Using container weights to determine irrigation needs: a simple method

R Kasten Dumroese, Mark E Montville, and Jeremiah R Pinto

ABSTRACT

Proper irrigation can reduce water use, water waste, and incidence of disease. Knowing when to irrigate plants in container nurseries can be determined by weighing containers. This simple method is quantifiable, which is a benefit when more than one worker is responsible for irrigation. Irrigation is necessary when the container weighs some target as a proportion of its weight at field capacity. Care should be taken when comparing target container weights because they can be calculated different ways. In the nursery, one easy method for obtaining weights is using a small, handheld portable balance.

Dumroese RK, Montville ME, Pinto JR. 2015. Using container weights to determine irrigation needs: a simple method. Native Plants Journal 16(1):67–71.

KEY WORDS
overhead irrigation, subirrigation, block weight, target weight, fertigation

NOMENCLATURE
USDA NRCS (2014)

In container nurseries, water is the most important, and perhaps the most dangerous, chemical used (Dumroese 2012). Although water is essential for plant growth, too much water can result in root and foliage diseases, and increased problems with cryptogams and insect pests, such as fungus gnats, the latter also being an important disease vector (James and others 1994, 1995; Landis 1998; Dumroese and James 2005; Dumroese and others 2006). Too frequent or excessive amounts of irrigation can result in leaching of nutrients and other chemicals from the medium with the potential to degrade surface and groundwater (Dumroese and others 1992, 1995; Juntunen and others 2002, 2003). Too little irrigation can promote the buildup of salts in the medium, which can harm root systems or even lead to seedling mortality (Landis and others 1989; Landis and Wilkinson 2014). Moreover, the frequency and amount of irrigation applied to crops can be a powerful tool during the hardening process; generally, reducing irrigation frequency promotes changes in seedling morphology that yields seedlings better conditioned for outplanting (Jacobs and Landis 2008).

Determining when to irrigate and how much to apply during an irrigation are, therefore, critical to proper irrigation

applications. Although nursery managers can determine when to irrigate based on tactile properties, sensors, or crop vigor, these methods do not generally supply the information necessary to know how much irrigation water needs to be provided (Landis and Wilkinson 2014). Moreover, qualitative methods such as tactile require a great deal of experience by the individual to be consistent. And, consistency among staff can also be hard to achieve; what one staff person considers "dry" another might consider "moist."

Gravimetric (weight-based) methods that rely on measuring the loss of water from the containers are common techniques for determining when and how much to irrigate (White and Mastalerz 1966; Landis and others 1989; Dumroese and others 2012; Landis and Wilkinson 2014). This simple method requires measuring the weight of a sown container when it is at field capacity (that is, the medium is irrigated until fully saturated and then allowed to freely drain for 30 to 60 min), and then subsequently reweighed at regular intervals (every day or

Some caution should be used when comparing "target container weights" because this can be measured different ways. For example, in operational settings, nursery managers often simply weigh the sown container at field capacity and, based on data from their facility, select a target container weight as a percentage of that field capacity weight. Because individual weights contributed by the medium, topdressings, the container (for example, Styrofoam block, Ray Leach "Cone-tainer" system, or Jiffy peat pellet system), and the water are not determined, the amount of water required to bring the container back to field capacity cannot be directly calculated. Many handbooks present this "manager technique" (Dumroese and others 1998, 2012; Landis and Wilkinson 2014) because it is simple. Although the "how much water is needed" question cannot be directly answered, growers can quickly determine from experience how long their irrigation system must run to bring containers to field capacity, and, to add about 10% more to ensure some drainage is occurring to prevent buildup of salts (Landis and others 1989).

For research papers published in journals, this calculation is often more refined, particularly if the scientists desire a more discrete idea of water depletion. Researchers therefore determine the individual weights for the empty container and oven dry weights of the medium and topdressing. The sum of these values is subtracted from the field capacity weight to obtain the weight of water. The target weight is based on a percentage of the actual weight of water "lost" through evaporation and transpiration. Because a kilogram of water equals a liter of water, this "scientist technique" yields an accurate estimate of the amount of irrigation to apply and allows scientists to avoid confounding irrigation and fertilizer amounts in their experiments (Dumroese and others 2011). Unfortunately, scientists, including ourselves, are often guilty of not explicitly stating how the target is calculated (for example, Zhu and others 2013). The take-home point is, however, that for a given target percentage, the manager technique will result in drier medium between irrigation events than will the scientist technique. Here is an example assuming an initial container field capacity of 16.2 kg and a desire to irrigate at a 70% target.

Scientist Technique

Container field capacity – (sum of empty container, oven-dry medium, seed covering) = water in medium at field capacity

16.2 kg – (4.7 kg + 1.2 kg + 2.3 kg) = 8.0 kg water

Water in medium at field capacity × 70% target = water available at 70% field capacity

8.0 kg × 0.7 = 5.6 kg water

Water available at 70% field capacity + (sum of empty container, oven-dry medium, seed covering) = target container weight

5.6 kg + (4.7 kg + 1.2 kg + 2.3 kg) = 13.8 kg

Manager Technique

Container field capacity × 70% target = target container weight

16.2 kg × 0.7 = 11.3 kg

Target container weight – (sum of empty container, oven-dry medium, seed covering; assumed the same as above because not measured with this technique) = water available at 70% field capacity

11.3 kg – (4.7 kg + 1.2 kg + 2.3 kg) = 3.1 kg water

Thus, seedlings cultured with irrigation determined using the scientist technique (5.6 kg) would have 80% more water than those grown using the manager technique (3.1 kg) at the 70% target even though the target container weight is only 22% greater (13.8 as compared with 11.3 kg, respectively).

so) identifying when irrigation is necessary. This technique works for any type of irrigation system, including subirrigation (Pinto and others 2008).

Irrigation is one of the idiosyncratic variables of a nursery. Depending on the media used, container depth, species, and the philosophy of the nursery manager, each manager should measure container weights, record them, and evaluate seedling growth over time to hone in on the irrigation schedule that yields the best seedling quality. Because the target container weight for irrigation can be measured in different ways (manager technique versus scientist technique; see sidebar), consistency in the technique, rather than the technique used, is most important. Some guidelines for container weights using the manager technique have been published (for example, Dumroese and others 1998, 2012; Landis and Wilkinson 2014), but these should be used as starting points for any nursery and should be evaluated throughout the growing season, because, for example, Dumroese and others (2011) found that for *Pinus ponderosa* Douglas ex Lawson & C. Lawson (Pinaceae) target weights could be reduced substantially with little to no effect on seedling morphology. Therefore, we encourage you to conduct your own trials within your unique setting following the guidelines of Wilkinson and Haase (2014).

We have observed that nurseries have devised several methods for measuring container weights. In smaller nurseries, containers are often carried to a central location where a single balance is used to measure the container weight (Figure 1). Larger nurseries often use a cart to transport a balance to various locations within the facility (Figure 2), or sometimes multiple balances are left in place under containers on various greenhouse benches (Figure 3). All of these methods have advantages and disadvantages.

The PRT Oregon nursery in Hubbard grows more than 70 stocktypes for a total of 10 million seedlings annually, and each stocktype is regularly evaluated for container weight. Therefore, an inexpensive, easy-to-use, and flexible system was required. The solution was to use wire hangers manufactured for hanging floral baskets. Staff take the four, 57-cm-long (22.5 in) wires that have a hook crimped at the end and string each wire through the air vents in the Styrofoam containers, twisting them together underneath so that the container can "hang" like a floral basket. This could, most likely, be done for any type of container that has air vents and is reasonably rigid. PRT Oregon staff record about 120 block weights per summer day using a portable, handheld, digital balance (Figure 4). Without otherwise moving the container, the hook on the balance is looped

Figure 1. Carrying containers to a stationary balance is one way to determine container weights. This works well where distances are short and only one balance is required. Photo by R Kasten Dumroese

Figure 2. A balance on a cart can be rolled to various locations within the nursery, reducing the amount of time spent transferring containers to and from the balance. Photo by R Kasten Dumroese

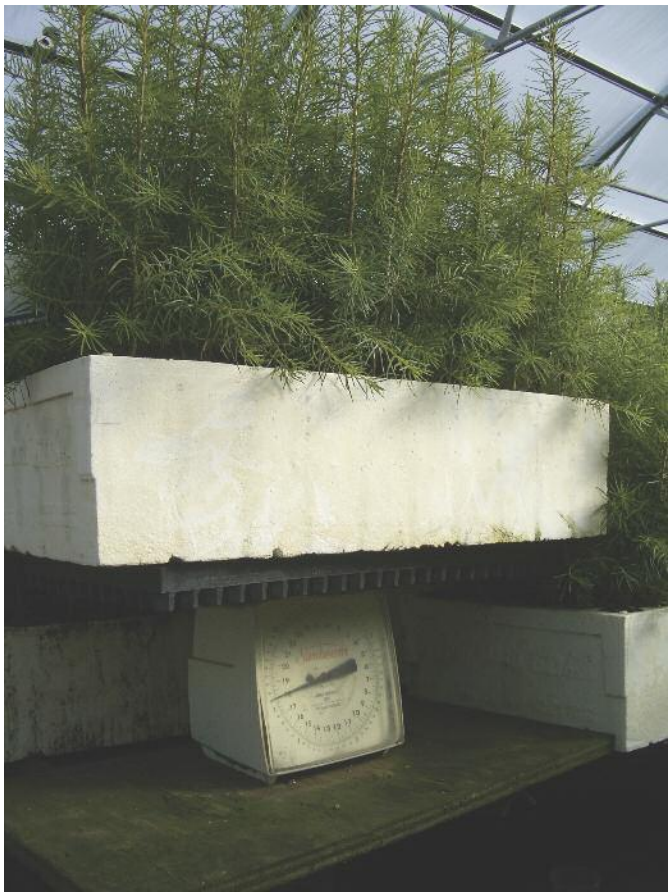

Figure 3. A balance left in place to measure container weights requires no movement of containers or balances, but many balances are needed when multiple species and stocktypes are produced. Photo by R Kasten Dumroese

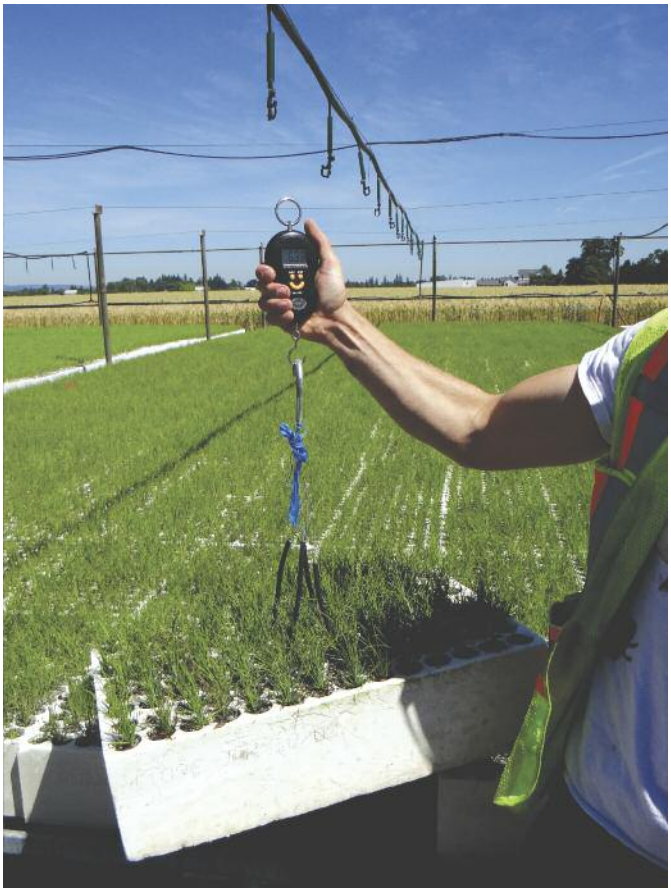

Figure 5. A container fitted with basket hangers has its weight measured with an inexpensive, portable, handheld, digital balance. Photo by R Kasten Dumroese

Figure 4. This digital, handheld Chestnut Tools Portable Electronic Scale is used to obtain container weights. Photo by Mark E Montville

around the crimped hook, and by simply lifting the container upward the container weight can be immediately read (Figure 5). That weight is recorded and compared to target weights to determine if irrigation is required. The wires are recycled from year-to-year. You may be able to find used wires that can be recycled, or they are available from nursery supply companies, ranging in price from US$ 0.40 to 2.40 each. The balance used at PRT Oregon is the Chestnut Tools Portable Electronic Scale (see Figure 4) that sells for about US$ 13 (Lee Valley Tools Ltd; http://www.leevalley.com). This particular unit can be set to English or metric units, will convert units, and is 99% accurate for loads ≥ 1 kg (2.2 lb) to a maximum of 40 kg (88 lb); it shows weights to the nearest one-hundredth, more than enough accuracy.

ACKNOWLEDGMENTS

We thank Drs Thomas D Landis and Robert R Tripepi for their thoughtful comments on an earlier draft. The use of trade or

firm names is for reader information and does not imply endorsement by the USDA Forest Service of any product.

REFERENCES

Dumroese RK. 2012. Integrated nursery pest management. In: Cram MM, Frank MS, Mallams KM, technical coordinators. Forest nursery pests. Washington (DC): USDA Forest Service, Agriculture Handbook 680. p 5–12.

Dumroese RK, James RL. 2005. Root diseases in bareroot and container nurseries of the Pacific Northwest: epidemiology, management, and effects on outplanting performance. New Forests 30:185–202.

Dumroese RK, Page-Dumroese DS, Wenny DL. 1992. Managing pesticide and fertilizer leaching and runoff in a container nursery. In: Landis TD, technical coordinator. Proceedings: Intermountain Forest Nursery Association. Fort Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-211. p 27–33.

Dumroese RK, Wenny DL, Page-Dumroese DS. 1995. Nursery wastewater: the problem and a possible remedy. In: Landis TD, Cregg B, technical coordinators. National proceedings, forest and conservation nursery associations. Portland (OR): USDA Forest Service, Pacific Northwest Research Station. General Technical Report PNW-365. p 89–97.

Dumroese RK, Landis TD, Wenny DL. 1998. Raising forest tree seedlings at home: simple methods for growing conifers of the Pacific Northwest from seeds. Moscow (ID): Idaho Forest, Wildlife and Range Experiment Station. Contribution 860. 56 p.

Dumroese RK, Pinto JR, Jacobs DF, Davis AS, Horiuchi B. 2006. Subirrigation reduces water use, nitrogen loss, and moss growth in a container nursery. Native Plants Journal 7:253–261.

Dumroese RK, Page-Dumroese DS, Brown RE. 2011. Allometry, nitrogen status, and carbon stable isotope composition of *Pinus ponderosa* seedlings in two growing media with contrasting nursery irrigation regimes. Canadian Journal of Forest Research 41:1091–1101.

Dumroese RK, Landis TD, Luna T. 2012. Growing native plants in nurseries: basic concepts. Fort Collins (CO): USDA Forest Service, Rocky Mountain Research Station. General Technical Report RMRS-GTR-274. 84 p.

Jacobs DF, Landis TD. 2008. Hardening. In: Dumroese RK, Luna T, Landis TD, editors. Nursery manual for native plants: a guide for tribal nurseries. Volume 1, Nursery management. Washington (DC): USDA Forest Service. Agriculture Handbook 730. p 216–227.

James RL, Dumroese RK, Wenny DL. 1994. Fungi carried by adult fungus gnats (Diptera: Sciaridae) in Idaho greenhouses. Missoula (MT): USDA Forest Service, Timber, Cooperative Forestry and Pest Management. Northern Region Report 94-5. 10 p.

James RL, Dumroese RK, Wenny DL. 1995. *Botrytis cinerea* carried by adult fungus gnats (Diptera: Sciaridae) in container nurseries. Tree Planters' Notes 46(2):48–53.

Juntunen M-L, Hammar T, Rikala R. 2002. Leaching of nitrogen and phosphorus during production of forest seedlings in containers. Journal of Environmental Quality 31:1868–1874.

Juntunen M-L, Hammar T, Rikala R. 2003. Nitrogen and phosphorus leaching and uptake by container birch seedlings (*Betula pendula* Roth) growth in three different fertilizations. New Forests 25:133–147.

Landis TD. 1998. Controlling cryptogams. Portland (OR): USDA Forest Service, Pacific Northwest Region, Cooperative Programs. R6-CP-TP-03-96. Forest Nursery Notes (Summer 1998):18–21.

Landis TD, Wilkinson KM. 2014. Water quality and irrigation. In: Wilkinson KM, Landis TD, Haase DL, Daley BF, Dumroese RK, editors. Tropical nursery manual: a guide to starting and operating a nursery for native and traditional plants. Washington (DC): USDA Forest Service. Agriculture Handbook 732. p 207–231.

Landis TD, Tinus RW, McDonald SE, Barnett JP. 1989. Seedling nutrition and irrigation. The container tree nursery manual, Volume 4. Washington (DC): USDA Forest Service. Agriculture Handbook 674. 119 p.

Pinto JR, Chandler R, Dumroese RK. 2008. Growth, nitrogen use efficiency, and leachate comparison of subirrigated and overhead irrigated pale purple coneflower seedlings. HortScience 42:897–901.

[USDA NRCS] USDA Natural Resources Conservation Service. 2014. The PLANTS database. URL: http://plants.usda.gov (accessed 16 Dec 2014). Greensboro (NC): National Plant Data Team.

White JW, Mastalerz JW. 1966. Soil moisture as related to container capacity. Journal of the American Society of Horticultural Science 89:758–765.

Wilkinson KM, Haase DL. 2014. Discovering ways to improve nursery practices and plant quality. In: Wilkinson KM, Landis TD, Haase DL, Daley BF, Dumroese RK, editors. Tropical nursery manual: a guide to starting and operating a nursery for native and traditional plants. Washington (DC): USDA Forest Service. Agriculture Handbook 732. p 360–376.

Zhu Y, Dumroese RK, Pinto JR, Li GL, Liu Y. 2013. Fall fertilization enhanced nitrogen storage and translocation in *Larix olgensis* seedlings. New Forests 44:849–861.

AUTHOR INFORMATION

R Kasten Dumroese
National Nursery Specialist
kdumroese@fs.fed.us

Jeremiah R Pinto
Research Plant Physiologist
jpinto@fs.fed.us

USDA Forest Service
Rocky Mountain Research Station
1221 South Main Street
Moscow, ID 83843

Mark E Montville
Nursery Manager
PRT Oregon
31783 South Meadows Road
Hubbard, OR 97032
mark.montville@prt.com