RPM container-grown swamp white oak for reforestation in Missouri floodplains. Grossman, B. C. and Gold, M. A. Proceedings of the Society of American Foresters 2000 National Convention:511-512. 2000.

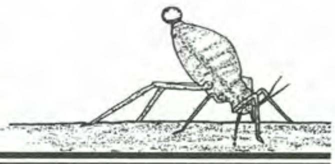
103. © Site preparation of abandoned fields and early establishment of planted small-sized seedlings of silver birch. Karlsson, A. New Forests 23(2):159-175. 2002.

104. © Soil water content and water relations in planted and naturally regenerated *Pinus halepensis* Mill. seedlings during the first year in semiarid conditions. Oliet, J., Planelles, R., Lopez Arias, M., and Artero, F. New Forests 23(1):31-44. 2002.

105. © Survival of artificially regenerated Scots pine on till soils with respect to varying dielectric properties. Sutinen, R., Teirila, A., Panttaja, M., and Sutinen, M.-L. Canadian Journal of Forest Research 32 (7):1151-1157. 2002.

106. © Three-year responses of ponderosa pine seedlings to controlled-release fertilizer applied at planting. Fan, Z., Moore, J. A., Shafii, B., and Osborne, H. L. Western Journal of Applied Forestry 17(3):154-164. 2002.

Pest Management



107. © The association of a *Longidorus* species with stunting and root damage of loblolly pine (*Pinus taeda* L.) seedlings. Fraedrich, S. W. and Cram, M. M. Plant Disease 86(7):803-807. 2002.

108. Cold fogging facts. Mabbett, T. Greenhouse Grower 20(13):80, 82, 84. 2002. A cold fogging system can deliver pesticides at low to ultra low volumes.

109. Coldframe and greenhouse pests. Miller, F. Nursery Management and Production 18(8):73-77. 2002. Identify and control insects and mites in propagation and production structures. Aphids, scales, thrips, fungus gnats and spider mites are discussed.

110. © Comparison of membrane filters as a tool for isolating Pythiaceous species from irrigation water. Hong, C., Richardson, P. A., and Kong, P. Phytopathology 92(6):610-616. 2002.

111. Different surfaces need different treatments for successful nursery hygiene. Mebalds, M. I. and Stovold, G. E. International Plant Propagators' Society, combined proceedings 2001, 51:182-187. 2002.

112. Disease management of greenhouse crops: the role of technology. Labuschagne, N. International Plant Propagators' Society, combined proceedings 2001, 51:51-54. 2002.

113. Fighting fungus gnats with IGRs. Cloyd, R. Greenhouse Grower 20(9):98, 100, 102. 2002. Insect growth regulators, such as Distance, when applied correctly can effectively control fungus gnat larvae on poinsettias.

114. © First report of the seed-pathogen *Geniculodendron pyriforme*, the imperfect state of the ascomycete *Caloscypha fulgens*, on imported conifer seeds in Germany. Schroder, T., Kehr, R., and Huttermann, A. Forest Pathology 32(4-5):225-230. 2002.

115. Fungus gnats -- common and damaging! Frodsham, A., Bodman, K., Steiner, M., and Goodwin, S. International Plant Propagators' Society, combined proceedings 2001, 51:177-181. 2002.

116. © *Fusarium* spp. and *Pinus strobus* seedlings: root disease pathogens and taxa associated with seed. Ocamb, C. M., Juzwik, J., and Martin, F. B. New Forests 24(1):67-79. 2002.

117. Hot water and copper coatings in reused containers decrease inoculum of *Fusarium* and *Cylindrocarpon* and increase Douglas fir seedling growth. Dumroese, R. K., James, R. L., and Wenny, D. L. HortScience 37(6):943-947. 2002.

118. Improving biological control by combining biocontrol agents each with several mechanisms of disease suppression. Guetsky, R., Shtienberg, D., Elad, Y., Fischer, E., and Dinoor, A. Phytopathology 92 (9):976-985. 2002.

119. Ionized copper as an effective control of problematic pathogens. Emmons, M. International Plant Propagators' Society, combined proceedings 2001, 51:504-506. 2002.

120. © Observations of *Phytophthora* spp. in water recirculation systems in commercial hardy ornamental nursery stock. Themann, K., Werres, S., Luttmann, R., and Diener, H.-A. European Journal of Plant Pathology 108(4):337-343. 2002.

121. © Occurrence and identification of *Phytophthora* spp. pathogenic to pear fruit in irrigation water in the Wenatchee River valley of Washington state. Yamak, F., Peever, T. L., Grove, G. G., and Boal, R. J. Phytopathology 92(11):1210-1217. 2002.

122. © Polymerase chain reaction primers for the detection of *Ceratobasidium bicorne* (uninucleate *Rhizoctonia*). Hantula, J., Lilja, A., and Veijalainen, A.-M. Forest Pathology 32(4-5):231-239. 2002.

123. Potential use of chlorine dioxide to control diseases in ornamental plant production systems. Chastagner, G. A. International Plant Propagators' Society, combined proceedings 2001, 51:275-279. 2002.

124. © Relative susceptibility of northern and southern provenances of *Pinus greggii* to infection by *Sphaeropsis sapinea*. Smith, H., Coutinho, T. A., Wolfaardt, F. W., and Wingfield, M. J. Forest Ecology and Management 166(1-3):331-336. 2002.

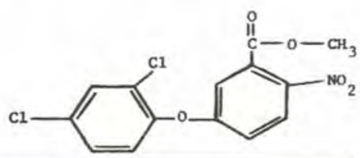
125. Should you use biofungicides? Hattori, K. Greenhouse Management and Production 22(10):47-49. 2002. Registered biological fungicides include Companion, PlantShield, Mycostop, SoilGard, Taegro, and AQ-10 biofungicide.

126. Species of *Fusarium* on *Pinus radiata* in New Zealand. Dick, M. A. and Dobbie, K. New Zealand Plant Protection 55:58-62. 2002.

127. Tips for managing *Botrytis*: comparing chemical controls. Hausbeck, M. Greenhouse Management and Production 22(12):59-60. 2002.

128. Tips for thrips. Thompson, S. P., Heinz, K. M., Bogran, C. E., and Krauter, P. C. Greenhouse Grower 20 (8):104, 108, 110, 112, 114. 2002. Follow these strategies for controlling thrips with natural enemy releases of predatory mites, predatory insects, parasitoids and pathogens.

Pesticides



129. © Herbicide safeners: uses, limitations, metabolism, and mechanisms of action. Abu-Qare, A. W. and Duncan, H. J. Chemosphere 48(9):965-974. 2002. Safeners, also called antidotes, antagonists and protectants, are applied with herbicides to protect crops against their injury.

Seedling Physiology and Morphology

130. © Anthocyanins of jack pine (*Pinus banksiana*) seedlings. Nozzolillo, C., Isabelle, P., Andersen, O. M., and Abou-Zaid, M. Canadian Journal of Botany 80 (6):796-801. 2002.

131. © Causes of variation in cold hardiness among fast-growing willows (*Salix* spp.) with particular reference to their inherent rates of cold hardening. Lennartsson, M. and Ogren, E. Plant, Cell and Environment 25(10:1279-1288. 2002.

132. © The chilling optimum of Idaho and Arizona ponderosa pine buds. Wenny, D. L., Swanson, D. J., and Dumroese, R. K. Western Journal of Applied Forestry 17(3):117-121. 2002.

133. © Chlorophyll fluorescence and variations in tissue cold hardiness in response to freezing stress in Douglas-fir seedlings. Rose, R. and Haase, D. New Forests 23(2):81-96. 2002.

134. © Effect of NaCl and high pH on seedling growth of 15 *Eucalyptus camaldulensis* Dehnh. provenances. Marcar, N. E., Zohar, Y., Guo, J., and Crawford, D. B. New Forests 23(3):193-206. 2002.

135. © Effect of seed size and growing media water availability on early seedling growth in *Eucalyptus globulus*. Humara, J. M., Casares, A., and Majada, J. Forest Ecology and Management 167(1-3):1-11. 2002.

136. © Effects of excessive nutrient supply and short day treatment on autumn frost hardiness and time of bud break in *Picea abies* seedlings. Floistad, I. S. Scandinavian Journal of Forest Research 17(4):295-303. 2002.

137. © Effects of phenology, water availability and seed source on loblolly pine biomass partitioning and transpiration. Barnes, A. D. Tree Physiology 22 (10):733-740. 2002.

138. © Effects of root freezing on the physiology and growth of *Picea glauca*, *Picea mariana* and *Pinus banksiana* seedlings under different soil moisture regimes. Coursolle, C., Bigras, F. J., and Margolis, H. A. Scandinavian Journal of Forest Research 17(3):206-217. 2002.

139. © The greater seedling high-light tolerance of *Quercus robur* over *Fagus sylvatica* is linked to a greater physiological plasticity. Valladares, F., Chico, J. M., Aranda, I., Balaguer, L., Dizengremel, P., Manrique, E., and Dreyer, E. Trees 16:395-403. 2002.

140. Photosynthetic performance of *Quercus petraea*, *Fagus sylvatica* and *Acer pseudoplatanus* planted under the canopy of a coniferous forest. Kazda, M., Schmid, I., and Klumpp, K. IN: Spruce monocultures in Central Europe - problems and prospects, p. 63-69. EFI Proceedings 33. 2000.

141. Plant morphology and leaf anatomy of sun and shade grown plants. du Toit, E. International Plant Propagators' Society, combined proceedings 2001, 51:44. 2002.

Seed

142. Acorn storage. Whitcomb, C. E. Nursery Management and Production 18(8):70-71. 2002. Know the differences in storing white oak group and red oak group seeds.

143. Changes in abscisic acid levels in embryo axes of Norway maple and sycamore seeds during maturation and dehydration. Pukacka, S. and Gawronska, H. Acta Physiologiae Plantarum 24(2):149-155. 2002.

144. Dormancy and germination in *Lonicera involucrata* var. *ledebourii*. Laursen, A. T. International Plant Propagators' Society, combined proceedings 2001, 51:413-416. 2002.

145. © Effect of collection date on capsule moisture content and germination of *Populus ciliata* Wall. ex Royle from central Himalaya. Pandit, A., Pant, K., and Ram, J. New Forests 23(2):121-130. 2002.

146. Effect of high temperatures on cone opening and on the release and viability of *Pinus pinaster* and *P. radiata* seeds in NW Spain. Reyes, O. and Casal, M. Annals of Forest Science 59(3):327-334. 2002.

147. © Effects of burying depth and seed size on seedling establishment of Japanese chestnuts, *Castanea crenata*. Seiwa, K., Watanabe, A., Saitoh, T., Kannu, H., and Akasaka, S. Forest Ecology and Management 164(1-3):149-156. 2002.

148. Embryo rescue and embryo excision -- what's the difference? Wiegrefe, S. J., Robacker, C. A., and Scheiber, S. M. International Plant Propagators' Society, combined proceedings 2001, 51:535-536. 2002.

149. Fusaria population associated with Douglas-fir and ponderosa pine seeds in Argentina. Lori, G. and Salerno, M. I. Seed Science and Technology 30(3):559-566. 2002.

150. © Identification of abscisic acid, indole-3-acetic acid, jasmonic acid, indole-3-acetonitrile, methyl jasmonate and gibberellins in developing, dormant and stratified seeds of ash (*Fraxinus excelsior*). Blake, P. S., Taylor, J. M., and Finch-Saveage, W. E. Plant Growth Regulation 37(2):119-125. 2002.

151. The importance of crop records and sowing rates in the propagation of woody plants from seed. Fordham, D. International Plant Propagators' Society, combined proceedings 2001, 51:243-246. 2002.

152. © Loblolly pine seed dormancy: constraints to germination. Cooke, J., Cooke, B., and Gifford, D. New Forests 23(3):239-256. 2002.

153. The Millennium Seed Bank Project and its approach to germination testing. Probert, R. International Plant Propagators' Society, combined proceedings 2001, 51:237-242. 2002.

154. Refinement and stratification of thinleaf alder and water birch seeds from New Mexico. Jones, C. L., Harrington, J. T., and Dreesen, D. R. Native Plants Journal 3(2):142-150. 2002.

155. Seed harvesting and processing: techniques that work. Barnes, H. W. International Plant Propagators' Society, combined proceedings 2001, 51:466-470. 2002.

156. Seed maturity affects the uniformity of cherry (*Prunus avium* L.) seed response to dormancy-breaking treatments. Finch-Savage, W. E., CLay, H. A., and Dent, K. C. Seed Science and Technology 30 (3):483-497. 2002.

157. Seed technologies to increase seed value in Tasmania. Donovan, N., Clark, R. J., and Hetherington, S. International Plant Propagators' Society, combined proceedings 2001, 51:119-123. 2002.

158. Separation of empty and dead-filled seeds from a seed lot of *Pinus patula* with IDS technique. Demelash, L., Tigabu, M., and Oden, P. C. Seed Science and Technology 30(3):677-681. 2002.

SO. Guidelines for producing quality longleaf pine seeds. Barnett, J. P. and McGilvray, J. M. USDA Forest Service, Southern Research Station, General Technical Report SRS-52. 21 p. 2002. ORDER FROM: USDA Forest Service, Southern Research Station, P.O. Box 2680, Asheville, NC 28802. Free.

Soil Management & Growing Media

Peat Moss
Selected Canadian Sphagnum

159. © Aggregate stability changes after organic amendment and mycorrhizal inoculation in the afforestation of a semiarid site with *Pinus halepensis*.

Caravaca, F., Garcia, C., Hernandez, M. T., and Roldan, A. Applied Soil Ecology 19(3):199-208. 2002.

160. The basic principles of selecting growth medium and fertigation of pot grown plants. Claassens, A. S. International Plant Propagators' Society, combined proceedings 2001, 51:58-59. 2002.

161. © Change in soil organic carbon following afforestation of former arable land. Vesterdal, L., Ritter, E., and Gundersen, P. Forest Ecology and Management 169(1-2 Spec. Iss.):137-147. 2002.

162. © Compost effects on soil physical properties and field nursery production. Gonzalez, R. F. and Cooperband, L. R. Compost Science and Utilization 10 (3):226-237. 2002.

163. Glomalin: hiding place for a third of the word's stored soil carbon. Comis, D. Agricultural Research 50 (9):4-7. 2002. Glomalin, a glycoprotein discovered in 1996, is produced by mycorrhizae and is a major component of soil organic matter.

164. Growth of herbaceous and woody perennials in spent mushroom substrate composted by aerated and static methods. Heuser, C., Holcomb, E. J., and Heinemann, P. H. International Plant Propagators' Society, combined proceedings 2001, 51:506-508. 2002.

165. Keeping your balance: correct alkalinity and pH levels are vital for nursery crop production. Altland, J. Digger 46(10):43-48. 2002.

166. Making an impact: a nursery's fertilizer practices have a lot to do with the soil's pH and the crop's nutrition. Atland, J. Digger 46(11):48-50. 2002.

167. Microbiological and chemical characterisation of composts at different levels of maturity, with evaluation of phytotoxicity and enzymatic activities. Queda, A. C. C., Vallini, G., Agnolucci, M., Coelho, C. A., Campos, L., and de Sousa, R. B. IN: Microbiology of composting, p. 345-355. H. Insam, N. Riddech, S. Klammer, eds. Springer-Verlag. 2002.

168. Pay attention to details. Bloodnick, E., Buechel, T., Bussieres, P., Fonda, H., and Moore, K. Greenhouse Management and Production 23(1):61-62, 64. 2003. Maximize the performance of a growing medium by paying attention to what happens to it from the time it arrives until the time it leaves with the finished crop.

169. Technology in soil sterilization. Martins, V. International Plant Propagators' Society, combined proceedings 2001, 51:47-48. 2002. Agrelek has developed a low-pressure steam generator that can generate steam of up to 120 kg/h.

170. Use of para formaldehyde as a potential soil sterilant: a preliminary investigation. Barnes, H. W. International Plant Propagators' Society, combined proceedings 2001, 51:488-491. 2002.

171. Using turkey litter compost in growing media. Chong, C. International Plant Propagators' Society, combined proceedings 2001, 51:390-394. 2002.

Tropical Forestry & Agroforestry

172. © The effect of increasing sediment accretion on the seedlings of three common Thai mangrove species. Thampanya, U., Vermaat, J. E., and Terrados, J. Aquatic Botany 74(4):315-325. 2002.

173. Effects of priming on germination of *Buddleja cordata* ssp. *cordata* (Loganiaceae) seeds and possible ecological significance. Gonzalez-Zertuche, L., Orozco-Segovia, A., Baskin, C., and Baskin, J. M. Seed Science and Technology 30(3):535-548. 2002.

174. Establishment of field nursery for cultivation of mangroves at Miani Hor, Pakistan. Rasool, F. and Saifullah, S. M. IN: Prospects for saline agriculture, p. 439-446. R. Ahmad and K.A. Halik, eds. Kluwer Academic Publishers. 2002.

175. Growth of a mangrove (*Rhizophora apiculata*) seedlings as influences by GA_3, light and salinity. Kathiresan, K. and Rajendran, N. Revista de Biologia Tropical 50(2):525-530. 2002.

176. © Propagating framework trees to restore seasonally dry tropical forest in northern Thailand. Elliott, S., Kuarak, C., Navakitbumrung, P., Zangkum, S., Anusarnsunthorn, V., and Blakesley, D. New Forests 23(1):63-70. 2002.

177. © Selection of *Leucaena* species for afforestation and amelioration of sodic soils. Goel, V. L. and Behl, H. M. Land Degradation and Development 13(5):387-393. 2002.

178. Techniques of germination and growth potential of some fuelwood species in northeastern Mexico.

Foroughbakhch, R., Hauad, L. A., Maiti, R. K., Rodriguez, M., Hernandez-Pinero, J. L., Badii, M. H., Cespedes, A. E., and Ponce-Moreno, E. E. Phyton 69 (1):17-22. 2000.

Vegetative Propagation and Tissue Culture

179. Comparative in vitro culture of white and green ash from seed to plantlet production. Van Sambeek, J. W., Preece, J. E., and Navarrete-Tindall, N. E. International Plant Propagators' Society, combined proceedings 2001, 51:526-534. 2002.

180. Cuttings production: alternative strategies and potential techniques for the future. Cameron, R. W. F. and Harrison-Murray, R. S. International Plant Propagators' Society, combined proceedings 2001, 51:191-195. 2002.

181. Development of a subirrigation system with potential for hardwood tree propagation. Coggeshall, M. V. and Van Sambeek, J. W. International Plant Propagators' Society, combined proceedings 2001, 51:443-448. 2002.

182. Effect of a simple evaporation cooling device for cutting propagation in arid lands. Fukasawa, K. International Plant Propagators' Society, combined proceedings 2001, 51:327-329. 2002.

183. © Effects of auxins (IBA and NAA) and season on rooting of juvenile and mature hardwood cuttings of *Robinia pseudoacacia* and *Grewia optiva*. Swamy, S. L., Puri, S., and Singh, A. K. New Forests 23(2):143-157. 2002.

184. Forcing the tissue. Preece, J. E., Van Sambeek, J. W., Henry, P. H., and Zaczek, J. American Nurseryman 196(7):26-30, 32, 34. 2002. Forcing softwood cuttings from woody stem segments is proving a reliable method to propagate many species.

185. The most tricky part of micropropagation: establishing plants in greenhouses and fields. Preece, J. E. International Plant Propagators' Society, combined proceedings 2001, 51:300-303. 2002.

186. Plant propagation techniques: a historical perspective. Geneve, R. International Plant Propagators' Society, combined proceedings 2001, 51:370-375. 2002.

187. Promising propagation. Berney, J. American Nurseryman 196(7):62-64. 2002. Australian researchers have developed a new in vitro strategy to produce difficult-to-propagate woody plants that are vigorous and fast-growing. With the In Vitro Soil (IVS) system, microcuttings are transferred to a porous sterile mix rather than agar.

188. Propagating under different plastics and shading materials. Adams, T. International Plant Propagators' Society, combined proceedings 2001, 51:597-600. 2002.

189. Propagation of cuttings in different media under different levels of drainage. Jorgensen, L. International Plant Propagators' Society, combined proceedings 2001, 51:351-357. 2002.

190. Rooting softwood cuttings collected from forced large stems of oakleaf hydrangea and American chestnut. Preece, J. E., Ledbetter, D. I., and Zaczek, J. J. International Plant Propagators' Society, combined proceedings 2001, 51:267-270. 2002.

191. Theory of grafting. MacDonald, P. T. International Plant Propagators' Society, combined proceedings 2001, 51:221-226. 2002.

192. Tissue culture acclimation. Armstrong, M. International Plant Propagators' Society, combined proceedings 2001, 51:304-307. 2002.

193. Vegetative propagation of some Eucalyptus species. Cliffe, D. O. International Plant Propagators' Society, combined proceedings 2001, 51:171-173. 2002.

Water Management

194. Capillary watering. Stocks, B. International Plant Propagators' Society, combined proceedings 2001, 51:146-148. 2002.

195. Dealing with water restrictions in your nursery. Beeson, R. C., Jr. International Plant Propagators' Society, combined proceedings 2001, 51:569-571. 2002.

196. Herbicides in your recycled irrigation water? Altland, J. Digger 46(9):45, 47, 48, 50, 52-54. 2002. There are ways to minimize, if not eliminate, chemical contamination.

197. How to conduct a greenhouse water-use audit. Thomas, P. A., Stegelin, F. E., and Pennisi, B. V. Greenhouse Management and Production 23(1):46-48, 50, 52. 2003.

198. Igloo irrigation. Rolfe, C. International Plant Propagators' Society, combined proceedings 2001, 51:148-152. 2002.

199. Irrigation time of day -- does it really matter? Warren, S. L. and Bilderback, T. E. International Plant Propagators' Society, combined proceedings 2001, 51:564-568. 2002.

200. Mineral nutrients in water: quality variation of rainwater, surface water, and ground water. Nihlgard, B. International Plant Propagators' Society, combined proceedings 2001, 51:358-365. 2002.

201. PAM protects against pollutants and pathogens. Lentz, R. D., Bjorneberg, D. L., Entry, J. A., and Sojka, R. E. Agricultural Research 50(7):4-6. 2002. PAM, polyacrylamide, prevents nutrients and microbes from ending up in irrigation runoff and thwarts erosion in furrow-irrigated fields.

202. Water and nutrient management planning -- monitoring of irrigation and fertilization practices. Lea-Cox, J. D. and Ross, R. S. International Plant Propagators' Society, combined proceedings 2001, 51:575-580. 2002.

203. Water management is key in reducing nutrient runoff from container nurseries. Bilderback, T. E. HortTechnology 12(4):541-544. 2002.

Weed Control

204. © The effect of hexazinone, sulfometuron, metsulfuron, and atrazine on the germination success of selected *Ceanothus* and *Rubus* species. Rose, R. and Ketchum, J. S. Western Journal of Applied Forestry 17 (4):194-201. 2002.

205. Effect of steam application on cropland weeds. Kolberg, R. L. and Wiles, L. J. Weed Technology 16 (1):43-49. 2002.

206. © The effects of surfactants on adhesion, spreading, and retention of herbicide droplet on the surface of the leaves and seeds. Basu, S., Luthra, J., and Nigam, K. D. P. Journal of Environmental Science and Health B37(4):331-344. 2002.

207. Improvement of an elutriation method for estimation of weed seedbank in the soil. Smutny, V. and Kren, J. Rostlinna Vyroba 48(6):271-278. 2002.

208. © Influence of developmental stage and time of assessment on hot water weed control. Hansson, D. and Ascard, J. Weed Research 42(4):307-316. 2002.

209. Know your enemy. Altland, J. Farwest Magazine 46(8):28-32. 2002. Understanding how plants react to pre-emergent herbicides will determine application timing, effectiveness and injury diagnosis.

210. Liverwort and algae: chemical control. Armstrong, M. International Plant Propagators' Society, combined proceedings 2001, 51:273-274. 2002.

211. Weed control from herbicide combinations with glyphosate. Shaw, D. R. and Arnold, J. C. Weed Technology 16(1):1-6. 2002.

212. Weed management and allelopathy in the greenhouse. Reinhardt, C. F. International Plant Propagators' Society, combined proceedings 2001, 51:55-56. 2002.

213. Yellow nutsedge (*Cyperus esculentus*) control and tuber yield with glyphosate and glufosinate. Nelson, K. A., Renner, K. A., and Penner, D. Weed Technology 16(6):360-365. 2002.

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