LEBANON REFORESTATION INITIATIVE

A GUIDE TO CONTAINER TREE SEEDLING PRODUCTION

2014

Preface

This manual was written for the Lebanon Reforestation Initiative to improve nursery practices and support seedling production in Lebanon. It is meant to fill the gap between practical experience and technical manuals and highlights some of the key aspects involved in container production through a series of step-by-step guides. Because of its brevity, this publication does not attempt to thoroughly explain the theory behind many plant propagation concepts discussed here, but instead is meant to be supplemented with other existing technical nursery publications.

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The nursery environment can have a high potential for injuries if necessary precautions are not taken. Consider the safety of yourself and your employees during daily activities. The information below outlines some key aspects of maintaining safety in the workplace.

Employer Responsibilities:

- Identify and warn workers about potential hazards at the nursery[1]
  Examples include: acids, fertilizers, pesticides, fungicides, machinery, etc.
- Label all hazardous chemicals and store them in a designated place such as a chemical cabinet
- Train your employees to use necessary precautions when handling hazardous materials and communicate about potential hazards verbally and in writing to make sure your employees understand the consequences associated with careless handling of dangerous materials

General Rules for Working with Chemicals:[1]

- Never store or handle unmarked chemicals
- Include the chemical name and potential hazards associate with its use on the container

If this data is not provided on the original container it should be printed and attached to the container used to store the chemical (See next page).

- Always wear protective equipment
- When mixing chemicals keep them below eye-level to avoid splashing your face

Protective Equipment:

- Goggles
- Respirator, mask, or scarf to cover the nose and mouth
- Long-sleeved shirt and pants made of washable materials
- Socks, shoes (not sandals), and gloves that extend past the wrist

[1]Occupational Safety and Health Administration. May 30, 2007. Landscaping and Horticulture Safety. www.osha.gov/dte/grant.../fy06/.../english_b_6_health_hazcom.ppt [Last accessed September 18, 2012].

Below is an example of a chemical label for sulfuric acid. An empty template is also provided below and can be cut out, photocopied, and used at your nursery.

Substance: Sulfuric Acid (H_2SO_4)

✔	Health Risk
✔	Flammability
✔	Physical Hazard
✔	Protective Wear

Details:

- Can affect your lungs when inhaled, higher exposures can cause a build-up of fluid in lungs
- Is a carcinogen
- Corrosive contact can severely burn the skin, eyes, and may lead to blindness
- Can cause headache, nausea, and vomiting
- Can cause permanent lung damage, damage teeth, and upset stomach
- Can enhance the combustion of other substances, will explode in a fire
- Will produce poisonous gases in a fire

Substance:

	Health Risk
	Flammability
	Physical Hazard
	Protective Wear

Details:

Substance:

	Health Risk
	Flammability
	Physical Hazard
	Protective Wear

Details:

Working with Acids:

When handling acids, always wear a face mask/goggles, gloves, and cover all exposed body parts.[1]

Store protective wear in one location that is easily accessible to all employees.

When diluting acids, always pour acid into water slowly. Never pour water into acid!

Why do you add acid to water and not the other way around:

When acid reacts with water a large amount of heat is released. When one adds water to acid, the initial concentration of acid is very high and so much heat is released that the solution may boil violently, causing concentrated acid to splash out of the container. However, if acid is added to water the acid concentration in the mixture is low and increases gradually, releasing only a small amount of heat, thus reducing the hazard.[2]

Proper Procedures for Mixing Acid:

1 Pour a desired amount of water into a bucket/container.

2 Put on rubber gloves, long sleeve shirt, apron, and goggles.

3 Place bucket lower than eye level (to prevent splashing acid into your face).

4 Slowly pour in the desired amount of acid, mixing the solution slowly.

Proper Acid Disposal:

1 Dilute acid by pouring it slowly into a container of water.

2 Make sure you have at least twice as much water as acid.

Do not dispose of acid indoors!

[2] Senese, F. January 1997. http://antoine.frostburg.edu/chem/senese/101/safety/faq/always-add-acid.shtml [Last accessed September 18, 2012]

General First Aid Steps for Acid Exposure:[3]

In case of skin contact:

1 Remove contaminated clothing as soon as possible.

2 Wash the affected area with large amounts of water and soap.

3 Seek medical attention as soon as possible.

In case of eye contact:

1 Flush eyes immediately with a large amount of water for at least 30 minutes.

2 Make sure that water reaches the underside of the upper and lower lids.

3 Contact medical help as soon as possible.

In case of inhalation:

1 Exit the affected area immediately and seek medical attention.

2 If the victim is unconscious they must be removed from the affected area immediately.

3 Rescue breathing must be administered, but precautions should be taken to avoid transfer of poisonous vapors into the rescuer's lungs.

4 Contact medical help as soon as possible.

Disposing of hazardous materials:[1]

Potentially hazardous materials include items such as:

- broken glass
- old chemical containers
- acid/chemical drenched towels
- other sharp materials

To avoid problems:

- Label potentially dangerous trash and trashcans containing that material
- Designate a box or container for broken glass and other sharp objects

[3] New Jersey Department of Health. Right to Know Fact Sheets. http://www.nj.gov/health/eoh/rtkweb/ [Last accessed September 18, 2012].

Working with Fertilizers:

Proper fertilizer use can enhance plant growth and help to produce healthy seedling; however, poor use and handling of fertilizers can be harmful to nursery employees and the environment. Some fertilizers are flammable, can cause irritation, and can contaminate ground water. To avoid these problems follow the guidelines provided below:

General Rules for Working with Fertilizers:[1]

When storing:

- Always store fertilizers in a correctly labeled containers/bags, in a dry place away from sources of heat or fire
- Place a fire extinguisher close to the fertilizer storage area in case of an emergency

When using:

- Workers should wear protective clothing when mixing fertilizers
- Use a backflow preventer to ensure that water containing fertilizer or pesticide is not mixed back in with water used for human consumption
- Monitor fertilizer runoff and take measures to avoid the mixing of runoff with surface water such as a stream or lake
- Mix slow release fertilizer into the media directly to avoid leaching of fertilizer that is top-dressed
- Remember that temperature and moisture of the growing media will influence the fertilizer release rate
- Know your fertilizer conversions and injector rates
- Reduce fertilizer runoff by placing species that require the same fertilization frequency into the same irrigation zones

Working with Machinery and Moving Parts:

Operating machinery such as cement mixers, tractors, media mixers, and so on may be required. Care must be taken by both the employer and the employees to insure that all hazards associated with moving parts, electricity, dust and other flying debris are eliminated. Follow the following steps to minimize risks:

General Rules for Working with Machinery and Moving Parts:

- Take the time to train and practice with new machinery and new employees
- Wear a respirator and goggles if dealing with fine materials that can be inhaled or lodged in eyes (i.e. mixing growing media and perlite)
- Keep fingers out of the way of any moving parts
- Before beginning to operate any machinery check your surroundings, if others are around, inform them about what you plan on doing

Taking notes is vital to the success of a nursery. Detailed records will help: a) assess progress of the current crop, b) plan for next year's crop production, and c) understand which practices were beneficial and which hindered progress.[1] The three components of this section will help with keeping records that lead to success:

1 The **Daily Checklist** is meant to be completed every day, preferably at the start of the day before beginning work. This will allow the grower to be aware of tasks that need to take place and plan daily activities accordingly.

2 The **Daily Irrigation Log** is designed to record the water status of each crop on a daily basis. The grower should use gravimetric weights to measure the weight of designated trays and calculate the dry down weight for each species. This will help determine whether the species should be watered *(See Section 5.1)*. If a crop is irrigated the following information should be recorded in the **Daily Irrigation Log**:

a. the amount/duration of application
b. fertilizer rate and type

3 The **Weekly Log** helps summarize the activities that take place every week. It includes information regarding the tasks that were completed, the amount of people and time required. In addition, the form helps summarize nursery financial records by providing space to document customer orders as well as the purchases made by the nursery on a weekly basis.

Below you will find examples of each form, in addition empty templates of the same forms can be found in the Appendix. These forms can be modified to better fit your nursery, but the general information should remain the same.

[1]Jacobs, D.F. and K.M. Wilkinson. 2009. Chapter 3: Planning crops and developing propagation protocols. In: Dumroese, R.K., Luna, T. and T.D. Landis, Editors. Nursery manual for native plants: A guide for tribal nurseries - Volume 1: Nursery management. Agriculture Handbook 730. Washington, D.C.: U.S. Department of Agriculture, Forest Service. p. 177-199.

Name: Matthew
Date: June 10, 2012

The Daily Checklist

Daily Task	Completed	Notes
Walk through the entire nursery and take a look at all of the crops; take note of any problems or tasks that needs to be done today	☑	weed the area around the Pinus pinea crop Check the Fraxinus crop for insect damage
Write down the temperature (take note of the temperature variation throughout the plant production area, if multiple thermostats are available)	☑	Location: main greenhouse Time: 8:30 (morning) High (C°): 38 Low (C°): 24
Weed the area around the plants	☑	Zone 2 and 3 (towards the back of greenhouse)
Check the sprinkler nozzles to make sure they are attached/clean	☑	Need to clean nozzles in the front of the greenhouse
Check whether plants need extra perlite, thinning, or sorting	☑	Need to add perlite to the Cedrus libani containers
Take block weights of all of the crops	☑	

Name: Matthew
Date: June 10, 2012

The Daily Irrigation Log

Species	Crop phase	Gravimetric weight per tray	Fertilization (rate, type)	Irrigation (amount/duration)
Fraxinus angustifolia subsp. syriaca	Early, week 2	7.3/8.5 kg x 100=85%	6 g of Basacote ® 6M per D40 container; mixed into media before sowing	Watered with an overhead sprinkler for 30 minutes
Pinus pinea	Middle, week 5	7.4/8.7 kg x 100=85%	100 ppm N of 30-10-10 Soluble fertilizer Peters Professional for 30 minutes	Fertilized with the overhead sprinkler with injector set to 1:200

Name: Matthew
Week: July 2-8, 2012

The Weekly Log

Tasks:	Duration:	Number of people required:	General Notes:
Sowing Pinus pinea, Cedrus libani, and Fraxinus angustifolia seeds	20 hours	2 people	Some seeds were moldy, may need to decrease moisture during storage
Mixing media and filling containers	10 hours	2 people	Running low on Cocopeat, need to purchase more
Weeding	3 hours	1 person	
Mixing Fertilizer	3 hours	1 person	

Orders:			Purchases:	
Species:	**Seedling number:**	**Purchaser:**	**Item/Service:**	**Amount:**
Cedrus libani	1000, D40 seedlings	LRI	Bough more cocopeat	100 bricks at $...
			Bought replacement nozzles for sprinklers	3 for $...

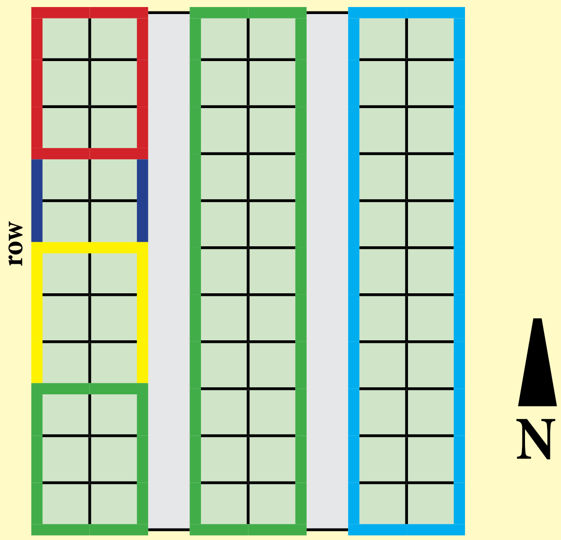
Careful crop planning is critical to successful nursery management. Crop planning allows the grower to visualized the entire production process, anticipate potential needs, and allow for <u>proper timing</u> so that the crop can be ready for the customer on a pre-designated date. The following steps must be considered when planning for crop production:[1]

1 Identify the amount of space available for plant production at your nursery.

2 Create a layout for the crop based on the number of seedlings that must be produced.

Take into account the available growing space, container type, germination rate, and potential mortality throughout the growing season.

Greenhouse



	Species	Container	Number
	Quercus calliprinos	D 40	300
	Fraxinus angustifolia	D 40	200
	Arbutus unedo	D 40	300
	Pinus pinea	D 40	1,400
	Cedrus libani	D 40	1,100

3 Identify the seed source for each crop and schedule collection or purchase.

Consider seed ripening date and the time required to collect and process the seeds.

4 Identify and schedule any treatments that are necessary prior to sowing.

Consider seed dormancy requirements, materials needed to treat seeds, and the duration of treatment needed for each species.

5 Schedule crop establishment.

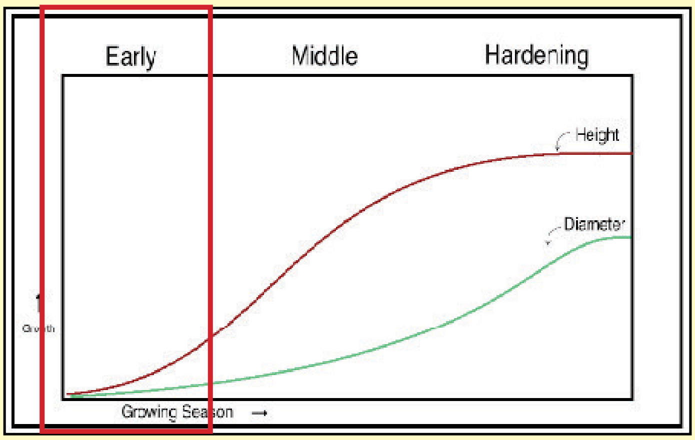
Consider the plant growth phases (Refer to Section 3.2) and the requirements for each.

6 Create a crop schedule that insures the production of a quality seedling by the target date.

This can be done electronically or by using a calendar.

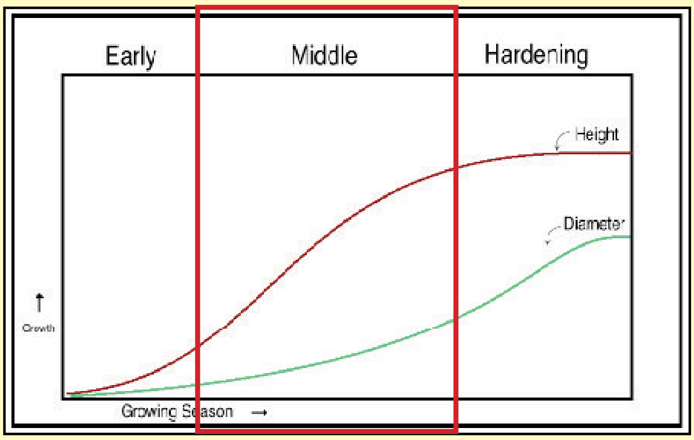
[1]Jacobs, D.F. and K.M. Wilkinson. 2009. Chapter 3: Planning crops and developing propagation protocols. In: Dumroese, R.K., Luna, T. and T.D. Landis, Editors. Nursery manual for native plants: A guide for tribal nurseries - Volume 1: Nursery management. Agriculture Handbook 730. Washington, D.C.: U.S. Department of Agriculture, Forest Service. p. 177-199.

Growers can monitor plants through observation and regular measurements. Seedlings follow three phases of development during nursery culture: *early, middle,* and *hardening phase*. **The timing of each phase will vary by species, sowing date, nursery culture, location, and weather. The following description simplifies each stage and provides a framework for keeping records to be referenced in the future:**[1,2]



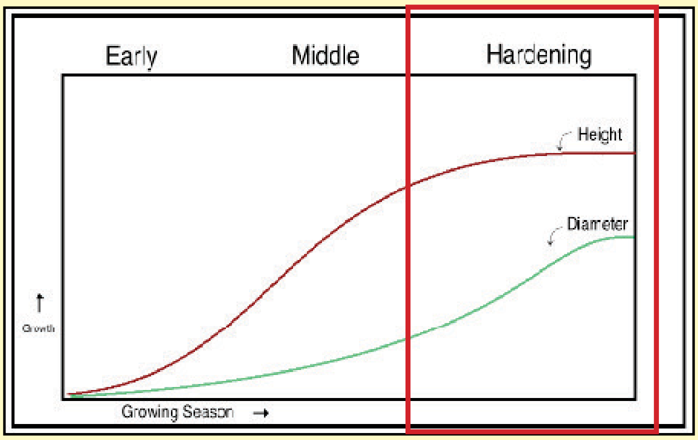
Early Phase	
Objective	• Maximize the number of containers filled with healthy seedlings • Phase can last 4 to 8 weeks depending on a species and culturing conditions • Phase is complete with the first flush of needles or true leaves
Growing Conditions	Temperature, humidity and light should be favorable for seed germination.
Irrigation	Keep the surface of the growing media moist. *Excess water can cause crop disease but too little water will prevent germination or damage newly germinated seedlings. Irrigation can be regulated using gravimetric weights (See Section 5.1) set to a percentage that allows for ample water to be available to the seedlings throughout this phase (i.e.>85%), or by setting irrigation frequency based on environmental conditions (i.e. water once a day or water twice a day if temperatures exceed 27°C).*
Fertilization	Fertilization is unnecessary in this phase. *If soluble fertilizer is applied, be sure the concentrations are low to avoid salt injury.*
Additional Information	**The first two weeks:** • Monitor the crop closely so that resowing, thinning, and transplanting can occur promptly • Resow the empty cells if germination hasn't occurred *Resowing outside of the two-week window will result in uneven crop age, a delay in crop schedule, and seedlings that will not reach the target size by outplanting.* • Thinning should start as soon as possible to reduce competition for resources (e.g. water, light, rooting space) among seedlings

[1]Jacobs, D.F. and K.M. Wilkinson. 2009. Chapter 3: Planning crops and developing propagation protocols. In: Dumroese, R.K., Luna, T. and T.D. Landis, Editors. Nursery manual for native plants: A guide for tribal nurseries - Volume 1: Nursery management. Agriculture Handbook 730. Washington, D.C.: U.S. Department of Agriculture, Forest Service. p. 177-199.



Middle Phase	
Objective	• Provide ample amounts of water, fertilizer, and sunlight to maximize seedling growth • Phase can last up to 3 months depending on species and environmental conditions • Phase is complete when 2/3 of target seedling height is achieved
Growing Conditions	Temperature, humidity and light should be optimized. *Temperatures should be maintained above 0°C. When temperatures approach 40°C, seedlings should be provided with shade and ample water to reduce drought stress and potential damage. Growing the crop during the longest photoperiods of the year can maximize light.*
Irrigation	Ample water should be provided (e.g.>80% gravimetric block weight) so the seedlings do not experience moisture stress (*See Section 5.1*)
Fertilization	Proper fertilization is critical during this phase. The fertilizer solution should provide all micro- and macronutrients so that the crop can reach target height, and maintain proper form and color. This can be achieved with an appropriate rate of slow release fertilizers or through a balanced application of soluble fertilizers (*See Section 6.1*)
Additional Information	• Pruning can be used to control seedling height during this phase (*See Section 3.3*) • If container type allows for it, seedlings should be sorted throughout this phase *Sorting involves rearranging containers (or trays) in a way that similar sized seedlings are grouped together. This practice reduces shading, maximizes the effectiveness of overhead irrigation, and allows for the maximum degree of uniformity among seedlings.* • Careful monitoring throughout this phase can help maximize seedling health and reduce the presence of pathogens

[2]Landis, T.D. 1990. The Container Tree Nursery Manual: Volume 6, Seedling propagation. Agric. Handbook No. 674. Washington, DC: U.S. Department of Agriculture, Forest Service. 173 p.



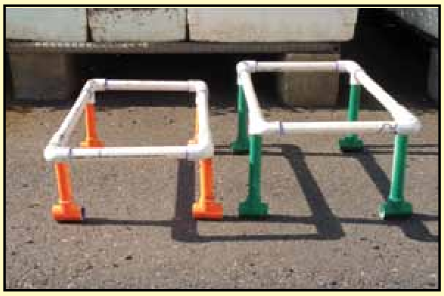
Hardening Phase	
Objective	• To divert shoot growth to stem and root growth and prepare seedlings for the stress that they will endure after nursery culture • Phase begins when 2/3 of the terminal shoot height is achieved • Phase complete when determinate seedlings have set bud or reached a dormant status
Growing Conditions	Ambient temperature and photoperiod will decrease as the growing season progresses, unless a climate-controlled greenhouse is used. Most plants will respond to a shortened photoperiod and decreasing temperatures by developing traits that facilitate hardiness. However, additional measures to reduce growth can be achieved through alterations in irrigation and fertilization regimes.
Irrigation	Irrigation water should slowly be reduced during this phase. This can be achieved through gradually lowering the percent saturation requirement (e.g. reduction in target gravimetric weight by 5% twice a month) (*See Section 5.1*).
Fertilization	If applied through an injection system, fertilization should be tapered halt shoot growth. A general reduction in mineral nutrients (particularly nitrogen) will facilitate hardening.
Additional Information	• Hardiness levels should vary based on when a seedling is outplanted • Growers should annually document when seedlings enter and exit each phase of growth *Having multiple years of records in addition to morphological data describing seedling height and root collar diameter during each phase will allow for better crop management and outplanting success.*

Pruning can be used to control seedling height, increase crop uniformity, control transpiration rates, and help meet target root to shoot ratios. Generally, only broadleaf species should be pruned, while conifers should not. The timing of pruning will depend on the species, container type, and the duration of nursery culture before outplanting. For pruning a large crop consider using a stencil. This will make pruning faster while maintaining crop uniformity. The stencil, along with an assortment of leg heights, can be prefabricated and color-coded to make using stencils with different leg heights easier. Follow the steps below to as a guide for pruning your crop:

1 Determine the target height for the crop (the height of the crop at the end of the growing season).

2 By measuring seedling shoot height you can determine how much needs to be removed. Growth rates can vary throughout the season, both between and within species. Remember the target height should be met before seedlings are outplanted.

3 Select a pre-fabricated stencil leg that meets your requirements, then assemble your stencil and begin pruning. Be careful to avoid folding plants over when placing the stencil on the crop.



4 Use a pair of large, sharp pruning shears. Placing the pruning shears along the edge of the stencil will allow for cutting many plants within and around the tray. This makes for a quick and uniform cutting operation.

5 When finished with an area, simply move the stencil along until the entire zone is pruned to an even height.

6 Remove the excess foliage from the pruned areas. **This is important!**

Excess foliage that is left in the crop after pruning will prevent irrigation water from reaching containers evenly, and increase potential vectors for crop disease.

The way seeds are treated directly after collection is important and will ultimately determine the quality of your seed lot (a specific collection). When you consider that a kilogram of seeds can yield several thousand seedlings, it is evident how important it is to treat seeds well from the time of collection. Handling and cleaning is dependent on the species and the reproductive structures they possess (e.g. cones/non-fleshy fruits vs. fleshy fruits). Before beginning the cleaning process, check if seeds of the species are orthodox or recalcitrant. This will determine whether or not they can be dried (*See Section 4.3*). The general guidelines for each type are described below:

Post-Harvest Handling of Cones and Non-Fleshy Fruits:

1 After collection, place seeds in burlap, cotton, or nylon screen bags to allow air flow and prevent fungal growth. Only fill bags half way to allow for cones/fruits to expand as they dry.[1]

Very small collections can be placed into paper sacks.

2 Label each bag with the species, elevation, collection location, date, and your name.

3 Place bags in a dry, well-ventilated area, either hanging up or on shelves with sufficient air flow. The temperature should remain between 18 and 27°C.


Photo by Emily Overton

4 Check cones/fruits often and check them for mold or insect damage.

5 If mold is present, it is a result of moisture and air circulation problems. Rearrange the cones/fruits so they get better air circulation - you can spread them out over a flat surface or a screen, but keep them out the direct sun.

6 Seeds should be cleaned (remove all bracts, cones, samaras, etc.), dried, and stored under refrigerated conditions (*See Section 4.3*).
For recalcitrant seeds: rinse in water and allow to air dry on a flat surface, at room temperature for up to 1 hour. Keep out of direct sun.
For orthodox seeds: allow to air dry on a flat surface at room temperature for (2 to 7 days, depending on species and weather). Monitor for mold and keep out of direct sun.

[1]Dumroese, R. K., Landis, T.D., Luna, T., and G. Hernandez. 2008. Simple methods for raising tree and shrub seedlings in Afghanistan. Washington, DC: U.S. Agency for International Development and U.S. Department of Agriculture, Foreign Agriculture Service, Office of Capacity Building and Development. 63 p.

Post-Harvest Handling of Fleshy Fruits:

1 Collect fleshy fruits in plastic bags or buckets and store them in a cool place until they can be cleaned.[1,2]

Keep fruits out of direct sun to reduce damage to seeds.


Photo by Tara Luna

2 Label each bag or bucket with the species, elevation, collection location, date, and your name.

3 If seeds are not covered by fleshy tissue, rinse them in water and allow them to air dry on a flat surface at room temperature for up to 1 hour. Keep out of direct sun.

If seeds are covered by fleshy tissue, do not allow them to dry out and clean seeds fas soon as possible (best done within a few hours of collection).

To clean:

1. Soak fruits in water for several hours to few days in order to soften the fleshy tissue
2. Change the water every 2-6 hours during soaking to allow for a sufficient amount of oxygen to remain in the water
3. Discard floating seeds, these are usually damaged or empty
4. Remove fleshy tissue by squeezing by hand, mashing the fruits with a wooden block, gently rubbing against a screen under running water, or using a food blender with bladed covered by a thick layer or tape or plastic
5. After the seed and fleshy tissue are separated, slowly add water to the seed and pulp mixture, all of the undesirable components (fleshy pulp and empty seeds) will float and the high quality seeds will sink
6. Remove the undesirable components and rinse the remaining seeds
7. If, after this rinse, seeds require more cleaning, they should be dried (1 to 3 hours)
8. Soak fruits for a few hours to a few days

4 Follow storage directions (*See Section 4.3*).

[2]Bonner, F.T., and R.P. Karrfalt, Eds. 2008. The Woody Plant Seed Manual. Agriculture Handbook No. 727. Washington, DC: U.S. Department of Agriculture, Forest Service. 1,223 p.

Many species of trees and shrubs have seeds that are prone to fungal and bacterial pathogens. Many of these pathogens will significantly decrease seed quality and subsequent germination. Fungal and bacterial presence can be reduced through careful control of the storage environment (i.e. storing seeds in cool, water-free environment, out of direct sunlight). Systematic inspection of each seed batch at least once every month during storage is also important. If seeds become moldy, soft, or discolored there are several things you can do to prevent the speread to the entire seed lot. These are listed below:

A **running water rinse** is a technique used to reduce pathogen damage to seeds.[1] It can be used prior to planting to reduce pathogens and allow seeds to absorb water (which is necessary for germination) or during stratification (if you notice fungal damage while seeds are in storage).[1,2]

1 Place seeds into a mesh bag and tie it to prevent seeds from spilling out.

2 Place bag under a gentle stream of cool, fresh, running water (under a sink faucet or a hose).

3 Allow for the water to rinse the seeds well, try to handle them carefully so they are not damaged in the process.

4 Gently shake the bag to allow for excess water to drip off, dry the seed gently with a towel or napkins if necessary.

5 Sow seeds immediately or place seeds back into the stratification.

If you cannot finish sowing all of the seeds on the same day:

1. *Place seeds back in the mesh bag*
2. *Tie and label the bag with the species name*
3. *Wrap in several moist napkins or a moist towel and wrap in plastic bag, but do not tie the bag closed to allow for some air circulation*
4. *Store in a cool place, preferably a refrigerator*
5. *Sow seeds as soon as possible!*

[1]James, R. L. and D. Genz. 1981. Evaluation of ponderosa pine seed treatments: effects on seed germination and disease incidence. Forest Pest Management Report 81-16. Missoula, MT: U.S. Department Agriculture, Forest Service, Northern Region.13 p.
[2]Kildisheva, O.A. and D.J. Regan. 2012. Seed Treatments for Containerized Seedling Production at the University of Idaho. Forest Nursery Notes 32(1): 10-15.

A **hydrogen peroxide rinse** can also be used for species more susceptible to fungal and bacterial problems.[3] This treatment can sometimes increase germination if used prior to sowing and is particularly useful for species in the *Rosaceae* family.

A **bleach rinse** can be used to disinfect seeds for which water or hydrogen peroxide are not effective in reducing mold[2].

Care should be taken with thin-coated seeds, such as Fraxinus or Acer species, which can be damaged through long exposure to concentrated bleach solutions.

1 Prepare a solution of one part hydrogen peroxide to three parts fresh water.

1 Prepare a solution of one part commercial bleach to five parts fresh water.

2 Place seeds in mesh bag, panty hose, or any other similar material and tie to prevent seeds from spilling.

3 Submerge seeds in solution and swirl the bag around in order to allow the solution to coat seeds evenly.

4 Continue doing this for 5 to 10 minutes.

5 Remove seeds from the solution and rinse the mesh bag thoroughly under fresh running water.

6 Sow seeds immediately or place seeds back into the stratification.

[3]Narimanov, A. A. 2000. Presowing treatment of seeds with hydrogen peroxide promotes germination and development in plants. Biologia 55: 425-428.

The way seeds are sufficiently stored depends on seed type (e.g. orthodox or recalcitrant). Generally, orthodox seeds must be dried prior to storage and can be stored for several years, while recalcitrant seeds should not be dried prior to storage and can be stored for only a short time. A detailed description of the two seed types are provided below:

Orthodox seeds can be stored for long periods of time (years) if they are dried sufficiently (to 10% or less of the original moisture content) without the loss of viability.[1,2] Temperatures below freezing (-1 to -5°C) will increase possible storage duration up to 6 years, but seeds can also be stored above freezing (0 to 5°C) for up to 3 years.

Many orthodox seeds have some level of dormancy, but specific information about which species have orthodox seeds requires annual germination tests of the same seed lots to assess whether viability is lost. Examples of genera with orthodox seeds are listed below:

- Can be stored for >6 years: *Abies, Alnus, Betula, Fraxinus, Larix, Picea, Pinus, Prunus, Tsuga,* and *Acacia*
- <4 years: *Carya, Fagus, Juglans, Pinus, Populus, Salix,* and some *Acer* species

Storing Orthodox Seeds:

1 Dry seeds (*See Section 4.1*).

2 After drying, remove seeds from adjacent tissue (cones, samaras, bracts). This can be done with a cone tumbler or by hand.

3 Place seeds into sealed containers (glass jar with a tight lid). Label with the species name, elevation, collection location, date, and your name.

4 Keep seeds at 0 to 5°C for up to 3 years; conduct a germination test every year to make sure seeds are still viable.

[1]Bonner, F.T.; Karrfalt, R.P., Eds. 2008. The Woody Plant Seed Manual. Agric. Handbook No. 727. Washington, DC: U.S. Department of Agriculture, Forest Service. 1,223 p.

Recalcitrant seeds cannot be dried and should stay between (25 and 45% of the original moisture content) but can be stored for short periods of time at low temperatures (-3 to 4°C).[1,2]

Generally, recalcitrant seeds are covered with fleshy or juicy tissue which helps maintain the seeds in a high-moisture environment. Specific information about which species have recalcitrant seeds requires annual germination tests of the same seed lots, but general examples of genera with recalcitrant seeds are listed below:

- Can be stored for several month to several years: *Aesculus, Quercus, Persea,* and some *Acer* species

Storing Recalcitrant Seeds:

1 Prepare seeds for storage, but **do not dry** them (*See Section 4.1*).

2 Place growing media in a large plastic bag and moisten to the extent that when squeezed a little water drips off.

3 Place seeds into the plastic bag filled with media and tie closed.

4 Label each bag with the species, elevation, collection location, date, and your name.

5 Seeds can be stored for a few months at -3 to 4°C, but should be monitored periodically for pathogen problems and rinsed if problems occur (*See Section 4.2*).

General Consideration for Seed Storage:

- Clean seeds from plant material (i.e. fruit tissue, seed appendages, bracts, etc.)
- If storing orthodox seeds, make sure seeds remain in a sealed container and do not absorb moisture during storage
- Maintaining stable temperatures and moisture levels in the storage area is critical
- Frequent germination tests (at least once a year) are an important way to assess the quality and storability of each seed lot

[2]Dumroese, R. K., Landis, T.D., Luna, T., and G. Hernandez. 2008. Simple methods for raising tree and shrub seedlings in Afghanistan. Washington, DC: U.S. Agency for International Development and U.S. Department of Agriculture, Foreign Agriculture Service, Office of Capacity Building and Development. 63 p.

Section 4.4: *Seed Imbibition Test*

Seeds must absorb water in order to germinate. However, seeds that are physically dormant are impermeable to water. A simple way to determine whether seeds can take up water is through an imbibition test.[1] The steps below outline the procedures:

1 Separate 100 to 400 seeds into four equal sets (samples).

2 Weigh seeds and write down the weight for each sample.

3 Place seeds into a mesh bag or pantyhose and tie the ends to make sure seeds do not fall out.

4 Place in bucket and soak for 48 hours in running water, or if running water is not available use an aquarium bubbler and change water at least every 6 hours.

5 After 48 hours, remove the seeds and spread them out on a napkin and pat dry, so there is no water on the seed surface.

6 Weigh the seeds and record the weight. Subtract the original weight from the new weight to determine if the seeds absorbed water.

[1]Bonner, F.T., and R.P. Karrfalt, Eds. 2008. The Woody Plant Seed Manual. Agriculture Handbook No. 727. Washington, DC: U.S. Department of Agriculture, Forest Service. 1,223 p.

Germination testing is a common procedure used to determine the quality, viability, and vigor of seeds prior to sowing.[1] This information can help growers gauge the number of seeds and containers necessary to produce the desired number of seedlings. If seeds are not damaged by pathogens, but they do not germinate, it can indicate the presence of seed dormancy. Dormant seeds require treatment prior to sowing. The sections below outline the steps necessary to conduct a germination test:

1 Separate 100 to 400 seeds into four equal sets (samples).

2 Fold several napkins (10 mm thick) and soak them in water; allow for the extra water to drip off, you should have 4 sets of moist, folded napkins.

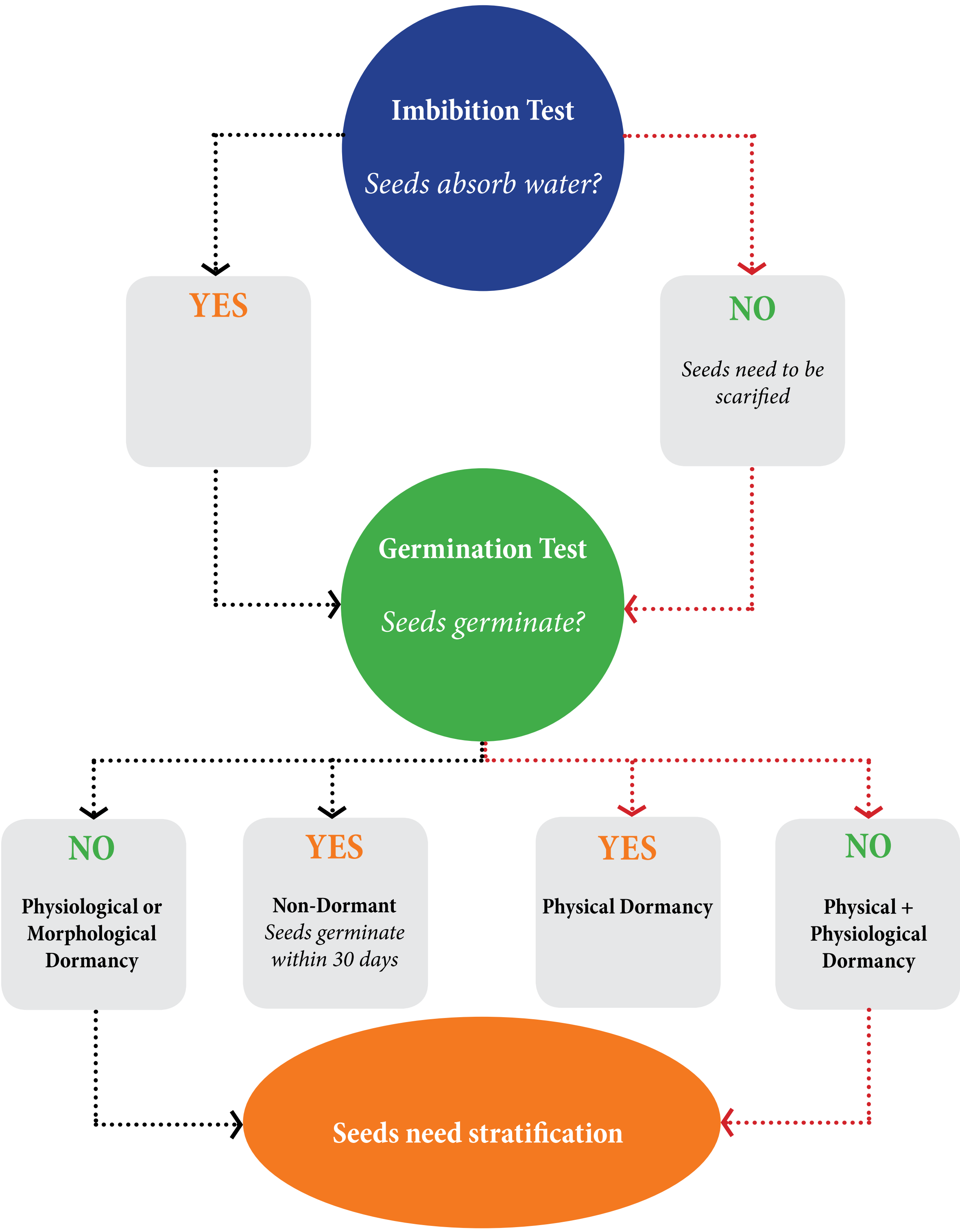
3 Place napkins into four containers and spread seeds evenly over the napkin surface. Close the lids or wrap a transparent plastic bag over the containers.

4 Place the containers or plates in a location which remains at room temperature (21-23°C) and receives some light (be sure to not put containers in direct sunlight).

5 Check on the seeds every 1 to 5 days for 30 days, writing down the seeds that germinate every time you check and removing the germinated seeds.

[1]Bonner, F.T., and R.P. Karrfalt, Eds. 2008. The Woody Plant Seed Manual. Agriculture Handbook No. 727. Washington, DC: U.S. Department of Agriculture, Forest Service. 1,223 p.

Seed dormancy is an evolutionary characteristic exhibited by seeds of many species. Determining the type of dormancy a seed possesses is the first step in improving germination.[1,2] The diagram below will guide you through identifying the type of seed dormancy:



[1]Baskin, C.C. and J.M. Baskin. 1998. Seeds: ecology, biogeography, and evolution of dormancy and germination. San Diego (CA): Academic Press. 666 p.
[2]Luna, Tara., Wilkinson, Kim. and R.K. Dumroese. 2009. Chapter 8: Seed germination and sowing options. Dumroese, R.K., Luna, T., and T.D. Landis, Editors. Nursery manual for native plants: A guide for tribal nurseries - Volume 1: Nursery management. Agriculture Handbook 730. Washington, D.C.: U.S. Department of Agriculture, Forest Service. 133-151 p.

Physiologically and morphologically dormant seeds often require a period of cold (1 to 5°C) and/or warm (22 to 30°C) stratification to before sowing in order to germinate.[1] Below is a step-by-step description of stratification:[2]

1 Place seeds in a labeled mesh bag and tie it closed.

2 Mix and moisten media to the extent that only a small amount of excess water drips off when the media is squeezed in your hand.

3 Fill a plastic bucket with the media and place the mesh bag with the seeds in the center of the bucket, making sure that the seeds are completely covered by the media.

4 Place a plastic bag tightly around the top of the bucket and poke 25 small holes in the plastic. Label the bucket with the species name and date.

5 Place the bucket in the refrigerator set to 1 to 5°C or 22 to 30°C.

6 Take the seeds out every 2 weeks and rinse them under clean, running water to eliminate any fungus and monitor their status.

7 Write down the species, date, and status of the seeds each time you check on them.

If seeds begin to germinate, they need to be sown as soon as possible.

[1]Bonner, F.T., and R.P. Karrfalt, Eds. 2008. The Woody Plant Seed Manual. Agriculture Handbook No. 727. Washington, DC: U.S. Department of Agriculture, Forest Service. 1,223 p.

[2]Kildisheva, O.A. and D.J. Regan. 2012. Seed Treatments for Containerized Seedling Production at the University of Idaho. Forest Nursery Notes 32(1): 10-15.

The frequency of irrigation can depend on many factors such as air temperature, sunlight, relative humidity, efficiency of the irrigation system, container type, seedlings size, etc. Although tactile assessments can be used to guide irrigation, this method is often inconsistent and can result in reduced growth and development of seedlings. By developing a gravimetric weight scale, the grower can track water availability more precisely and assess potential water stress (often not apparent through tactile assessment). To create and use a gravimetric weight scale, please follow the steps below:

1 Begin by watering the entire crop to full saturation (or field capacity).

The time required to reach saturation will depend on the media and irrigation system, but the point at which water begins to drip from the bottom of the containers indicates full saturation.

2 Select a minimum of one tray within each crop (if you have several different watering zones, make sure that you have selected at least one tray in that zone).

3 Mark the trays so you can find them easily (attaching flagging, twine, or a wire handle can make locating and lifting the containers easier).

4 Allow one hour to pass.

5 Weigh the selected trays.

6 Write down:
a. species
b. weight
c. location, and/or watering zone

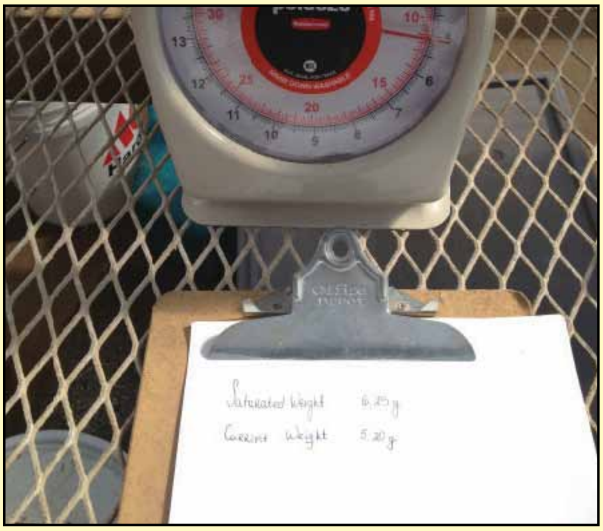
The information you recorded is the saturated weight (field capacity) of that container and will be the basis for determining when to irrigate.

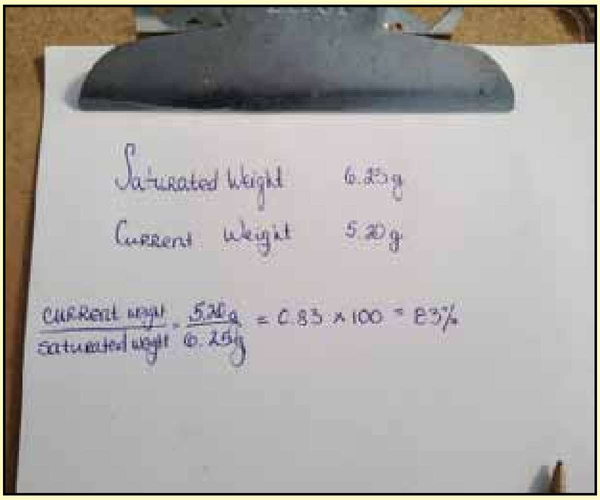
7 When finished weighing, return the trays to their original locations.

8 Wait 24 hours before weighing the tray again.

9 Re-weigh each of the designated trays, writing down the new weight.

10 Divide the new weight of the tray by the original weight, then multiply the result by a 100 to determine the percent water content (percent saturation) of the containers.





11 Use the calculated percentage to determine whether seedlings need to be irrigated.

The desired saturation values for each crop should be set at the beginning of the growing season and should change systematically throughout the season in correspondence with the growth phase of the crop (See Section 3.2).

12 Repeat on a daily basis.

When temperatures are above 35°C, container weights should be measured more frequently.

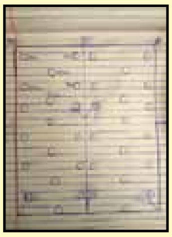
Section 5.2: *Assessing Irrigation Uniformity within a Watering Zone*

Regardless of the type of overhead irrigation system used at your nursery, problems with irrigation uniformity can arise for various reasons such as system design, plugging of nozzles, and general wear on equipment. Uneven irrigation can cause problems in crop production and should be monitored monthly. A simple technique for checking irrigation uniformity is through conducting a "cup test".[1] Follow the steps below to perform the test:

1 Select a crop watering zone.

2 Arrange equal sized cups (disposable plastic cups work well) in an evenly spaced grid throughout the crop.

3 Draw a simple map that describes the location of cups and nozzles (for fixed irrigation systems).



4 Irrigate the zone for 10 minutes.

5 Turn off the irrigation.

6 With a graduated cylinder measure the amount of water that has collected in each cup and put that number next to the location of that cup on your map.

If a graduated cylinder is not available, use a ruler and measure the depth of water in each cup.

7 Some variation in the results is natural, but if you see dramatic differences examine the irrigation nozzles, hose, and other components to find the potential problem.

If nozzles become clogged, soak them in a solution of household vinegar and/or clean them with a small wire to dislodging nutrient buildup.

[1]Landis, T.D.; and K.M. Wilkinson. 2009. Chapter 10: Water quality and irrigation. In: Dumroese, R.K., Luna, T., and T.D. Landis, editors. Nursery manual for native plants: A guide for tribal nurseries - Volume 1: Nursery management. Agriculture Handbook 730. Washington, D.C.: U.S. Department of Agriculture, Forest Service. p. 177-199.

Inherently, growing media used in nurseries contains a very small amount of nutrients. Therefore, necessary nutrients are provided through added fertilizers. Essential nutrients can be broken up into macro- and micronutrients.[1] Macronutrients are required in relative large quantities, while micronutrients are only necessary in small amounts.

Macronutrients

N	Nitrogen	• A part of chlorophyll - the green plant pigment is necessary for photosynthesis • Aids plants with rapid growth
S	Sulfur	• Aids in protein and chlorophyll formation • Promotes root growth • Improves plant cold tolerance
P	Phosphorus	• Essential for photosynthesis • Aids in proper plant maturation • Improves plant stress tolerance • Promotes rapid growth • Encourages blooming and root growth
K	Potassium	• Aids in photosynthesis • Improves stress tolerance • Reduces disease
Ca	Calcium	• Responsible for nutrient transport and retention • Improves plant strength
Mg	Magnesium	• Essential for photosynthesis • A necessary component in promoting plant growth
Si	Silicone	• Improves plant stress tolerance

Micronutrients

Fe	Iron	• Necessary for chlorophyll formation
Mo	Molybdenum	• Aids in nitrogen use
B	Boron	• Necessary for nutrient use and regulation • Aids in energy production
Cu	Copper	• Essential for reproduction • Promotes root development
Mn	Manganese	• Necessary for use of stored energy
Na	Sodium	• Aids in photosynthesis • Helps maintain turgor
Zn	Zinc	• Necessary for use of stored energy • Helps regulate growth
Ni	Nickel	• Improves growth
Cl	Chlorine	• Necessary for metabolism

[1]Landis, T.D. 1989. Mineral nutrients and fertilization. In: Landis, T.D.; Tinus, R.W., McDonald, S.E., and J.P. Barnett. The Container Tree Nursery Manual, Volume 4. Agriculture Handbook 674. Washington, DC: U.S. Department of Agriculture, Forest Service. p.1-67.

Nutrients must be available in a mineral form that is conducive to plant absorption. Monitoring your fertilizer selections for the presence of all necessary mineral nutrients before application will allow for the production of healthy seedlings. This can be achieved through regular monitoring (*See Sections 2 and 3.2*). **Nutrients can be added to the growing media in form of (1) slow release or (2) soluble fertilizers.[1] The section below describes the principles of each method and the advantages and disadvantages of each:**

Slow-release fertilizers come in the form of capsules that have been manufactured to contain a suite of nutrients.[1] Once irrigation water reaches the capsules, they expand slightly, allowing for some nutrients to be released into the growing media.

For seedling production, slow-release pellets should be pre-mixed into growing media before containers are filled and seeds are sown. Top dressing containers or pots with slow-release pellets is also an option, though less effective.

To select an appropriate slow-release fertilizer consider the following:

1 Does the selected fertilizer contain all of the necessary macro- and micronutrients?

2 How long do seedlings need to be fertilized?
In order to produce a quality crop by the target date, fertilization must occur at the appropriate rate and correspond with plant development throughout the growing season. Slow-release fertilizers are designed to release nutrients for a predetermined duration, which is stated on the product label.

Products like Basacote® 6M PLUS, are rated to release nutrients for over 6 months (majority of the growing season).

3 What are the average temperatures in your greenhouse during the growing season?
The rate of nutrient release is dependent on the moisture and temperature of the growing media. It is important to examine the product label where duration and release rates are specified. Fertilizer release rates are calculated for a target temperature and moisture level. If the average growing season temperatures at the nursery are higher than those stated on the product label, the grower must account for the increased nutrient release rates.

Soluble fertilizers come in a number of different forms, usually consisting of dry powder or granules. A grower must acquire fertilizers that supply plants with all the nutrients required on development. Usually several types of nutrients must be mixed together to reach an appropriate fertilizer formulation.

The specific fertilizer solution is then distributed through the injection system to a network of distributing sprinklers or a traveling overhead boom.[1,2]

Considerations for soluble fertilizers:

1 **Does the selected fertilizer solution account for ample amounts nitrogen, phosphorous, and potassium? Does it contain necessary macro- and micronutrients?** (*See next page*)

2 **Are the dilution rate, injection rate, and number of seedling taken into consideration in the fertilizer calculation?**

3 **Are the injector, sprinklers, or boom calibrated to ensure sufficient and not toxic levels of fertilizer solution are reaching plants?**

Remember to make sure that your fertilizer injector has a backflow preventer, to eliminate the possibility of fertilizer re-entering the water line and contaminate drinking water!

[2] Nelson, PV. 1978. Greenhouse operation and management. Reston, VA: Prentice-Hall, Inc. 518 p.
[3] Matthews, R.G. 1986. Personal communication. British Columbia Ministry of Forests, Victoria, BC.
[4] Matthews, R.G. 1983. Seedling production for Crown lands in British Columbia: guidelines for commercial container nurseries. Victoria, BC: British Columbia Ministry of Forests, Silviculture Branch; 1983; 45 p.65

Slow-Release Fertilizers [1,2,3,4,5]	
Advantages	**Disadvantages**
• Low-tech fertilizing option • No injectors/pumps are needed • Requires a one-time application at the start of the growing season • Lower labor costs (less time spent fertilizing) • Less room for error	• Controlling balance and concentration of nutrients is not possible without labor intensive amendments • Distribution of slow-release pellets is not always uniform across containers in a large crop (though this can be minimized with careful mixing procedures)

Soluble Fertilizers [1,2,3,4,5]	
Advantages	**Disadvantages**
• Precise control of the balance and concentration of nutrients at each irrigation event • The ability to adjust fertilizers, nutrients, and concentrations at each irrigation event • Low chance of over- or under-fertilizing a crop; which can prevent salt build up, or nutrient deficiencies	• Requires specialized injection and an irrigation systems that can evenly distribute fertilizer • Demands precise calculations and mixing of fertilizers to provide the spectrum of nutrients needed for plant development • Higher labor cost due to regular mixing and application of fertilizers • Requires regular measurement and calibrations

[5] Matthews, R.G. 1982. Contrasting approaches to containerized seedling production: 1. British Columbia. In: Scarratt, J.B., Glerum, C., and C.A. Plexman, Eds. Proceedings of the Canadian Containerized Tree Seedling Symposium; 1981 September 14-16; Toronto, ON. COJFRC Symposium Proceedings O-P-10. Sault Ste. Marie, ON: Canadian Forestry Service, Great Lakes Forest Research Centre p. 115-122.

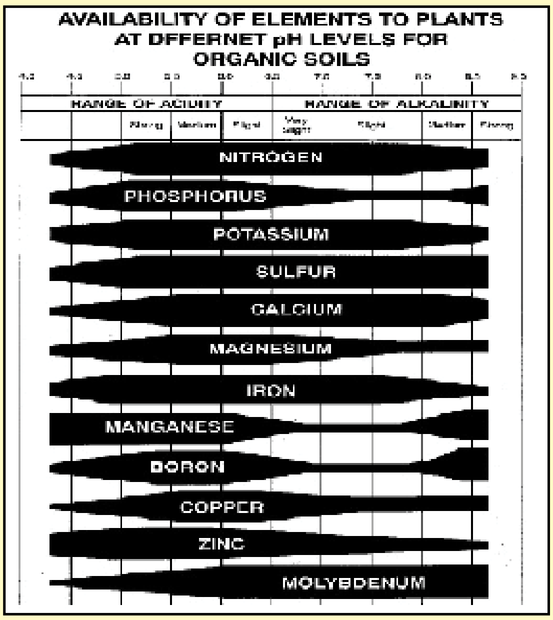
Container media is the reservoir for a seedling's nutrients. Problems in the reservoir that restrict the plants ability to absorb nutrients will cause seedlings to experience deficiencies. pH and electrical conductivity (EC) can be used as indicators of nutrient status and growing conditions in the media.

pH is a measure of hydrogen ion activity and indicates how acidic or basic (alkaline) a solution is at a given temperature.[1,2]

Battery acid	1	Strongly acidic
Pure water at 23°C	7	Neutral
Lye	12	Strongly Basic

Nutrient absorption is influenced by pH and different nutrients have specific pH ranges for optimal plant absorption. The optimal pH for conifers is 5.5 and 6.5 for broadleaf species[3].

Growing media that is either too acidic or too basic may cause reduced absorption of certain nutrients by the plant. The presence of natural minerals in irrigation water (e.g. calcium) can increase the pH, making the media more basic.



EC is a measure of electrical conductivity.[1,2] Pure water is a poor conductor, while salts in solution are good conductors of electricity. Fertilizers are considered to be salts. As the amount of fertilizer in solution increases, its electrical conductivity increases and so does the EC measurement values.

Excessive salt levels can be detrimental to root growth, cause salt burns, and harm seedling development. However, an EC value is not an absolute measurement; a trend seen over the entire growing season is more important than a one-time measurements.

An EC value that is high may indicate poor drainage in the containers, which causes the build-up of nutrients in the media. An EC value that is low may indicate a lack of nutrient retention in the media.

0-1 mS/cm	very low	sufficient for early phase
1-2.5 mS/cm	low	good for early phase
2.5-4.6 mS/cm	normal	good for middle phase
4.6-6.5 mS/cm	high	dangerous in warm temperatures (>25°C)
6.6-7.8 mS/cm	very high	damage to plants
> 7.8 mS/cm	dead plants	severe root damage
*values will vary slightly by species[3]		

[1]Fisher PR, and W.R. Argo. 2005. Electrical conductivity of growing media: why is it important? GMPro 25(5):54-58.
[2]Cregg, B.M. 2005.Conifer Nutrition. Michigan Landscape Magazine. September/October: 42-45.
[3]Dumroese, R.K. 2012. Media Electrical Conductivity Readings in Container Nurseries: Why Bother? Usefulness, Meters, Conducting Tests, and Interpreting Results. PPT presentation. USFS Rocky Mountain Research Station. Moscow, Idaho.

Systematic pH and EC measurements throughout the growing season can be used as tools to gauge fertilization practices and make changes in order to maintain a productive root environment. Take and record pH and EC readings regularly and evenly across your crops. Over time you will accrue data that will help you determine the ideal pH and EC values for the production of healthy seedlings at your nursery. The steps below describe the "pour-thru" method for taking EC and pH measurements.[3,4]

You will need:

- pH meter(s)
- EC meter(s)
- Distilled water (with a pH ~ 7 and EC of ~0)
- Nursery water (used for crop irrigation)
- Clean cups or beakers (>50ml)
- A sample of plants (≥10 seedlings; ≥ 3 trays)

1 Begin by calibrating your meters. For a pH meter use at least two buffer solutions. Follow the directions provided with your unit carefully.

2 Take baseline readings of both the distilled water and the local water source.

Complete before using both the pH and EC meters.

3 Place cups or beakers beneath the containers that you will be measuring.

The vessel should have enough room to hold 50ml.

4 Begin to pour distilled water through the selected containers.

Start by pouring 25ml, then add 25ml every minute. Stop when you see that at least 50ml of leachate has accumulated in the cups below the containers.

5 Wait at least 15 minutes for the leachate to settle, then begin measurement.

- *Let the sensor sit in a solution until it is stable then record that value*
- *Make sure all the leachate solutions have settled for the same amount of time*
- *Between measurements, rinse the sensor on the meter with distilled water*

[4]Whipker, B.E., Cavins, T.J., and W.C. Fonteno. 2001. The 1, 2, 3's of PourThru. [http://www.ces.ncsu.edu/depts/hort/floriculture/Florex/PourThru%20Handout%20123s.pdf] (Accessed 24 May 2006). Raleigh (NC): North Carolina State University. Department of Horticultural Science.

After each growing season, containers will be covered with used media, root particles, and invisible pathogenic organisms. Vectors for liverworts, moss, algae and many weed species will also be present. In order to reuse these containers, without spreading disease to your new crop, be sure to sterilize the containers. In addition to sterilizing containers, areas of seed storage and those associated with plant propagation (i.e. greenhouse benches, outdoor growing areas, media storage rooms, pumps, injectors, and irrigation systems) should also be cleaned.[1]

To clean containers:

Prior to sterilization, wash containers under running water to remove media and other debris that may remain on the container walls.

The Bleach Method:

Household bleach can be used effectively as a disinfectant.

Wear protective equipment!

1 Mix a solution of 1 part bleach to 9 parts water.

2 Place mixture in a large volume (i.e. a holding tank, large tub).

3 Dip the containers in solution.

4 Store containers in a clean unexposed area (or covered by plastic or tarp) until next use.

The Heat Method:

Steam, aerated steam, or dry heat can be used to effectively disinfect containers.

1 Using a metal dip tank or other mechanical techniques, make sure temperatures are maintained between 75 and 85°C inside the unit (temperatures closer to 80°C achieve the best results). Do not use higher temperatures, as they may damage the containers.[2]

3 Allow containers to remain in the sterilization environment for at least 30 seconds. Make sure that high temperatures are maintained for the entire duration.

[1]Landis T.D., Tinus, R.W., McDonald, S.E., and J.P. Barnett. 1989. The biological component: nursery pests and mycorrhizae. The container tree nursery manual. Volume 5. Washington (DC): USDA Forest Service. Agricultural Handbook 674. 171 p.
[2]Baker, K.F., and C.N. Roistacher. 1957. Heat treatment of soil. In: Baker, K.F. The U.C. system for producing healthy container-grown plants. California Agriculture Experiment Station Extension Service, Manual 23. Parramatta, Australia: Australian Nurserymen's Association Ltd.: 123-137.

To clean greenhouse and plant propagation areas:

Prior to sterilization, sweep and wash floor (if appropriate) with running water to remove media and other debris that may remain from the growing season.

1 Mix a solution of one part bleach to nine parts water. Wear protective equipment!

2 Place mixture in a backpack sprayer or a spray bottle.

3 Spray the solution in the desired areas, trying to cover the surfaces uniformly.

General Pest Control Measures:

Prevention of phytosanitary issues can be achieved by following a few simple practices.

Animal and Insect Pests:

Create physical barriers to deter insects, rodents, birds, and other pests from your crop

Elevated tables, mesh screens, nets, concrete or cinder block walls can be used as physical barriers

Biological control measures such as cats, and predatory insects, or physical traps can be used to eliminate insects that are already present

Fungal and Bacterial Pests:

Keeping the nursery clean should be one of the top priorities

Remove potential disease vectors (e.g. weeds, infected or dead plants, plant material brought in from other areas)

Sweep and remove dead/decaying organic materials regularly

Make sure that a constant air flow is maintained in the growing environment

Reduce standing water

[2]Baker, K.F., and C.N. Roistacher. 1957. Heat treatment of soil. In: Baker, K.F. The U.C. system for producing healthy container-grown plants. California Agriculture Experiment Station Extension Service, Manual 23. Parramatta, Australia: Australian Nurserymen's Association Ltd.: 123-137.

Appendix: *Additional Resources*

The list below provides supplemental information that you may find useful:

Youtube channel with video tutorials for various topics disscussed in this manual:
http://www.youtube.com/TargetSeedlings

Electronic resources and publications from the University of Idaho Center for Forest Nursery and Seedling Research: http://research.uidaho.com

Books and Manuals:

Navarrete, P.; Navarro, M.A.; Cerrillo, R.; Palacios Rodríguez, G.; Chnais, E.; and Salman, H. (2011). Forest nurseries in Lebanon for native species production. Gland, Switzerland and Malaga, Spain: IUCN, Cordoba, Spain: University of Cordoba-IDAF, and Beyrouth, Lebanon: Association for Forest Development and Conservation. 120 p.

Dumroese, R.K; Landis, T.D.; Luna, T.; Hernandez, G. 2008. Simple methods for raising tree and shrub seedlings in Afghanistan. Washington, DC: U.S. Agency for International Development and U.S. Department of Agriculture, Foreign Agriculture Service, Office of Capacity Building and Development. 63 p.

Dumroese, R.K.; Luna, T.; Landis, T.D., editors. Nursery manual for native plants: A guide for tribal nurseries - Volume 1: Nursery management. Agriculture Handbook 730. Washington, D.C.: U.S. Department of Agriculture, Forest Service. 302p.

Dumroese, R.K., T.D. Landis, T. Luna. 2012. Raising native plants in nurseries: basic concepts. Gen. Tech. Rep. RMRS-GTR-274. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 84 p.

Baskin, C.C. and Baskin, J. M. 1998. Seeds: ecology, biogeography and evolution in dormancy and germination. San Diegeo, CA: Academic Press. 666 p.

Bonner, F. T. and R.P. Karrfalt. 2008. The Woody Plant Seed Manual. Agricultural Handbook No. 727. Washington, DC: U.S. Department of Agriculture, Forest Service. 1,223 p.

Substance:

	Health Risk
	Flammability
	Physical Hazard
	Protective Wear

Details:

Substance:

	Health Risk
	Flammability
	Physical Hazard
	Protective Wear

Details:

Substance:

	Health Risk
	Flammability
	Physical Hazard
	Protective Wear

Details:

Substance:

	Health Risk
	Flammability
	Physical Hazard
	Protective Wear

Details:

Name:
Date:

The Daily Checklist

Daily Task	Completed	Notes
Walk through the entire nursery and take a look at all of the crops; take note of any problems or tasks that needs to be done today	☐	
Write down the temperature (take note of the temperature variation throughout the plant production area, if multiple thermostats are available)	☐	Location: Time: High (C°): Low (C°):
Weed the area around the plants	☐	
Check the sprinkler nozzles to make sure they are attached/clean	☐	
Check whether plants need extra perlite, thinning, or sorting	☐	
Take block weights of all of the crops	☐	

Name: ***Week:***				
The Weekly Log				
Tasks:	**Duration:**	**Number of people required:**	**General Notes:**	
Orders:			**Purchases:**	
Species:	**Seedling number:**	**Purchaser:**	**Item/Service:**	**Amount:**

Name:
Date:

The Daily Irrigation Log

Species	Crop phase	Gravimetric weight per tray	Fertilization (rate, type)	Irrigation (amount/duration)

Notes

Notes

Notes