Influence of nursery cultural practices on western larch seedling development

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Introduction

Western larch (*Larix occidentalis* Nutt.) is an important tree species grown for bird and mammal habitat, watershed restoration, a wide variety of timber resources and, aesthetically, provides us with stunning colors throughout the entire year. Throughout the northwestern USA western larch has the ability to successfully regenerate in disturbed areas (i.e. clearcuts and burned sites) which makes it an important pioneer species. However, with growing needs for post-fire restoration and reforestation following timber harvest, western larch seedling demand is high.

Many nurseries in the Inland Northwest of North America sow western larch seeds in early April in 60-80 mL containers to be grown to a target height of 16 to 20 cm (Dumroese and Wenny 1992). Height targets are often surpassed midway through the growing season, and while pruning can maintain adequate shoot-to-root, this is not often practiced because it can present other quality issues. Thus, these excessive shoot heights can impede the outplanting success of the species.

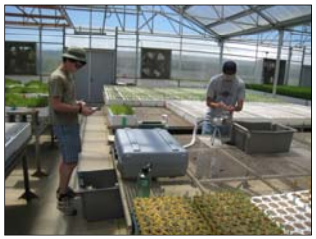
Common nursery cultural practices used to manipulate seedling growth include altering sow dates and tailoring nutritional regimes (Duryea and Landis 1984). Fertilization alteration can be used as one of the most effective means of controlling both the rate and type of growth that occurs in container nurseries (Landis *et al.* 1989). A later sow date may result in shorter seedlings.

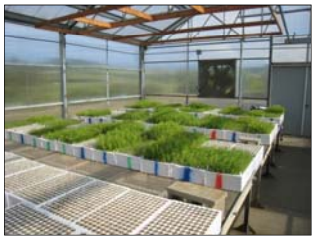
The objective of this study is to determine the impact of two nursery cultural practices (sow date and nutritional regime) on western larch seedling height and root-collar diameter at the mid-point of the growing season as a means of identifying the likelihood of these methods aligning seedling development with targets. Furthermore, a secondary objective is to quantify seedling net photosynthetic assimilation and intrinsic water use efficiency to determine the physiological effects of these cultural practices on western larch seedlings. The aim of this study is to establish an effective growing regime for western larch seedlings that enables them to meet target seedling specifications, thus ensuring better outplanting success.

Materials and methods

Seedlings were sown at 28 day intervals (1 March, 29 March, 26 April, 24 May) into Styroblock™ containers (90 mL per cavity; Beaver Plastics, Edmonton, AB). Three rates [(low = 5 kg m^{-3}), (medium = 8 kg m^{-3}), (high = 11 kg m^{-3})] of controlled-release fertilizer (Osmocote Exact Lo-Start 15+8+10 + 3MgO + TE, Scotts Company, Marysville, OH) with a 12-14 month release were incorporated into the growing media. Net photosynthetic assimilation (A_{net}) and stomatal conductance (g_s) were quantified using an LI-6400 infrared gas analyzer (LI-COR, Inc., Lincoln, NE) and LI-6400-05 conifer chamber. Measurements were conducted on 22 June and 19 July between 1000-1330 h. Ambient photosynthetically active radiation was in excess of 800 µmol m^{-2} s^{-1}. Two seedlings per treatment replication were measured for a total of 6 samples per treatment. A controlled CO_2 source was maintained at 400 µmol mol^{-1} to provide a reference CO_2 level for gas exchange measurement. Temperature within the chamber was maintained at approximately 24°C during measurement. Intrinsic water use efficiency was calculated as A_{net}/g_s.

The experiment was established as a randomized complete block design. Analysis of Variance was used to identify differences in seedling height and root-collar diameter growth, net photosynthesis and intrinsic water use efficiency. Differences significant at α = 0.05 were grouped using Tukey's HSD. Significant interactions are not presented. SAS (Cary, NC) software was used for all data analyses.





Results

Both date of sowing (Figure 1) and fertilization rate (Figure 2) had an impact on seedling development. Sow date had a significant effect on height ($p < 0.0001$), root-collar diameter ($p < 0.0001$) and net photosynthetic assimilation ($p = 0.029$) for both measurement dates. Water use efficiency was impacted by sow date at the June measurement ($p < 0.0001$) but not in July ($p = 0.8191$). Rate of fertilization had a significant effect on height ($p < 0.0001$) and root-collar diameter ($p = 0.0016$) for both measurement dates. Net photosynthetic assimilation was impacted by fertilization rate at the July measurement ($p = 0.0125$), but not in June ($p = 0.3205$). Water use efficiency was not significantly influenced by rate of fertilization on either measurement date ($p \geq 0.3286$).

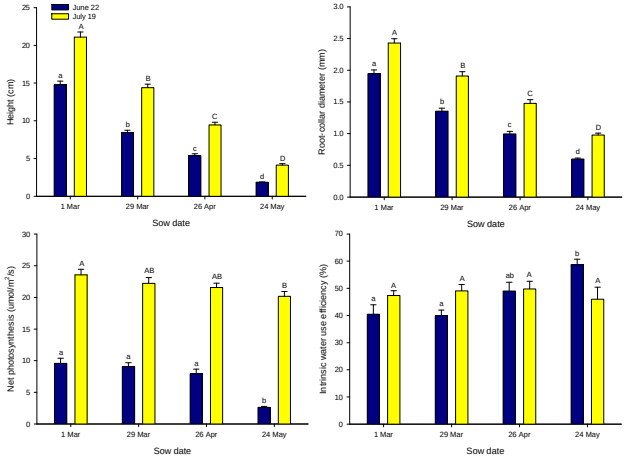


Figure 1. Effect of sow date on seedling height, root-collar diameter, net photosynthesis and intrinsic water use efficiency measured during the growing season. Lower-case letters represent significant differences using Tukey's HSD (α = 0.05) between treatments for June 22 measurement, upper-case for 19 July.

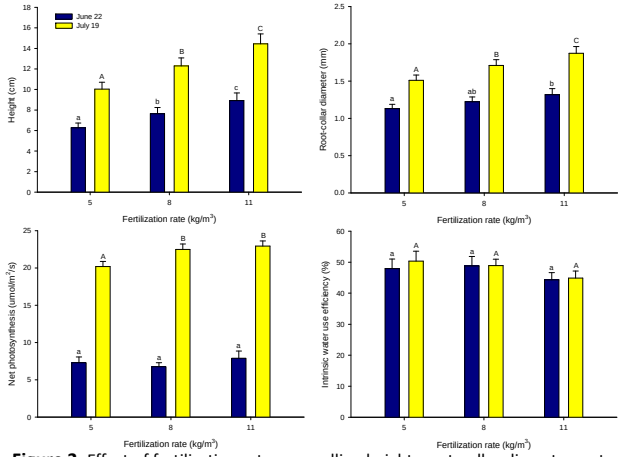


Figure 2. Effect of fertilization rate on seedling height, root-collar diameter, net photosynthesis and intrinsic water use efficiency measured during the growing season. Lower-case letters represent significant differences using Tukey's HSD (α = 0.05) between treatments for June 22 measurement, uppercase for 19 July.

Discussion

Differences in height and root-collar diameter based on sowing date within the March to May sowing window remained proportional as time progressed, with earlier sown seedlings being significantly larger. While seedlings sown on 1 March had surpassed the target height of 20 cm by 19 July, all others were still below 16 cm. Increasing fertilization rate resulted in greater height and root-collar diameter as well, with more pronounced differences in at the second measurement date. Given the trend in seedling development associated with increasing fertilization rate, it is possible that a positive growth response could be achieved with a rate of fertilization of more than 11 kg m^{-3}.

A_{net} was very low when first measured on young (28-day old) seedlings, however it became relatively uniform over time. Fertilization rate resulted in increased A_{net}. These trends, which point to higher N concentrations within the leaf resulting in increased A_{net}, correspond with other results (Reich *et al.* 1998). It appears that increasing fertilization rates beyond 8 kg m^{-3} will not result in further significant increases in A_{net} and will most likely result in luxury consumption by the plant, which may enhance seedling growth upon outplanting (Salifu and Timmer 2003). Younger seedlings had higher intrinsic water use efficiency early on, but those differences diminished as time elapsed. Fertilization rate had no effect on intrinsic water use efficiency.

Conclusions and future directions

Delaying sowing of seed beyond March 1st could allow western larch seedlings to obtain a maximum target height of 20 cm. However, delaying sowing too long could result in not meeting height and root-collar diameter targets. Based on growth to this point, seedlings that received only 5 kg m^{-3} may not reach adequate height.

Differences in A_{net} were only apparent between the youngest and oldest seedlings and between the three fertilizer rates when measured 19 July. Western larch intrinsic water use efficiency remained relatively constant despite fertilization rate and sow date manipulation, indicating growers can cater growing regimes to reach target seedling specifications without negatively impacting seedling physiological status.

These results present the intermediate measurements of an ongoing study. As seedling growth has been effectively manipulated at the mid-point of the growing season, focus must be turned to those cultural practices that will result in height growth cessation to maintain seedlings in the target morphological range. Thus, response of western larch to photoperiod manipulation is being tested as another cultural practice to better control the morphological and physiological characteristics of the seedlings.

Acknowledgements

This project was conducted as part of the University of Idaho Center for Forest Nursery and Seedling Research Summer Internship Program. The authors thank Annette Brusven, Susan Morrison, Jeremy Pinto, Raini Pippy, Donald Regan and Amy Ross-Davis for their input and contributions to the study.

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