Evaluation of Three Growing Media Substrates for Western Larch Seedling Production at the USDA Forest Service Coeur d'Alene Nursery

Anthony S. Davis, Kent Eggleston, Jeremy R. Pinto, R. Kasten Dumroese

Anthony S. Davis is Assistant Professor of Native Plant Regeneration and Silviculture and Director of the Center for Forest Nursery and Seedling Research, College of Natural Resources, University of Idaho, PO Box 441133, Moscow ID 83844-1133; Tel: 208.885.7211; E-mail: asdavis@uidaho.edu. **Kent Eggleston** is Horticulturist/Forester, USDA Forest Service Coeur d'Alene Nursery, 3600 Nursery Road, Coeur d'Alene, ID 83814; E-mail: keggleston@us.fed.us. **Jeremy R. Pinto** is Botanist and Tribal Nursery Coordinator, USDA Forest Service, Rocky Mountain Research Station, 1221 South Main Street, Moscow, ID 83843; E-mail: jpinto@fs.fed.us. **R. Kasten Dumroese** is National Nursery Specialist, USDA Forest Service, Rocky Mountain Research Station, 1221 South Main Street, Moscow, ID 83843; E-mail: kdumroese@fs.fed.us.

Davis, A.S.; Eggleston, K.; Pinto, J.R.; Dumroese, R.K. 2009. Evaluation of three growing media substrates for western larch seedling production at the USDA Forest Service Coeur d'Alene Nursery. In: Dumroese, R.K.; Riley, L.E., tech. coords. 2009. National Proceedings: Forest and Conservation Nursery Associations—2008. Proc. RMRS-P-58. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 37–41. Online: http://www.fs.fed.us/rm/pubs/rmrs_p058.html.

Abstract: In response to concerns regarding growing media substrate costs, and the impact of growing media on seedling quality, we evaluated three peat-based growing media substrates at the USDA Forest Service Coeur d'Alene Nursery in Idaho. Current medium consists of 80:20 peat:fresh Douglas-fir sawdust (v:v). Two other substrates, 75:25 peat:fine screened Douglas-fir bark (v:v) and 100% peat were explored as alternatives. Although sawdust and bark are currently sold at less than half the cost of peat, making them interesting alternatives from a financial basis, we found that western larch seedlings performed best when grown in either the 100% peat medium or the peat:bark medium.

Keywords: sawdust, Douglas-fir bark, peat, growth rate, nitrogen immobilization

Introduction

Most container forest tree seedlings produced in the Inland Northwest of the United States are grown using a Sphagnum peat-based substrate. Given the high cost of peat moss, and environmental concerns regarding its production, amendments are considered a viable way to reduce overall peat consumption. Sawdust, pine bark, and coconut coir can be used as organic amendments, while perlite, sand, and vermiculite are often incorporated as inorganic components of growing media mixes (Landis and others 1990).

Growing medium is known to affect plant performance in bareroot and container nursery production (Rose and Haase 2000; Davis and others 2006; Salifu and others 2006). With that in mind, and realizing the increasing costs of growing media, the USDA Forest Service Coeur d'Alene Nursery in Idaho has been interested in finding an alternative growing substrate. The nursery had previously shifted from a 100% peat substrate to a substrate consisting of 80:20 peat:sawdust by volume to reduce costs. Decreased growth, however, was observed with this mix. To offset this problem, fertilizer rates were increased. While this provided some relief from the high cost of peat, it did not identify the most effective method of producing seedlings, and left production costs vulnerable to fluctuations in fertilizer costs. Because sawdust and bark are each currently about 40% of the cost of peat, they represent economically viable alternatives to 100% peat. Thus, our study objectives were to: (1) determine the influence of growing medium on western larch (*Larix occidentalis*) seedling morphology; and (2) assess the physical and chemical properties of three common growing media used for container seedling production.

Materials and Methods

We tested three growing media: (1) 80:20 (v:v) Sphagnum peat:fresh Douglas-fir (*Pseudotsuga menziesii*) sawdust (current medium at Coeur d'Alene); (2) 100% peat; and (3) 75:25 (v:v) Sphagnum peat:finely screened (≤0.95 cm particle size; Buamscha and others 2007) Douglas-fir bark. Western larch seeds of a single source were sown on 4 February 2008 into Styroblock™ (Beaver Plastics, Acheson, Alberta, Canada) 160/90 (315B) containers, each filled with one of three media types. Each Styroblock™ represented one replication, and as media mixes were replicated six times, this led to a total of 18 Styroblock™ containers (3 treatments x 6 replications). Seedlings were fertigated when block weights reached 80% of their weight at field capacity (see table 1 for fertilizer composition), which corresponded to approximately twice weekly during rapid growth.

On 18 May 2008 (105 days after sowing), we randomly selected five seedlings from each container for evaluation of height, root-collar diameter, and shoot and root dry weight. We also determined the bulk density, cation exchange capacity (CEC), and carbon-to-nitrogen ratio (C:N) of each medium.

We analyzed data using analysis of variance (ANOVA) for a randomized complete block design to identify differences among treatments for seedling height, root-collar diameter, and root volume, as well as soil physical and chemical properties. To minimize the possibility of making a Type II error, a significance level of $\alpha = 0.05$ was selected for analysis of treatment differences using Tukey's mean separation test. For seedling parameters, the experimental unit was each group of 30 seedlings from a treatment replication, and the observational unit was each individual seedling. SAS® software (SAS Institute, Cary, NC) was used for all data analyses.

Results and Discussion

Media Properties

Bulk density was lowest in 100% peat, and was 29% and 58% higher in the peat:sawdust (80:20) and peat:bark (75:25) mixes, respectively (fig. 1). This result was expected given the inherently higher bulk densities of bark and sawdust compared to peat (Landis and others 1990). Despite being statistically significant, we believe these differences have little biological significance; our bulk density values were below the point (<20%) at which one would expect to see reduced or irregular root growth (Heilmen 1981; Seigel-Issem and others 2005). CEC was highest in 100% peat, and 30% and 27% lower in the peat:sawdust and peat:bark mixes, respectively (fig. 2). This, too, was expected, given that pine bark has about one-third the CEC of peat (Landis and others 1990). C:N was lowest in 100% peat, and was 58% and 36% higher in the peat:sawdust and peat:bark mixes, as was expected given the known high C:N of sawdust (Kanamori and Yasuda 1979; Davis and others 2007). The significant differences observed in C:N, however, may have biological implications. Kanamori and Yasuda (1979) found that peat moss and softwood bark immobilized very little applied nitrogen, whereas sawdust immobilized much more. Decreased nitrogen availability due to immobilization could lead to reduced seedling growth.

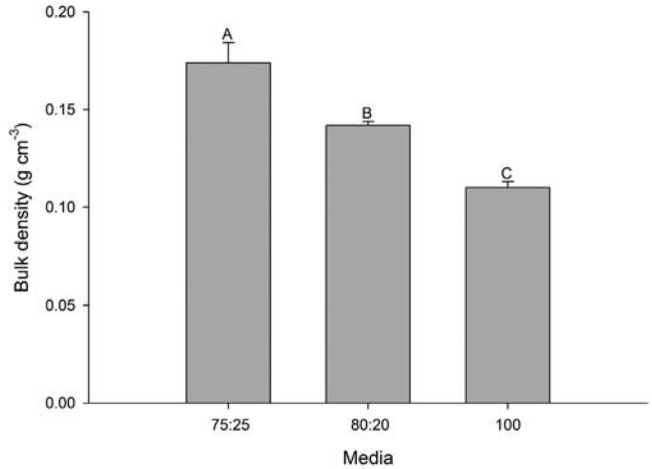

Figure 1. Bulk density of three media mixes (75:25 = 75% peat, 25% fine screened Douglas-fir bark by volume; 80:20 = 80% peat, 20% fresh Douglas-fir sawdust by volume; 100 = 100% peat). Different letters indicate significant differences at $\alpha = 0.05$.

Table 1. Fertilizer properties used for seedlings grown in this study.

Nutrient	Application rate (ppm)
Nitrogen	230
Phosphorus	23
Potassium	96
Magnesium	40
Calcium	89
Sulfur	45

Seedling Morphology

Seedling height and root-collar diameter in 100% peat and the peat:bark mixture were significantly greater than those grown in peat:sawdust (figs. 3 and 4). Peat:sawdust seedlings were smaller than those called for in the seedling specifications at Coeur d'Alene Nursery. We believe these differences in seedling morphology were due to the microbial immobilization of nitrogen driven by the aforementioned high C:N that occurs in sawdust, which corresponds with the conclusions of Haynes and Goh (1977). In the peat:sawdust medium, it is possible that the immobilized nitrogen will be remineralized later in the growing season and available to seedlings (Kanamori and Yasuda 1979). From a grower's perspective, this unpredictable (Buamscha and others 2008) addition of nitrogen may lead to unacceptable changes in seedling characteristics later in the growing season (that is, lammas growth or foliage more susceptible to blight caused by *Botrytis* spp.). Perhaps more importantly, the less than optimum growth of seedlings early in the growing season indicates reduced efficiency of resources (greenhouse heat, water, fertilizer, and labor), which translates into higher costs.

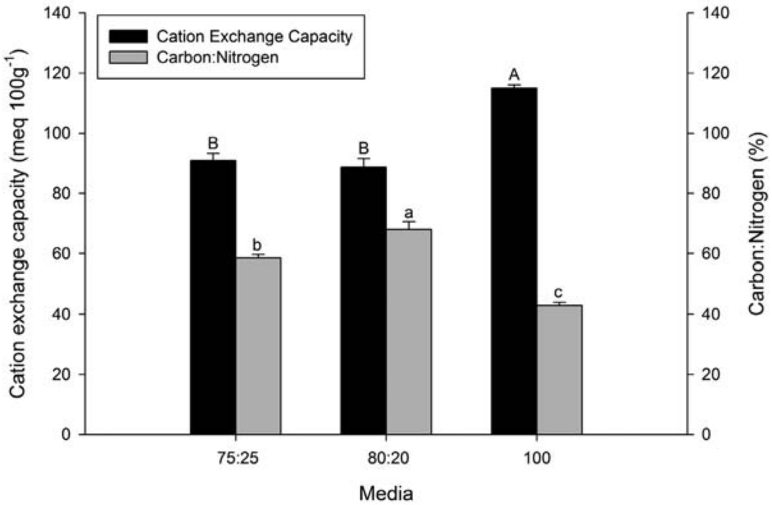

Figure 2. Cation exchange capacity and carbon-to-nitrogen ratio (C:N) of three media mixes (75:25 = 75% peat, 25% fine screened Douglas-fir bark by volume; 80:20 = 80% peat, 20% fresh Douglas-fir sawdust by volume; 100 = 100% peat). Different letters indicate significant differences at $\alpha = 0.05$.

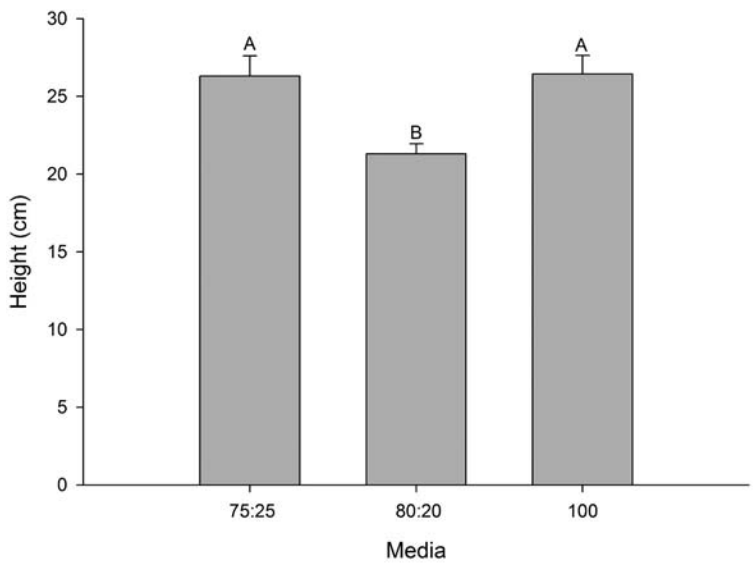

Figure 3. Height of western larch seedlings grown for 105 days in three media mixes (75:25 = 75% peat, 25% fine screened Douglas-fir bark by volume; 80:20 = 80% peat, 20% fresh Douglas-fir sawdust by volume; 100 = 100% peat). Different letters indicate significant differences at $\alpha = 0.05$.

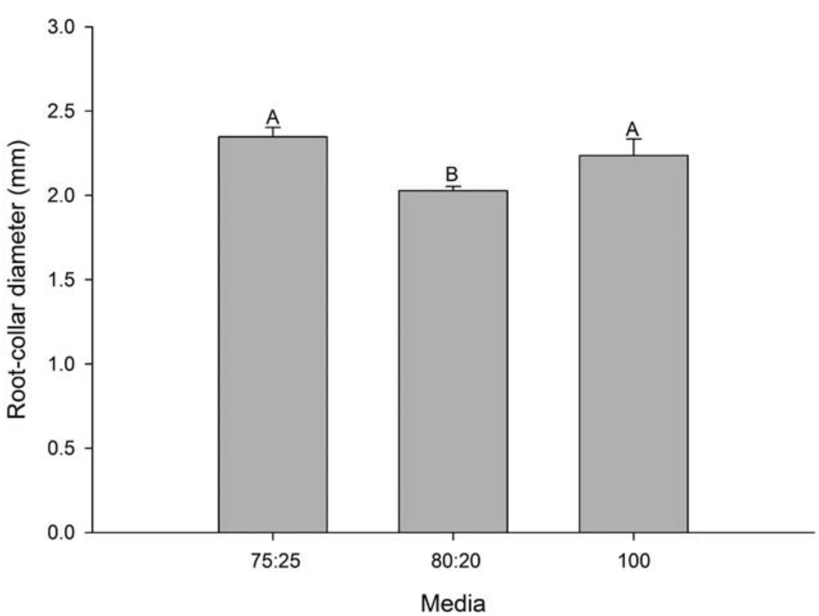

Figure 4. Root-collar diameter of western larch seedlings grown for 105 days in media mixes (75:25 = 75% peat, 25% fine screened Douglas-fir bark by volume; 80:20 = 80% peat, 20% fresh Douglas-fir sawdust by volume; 100 = 100% peat). Different letters indicate significant differences at $\alpha = 0.05$.

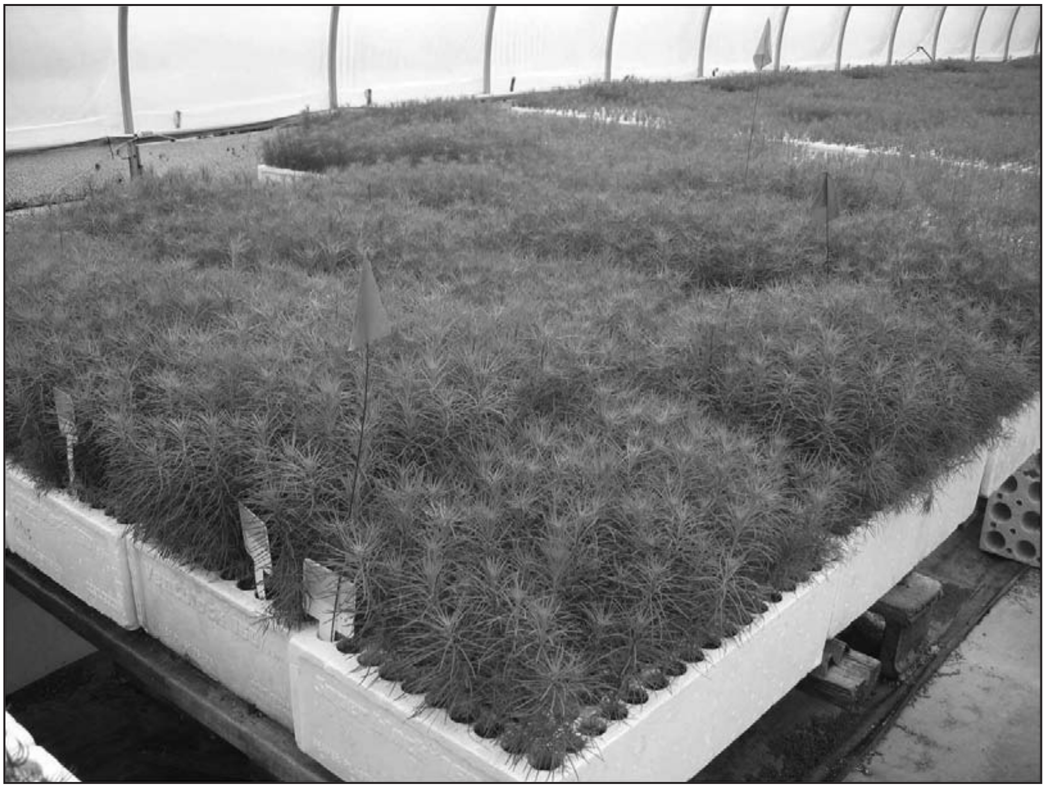

Figure 5. Photograph of trial allowing for ocular assessment of variability in seedling morphology.

Management Implications

We clearly observed variability in seedling quality caused by growing media substrate (fig. 5). Seedlings grown in peat:sawdust did not meet the criteria desired for lifting, whereas those grown in the other substrates did. Examining substrate cost under current economic conditions and subsequent seedling performance, we feel that using the 75:25 peat:bark mixture at the Coeur d'Alene Nursery is a prudent choice (table 2). Continuous evaluation of growing media and fertilization protocols under different economic conditions is an important component of producing quality, cost effective seedlings. As growers seek alternatives, however, we urge them to use caution and test changes to regimes on small batches of seedlings rather than an entire crop. The disadvantage, however, is that the results of any operational studies can be easily compromised by poor study design or execution. We encourage growers to consult with nursery specialists and read Dumroese and Wenny (2003) to ensure their tests provide meaningful results.

Table 2. Summary of findings pertaining to selecting a growing medium for use at the USDA Forest Service Coeur d'Alene Nursery. (Costs as of June 2008.)

Growing medium	Cost (US$/ yd)	Seedling morphology	Medium C:N
100% peat	38.00	Meets specifications	Low
80:20 peat:sawdust	33.40	Below specifications	High
75:25 peat:bark	32.25	Meets specifications	Medium

Acknowledgments

This project was supported through funding provided by the USDA Forest Service Coeur d'Alene Nursery, the University of Idaho Center for Forest Nursery and Seedling Research, and the USDA Forest Service Reforestation, Nurseries, and Genetic Resources team. Wade Pruett (Phillips Soil Products), Heather Gang (University of Idaho Center for Forest Nursery and Seedling Research), and Amy Ross-Davis provided additional support.

References

Buamscha MG, Altland JE, Horneck DA, Sullivan DM, Cassidy J. 2007. Chemical and physical properties of Douglas-fir bark relevant to the production of container plants. HortScience 42: 1281-1286.

Buamscha MG, Altland JE, Sullivan DM, Horneck DA, McQueen JPG. 2008. Nitrogen availability in fresh and aged Douglas-fir bark. HortTechnology 18:619-623.

Davis AS, Jacobs DF, Wightman KE, Birge ZD. 2006. Organic matter added to bareroot nursery beds influences soil properties and morphology of *Fraxinus pennsylvanica* and *Quercus rubra* seedlings. New Forests 31:293-303.

Davis AS, Jacobs DF, Wightman KE. 2007. Organic matter amendment of fallow forest tree seedling nursery soils influences soil properties and biomass of a sorghum cover crop. Tree Planters' Notes 52:2-6.

Dumroese RK, Wenny DL. 2003. Installing a practical research project and interpreting research results. Tree Planters' Notes 50(1):18-22.

Haynes RJ, Goh KM. 1977. Evaluation of potting media for commercial nursery production of container-grown plants. New Zealand Journal of Agricultural Research 20:371-381.

Heilman P. 1981. Root penetration of Douglas-fir seedlings into compacted soil. Forest Science 27:660-666.

Kanamori T, Yasuda T. 1979. Immobilization, mineralization and the availability of the fertilizer nitrogen during the decomposition of the organic matters applied to the soil. Plant and Soil 52:219-227.

Landis TD, Tinus RW, McDonald SE, Barnett JP. 1990. The container tree nursery manual. Volume 2, containers and growing media. Washington (DC): USDA Forest Service. Agriculture Handbook 674. 88 p.

Rose R, Haase DL. 2000. The use of coir as a containerized growing medium for Douglas-fir seedlings. Native Plants Journal 1:107-111.

Salifu KF, Nicodemus MA, Jacobs DF, Davis AS. 2006. Evaluating chemical indices of media for nursery production of *Quercus rubra* seedlings. HortScience 41:1342-1346.

Siegel-Issem CM, Burger JA, Powers RF, Ponder F, Patterson SC. 2005. Seedling root growth as a function of soil density and water content. Soil Science Society of America Journal 69:215-226.

The content of this paper reflects the views of the authors, who are responsible for the facts and accuracy of the information presented herein.