Photosynthesis

1. Black, C.H. 1988. Interaction of phosphorus fertilizer form and soil medium on Douglas-fir seedling phosphorus content, growth and photosynthesis. Plant-and-Soil 106(2): 191-199.

Keywords: nursery operations
nursery fertilization
growth
tree physiology
photosynthesis

Abstract: Douglas-fir seedlings were grown in containers in peat-vermiculite or mineral soil each amended with different levels of concentrated superphosphate (CSP) or a granulated North Carolina phosphate rock (RP). Dilute acid-fluoride extractable phosphorus (DAP), seedling photosynthesis, weights, and tissue P concentrations were measured at 65 + 3 and 105 + 3 days.DAP was highly correlated with soluble fertilizer P (but not total P) added at the beginning of the experiment. Considerable soluble P was lost from peat-vermiculite but not from the mineral soil. Seedling total P content was proportional to the amount of soluble P per container at both harvests, but was greater for a given level of soluble P in the organic versus the mineral medium. Added soluble P increased foliar P concentrations, plant P content, and dry weight. Net carbon uptake was highly correlated with added levels of soluble P, foliar P concentrations, and with total P content. The internal efficiency of P from the RP source was less than P from CSP with respect to P content versus growth, net CO2 uptake, and net photosynthesis rates. At the end of the experiment, seedling P content plus DAP remaining in the media for the higher fertilizer rates accounted for 75% of the originally added soluble P in the mineral soils, but for only 15% in the organic media.

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Non-OSU Link

2. Brix, H. 1993. Fertilization and thinning effect on a Douglas-fir ecosystem at Shawnigan Lake: a synthesis of project results. B.C. Ministry of Forests FRDA-Report 196. X + 64 p.

Keywords: fertilization
thinning
growth
tree morphology
tree/stand health
carbon allocation
wood quality
tree physiology
photosynthesis
economics

Abstract: Treatments were initiated in 1970-71 in a 24-year-old Douglas fir (Pseudotsuga menziesii) near Shawnigan Lake, Vancouver Island, British Columbia, to determine the effects of 3 intensities of thinning (removing none, one-third and two-thirds of basal area) and 3 levels of urea fertilizer (0, 224 and 448 kg N/ha) on the growth and biology of the trees. Subsidiary experiments were established

during 1972-87 to examine the effects of high doses of urea (672-1344 kg N/ha), ammonium nitrate as an N source instead of urea, understoreyresponse to thinning and fertilizer, and responses to P and S fertilizer.

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Non-OSU Link

3. Dosskey, M.G., L. Boersma and R.G. Linderman. 1993. Effect of phosphorus fertilization on water stress in Douglas fir seedlings during soil drying. Plant-and-Soil 150(1): 33-39.

Keywords: fertilization
tree/stand protection
growth
tree physiology
photosynthesis

Abstract: A growth chamber experiment was conducted to determine if P fertilizing to enhance the P nutrition of otherwise N and P deficient Douglas fir (Pseudotsuga menziesii) seedlings reduces water stress in the seedlings during drought periods. Seedlings were grown in pasteurized mineral soil under well watered conditions and fertilized periodically with a small amount of nutrient solution containing P at three levels: 0, 20, or 50 mg/litre. By age 6 months, leaf nutrient analysis indicated that N and P were deficient in control (0 mg P/litre) seedlings. The highest level of P fertilizer, which doubled leaf P concentration, did not affect plant biomass, suggesting that N deficiency was limiting growth. When these seedlings were subjected to drought, there was no effect of P fertilizing on leaf water potential or osmotic potential. Furthermore, P fertilized seedlings had lower stomatal conductance and net photosynthesis rate. These results indicate that enhanced P nutrition, in the presence of N deficiency, does not reduce water stress in Douglas fir seedlings during drought periods.

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Non-OSU Link

4. Driessche, R.v.-d. 1987. Importance of current photosynthate to new root growth in planted conifer seedlings. Canadian-Journal-of-Forest-Research 17(8): 776-782.

Keywords: nursery operations
tree physiology
photosynthesis
tree morphology

Abstract: Reports are given of 6 experiments. Two-yr-old seedlings of Douglas fir and Sitka spruce, labelled with 14CO2 in Oct. and kept outdoors, contained 14C in old roots but little in new roots when placed in a growth chamber in Jan. New roots were highly radioactive in seedlings labelled with 14CO2 after 12 days' growth in Jan., indicating that current photosynthate was the primary C source for new roots. These results agreed with an experiment in which the number and wt. of new roots on 1+1 Douglas fir transplants were directly related to light intensity. Net photosynthesis (Pn) of similar Douglas fir nursery stock after cold storage was inadequate to supply C for respiration and new root growth under 16-h photoperiods of 200 micro E/msuperscript 2 per s, although

new root growth occurred. This suggested that reserves contributed to respiration. Douglas fir seedlings began transpiration immediately after planting in moist soil. Two-yr-old lodgepole pine seedlings grown outdoors over winter with root systems maintained at <more or =>10 degrees C produced more new roots in spring than seedlings grown outdoors without heated roots or in a greenhouse; no relations were observed between new root growth and Pn.

OSU Link
Non-OSU Link

5. Folk, R.S., S.C. Grossnickle, P. Axelrood and D. Trotter. 1999. Seed lot, nursery, and bud dormancy effects on root electrolyte leakage of Douglas-fir (Pseudotsuga menziesii) seedlings. Canadian-Journal-of-Forest-Research 29(8): 1269-1281.

Keywords: nursery operations
tree physiology
tree/stand health
photosynthesis
growth
tree phenology

Abstract: The effects of seed lot, nursery culture, and seedling bud dormancy status on root electrolyte leakage (REL) of Douglas-fir (Pseudotsuga menziesii) seedlings were assessed to determine if these factors should be considered when interpreting REL for seedling quality. The relationships of REL to survival, net photosynthesis (Pn), stomatal conductance (gwv) mid-day shoot water potential (Psi mid), root growth capacity (RGC), and relative height growth were determined for each factor in experiments in 1994-95 in nurseries inBritish Columbia. Nursery culture had no effect on the relationship between REL and all other measured attributes. Seed lot affected the relationship between REL and Pn, Psi mid, and survival. However, critical REL (i.e., lowest value associated with detectable root damage) and PS80 REL (i.e., level associated with an 80% probability for survival) were similar between seed lots. Bud dormancy status affected the relationship between REL and survival, RGC, and relative height growth. Control levels of REL, critical REL, and PS80 REL decreased as the number of days required for 50% terminal bud break declined. Thus, terminal bud dormancy status must be known before REL can be used to assess seedling quality. If the bud dormancy status of Douglas-fir populations is known, then critical and PS80 REL levels may be useful as indices of root damage.

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Non-OSU Link

6. Mitchell, A.K. and T.M. Hinckley. 1993. Effects of foliar nitrogen concentration on photosynthesis and water use efficiency in Douglas-fir. Tree-Physiology 12(4): 403-410.

Keywords: fertilization
tree physiology
photosynthesis

Abstract: Leaf-level physiological processes were studied in Douglas fir (Pseudotsuga menziesii) to determine whether apparent increases in stand-level water use efficiency (WUE) observed in response

to nitrogen (N) fertilization were attributable to foliar N effects on carbon fixation rates or on stomatal control of water loss. Photosynthesis and transpiration were measured at different light intensities and ambient CO2 molar fractions and comparisons were made between current-year shoots with average foliar N concentrations of 1.58% (high-N) and 1.25% (low-N). Photosynthetic rates and foliar N concentrations were positively correlated. In response to light, photosynthesis and stomatal conductance were closely coupled and a similar coupling was observed in response to different ambient CO2 concentrations. Partitioning the photosynthetic responses into mesophyll and stomatal components indicated that foliar N altered mesophyll conductance but not stomatal control of water loss. High-N shoots had significantly greater rates of photosynthesis and transpiration than low-N shoots and, as a result, instantaneous WUE did not differ significantly between high-N and low-N shoots.

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Non-OSU Link

7. Newton, M., D.S. Preest and D.E. White. 1987. Effect of relieving moisture stress with extended weed control in Douglas-fir. Proceedings-of-the-Western-Society-of-Weed-Science (Vol.40): 129-130.

Keywords: release treatments
chemical release
growth
tree physiology
soil properties
photosynthesis

Abstract: The growth of Douglas fir Pseudotsuga menziesii seedlings was increased during the first 5 years by controlling grasses and forbs in 7 herbicide regimes during the 1st 3 years, the effect diminishing with time after planting. Devegetated plots had more available moisture through the growing season than those with Agrostis tenuis or mixed mixed grass/forb cover dominated by A. tenuis or Hypochaeris radicata. Tree moisture stress followed soil moisture but only after allowing for large fluctuations of diurnal stress. Weed control relieved moisture stress in trees. P. menziesii photosynthesis tended to shut down in the region of -2.0 MPa moisture stress. For the 1st 3 years in a favourable coastal environment approx. 1700 MPa-h above -2.0 MPa was estimated to be required for survival. Increments of moisture beyond that would contribute significantly to growth.

OSU Link
Non-OSU Link

8. Parke, J.L., R.G. Linderman and C.H. Black. 1983a. The role of ectomycorrhizas in drought tolerance of Douglas-fir seedlings. New-Phytologist 95(1): 83-95.

Keywords: nursery operations
tree/stand protection
photosynthesis
tree physiology
mycorrhizal response

Abstract: Pseudotsuga menziesii seedlings were watered daily or conditioned to cyclic drying and re-wetting of the soil. Net photosynthesis rates of mycorrhizal and non-mycorrhizal seedlings watered daily were similar but drought-stressed mycorrhizal seedlings fixed CO2 at a rate 10 times that of non-mycorrhizal ones. Total leaf water potentials of mycorrhizal plants were lower than those of non-mycorrhizal plants but they recovered more rapidly. Non-mycorrhizal seedlings and those inoculated with 4 ectomycorrhizal fungi were allowed to dry, then re-watered and compared for their ability to tolerate and recover from drought. Those inoculated with Rhizopogon vinicolor were the least affected by drought. Net photosynthetic rate of R.-inoculated seedlings 24 h after re-watering was 7 times greater than that of non-mycorrhizal seedlings. The transpiration rate of R.-inoculated seedlings was low before desiccation, declined rapidly during the drought period and, after re-watering, quickly resumed a rate higher than that for other treatments.

OSU Link
Non-OSU Link

9. Prasad, R. 2000. Some aspects of the impact and management of the exotic weed, Scotch broom (Cytisus scoparius (L.) Link) in British Columbia, Canada. Journal-of-Sustainable-Forestry 10(3/4): 341-347.

Keywords: release treatments
manual release
growth
photosynthesis

Abstract: A recent cutover area near Maple Mountain, Duncan, British Columbia, was planted with 2+1 Douglas fir (Pseudotsuga menziesii) seedlings in 1994. Scotch broom (Cytisus scoparius) invaded the site rapidly. Growth (height and root collar diameter) of Douglas fir seedlings was monitored for 2 years on uncleared plots and on plots where the dense canopy of broom was manually cut and completely removed. Results showed that the broom reduced photosynthetically active radiation by 71% and growth of Douglas fir by 45-46%. Formulations of 3 fungal pathogens
(Fusarium tumidum, Pleiochaeta setosa, Chondrostereum purpureum) were tested in a greenhouse for their effects on growth of Scotch broom seedlings. Only F. tumidum was effective, suppressing the growth of 1-, 3- and 6-month-old seedlings.

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Non-OSU Link

10. Price, D.T., T.A. Black and F.M. Kelliher. 1986. Effects of salal understory removal on photosynthetic rate and stomatal conductance of young Douglas-fir trees. Canadian-Journal-of-Forest-Research 16(1): 90-97.

Keywords: release treatments
manual release
photosynthesis
tree physiology
soil properties
growth

Abstract: Studies were made in a thinned 32-yr-old Douglas fir stand on a drought-prone site on the E. coast of Vancouver Island. Four pairs of similar trees were selected and
the salal (Gaultheria shallon) understorey was removed completely from around one of each pair. The root zones of each tree were isolated using plastic sheeting buried to bedrock.
Photosynthesis, stomatal conductance, soil water potential and canopy microclimate were measured intensively in one pair on 4 clear days during an extended dry period in June 1982. B.a. increment of the four pairs of trees was measured over 3 growing seasons. To determine the effect of soil water potential on tree photosynthesis, the same variables were measured for 3 consecutive days in Aug. 1982 for another tree initially subjected to a soil water potential of approx. -1.6 MPa, but irrigated to approx. -0.02 MPa between days 1 and 2. Solar irradiance decreased markedly between days 2 and 3, thus creating a unique data set. Results showed that removal of the understorey significantly increased rates of photosynthesis in Douglas fir, both diurnally and seasonally. Photosynthesis was not generally limited by stomatal conductance unless vapour pressure deficit was high and photon flux density was saturating. Improved tree growth after understorey removal was due to the increased soil water potential that increased both photosynthetic capacity and stomatal conductance.

OSU Link
Non-OSU Link

11. Turner, J. and S.J. Mitchell. 2003. The effect of short day treatments on containerized Douglas-fir morphology, physiology and phenology. New-Forests 26(3): 279-295.

Keywords: nursery operations
growth
tree morphology
tree physiology
photosynthesis
tree phenology

Abstract: The effect of short day treatments ('blackout') on Douglas-fir
(Pseudotsuga menziesii (Mirb.) Franco) container seedlings at the time of lift and following cold storage was investigated. Variables measured included height, root collar diameter (RCD), root growth capacity (RGC), photosynthetic efficiency after -18 degrees C freezing (PEF), and days to terminal bud break (DBB). From one to four blackout dormancy induction treatments were started on three dates (July 12, July 26, and August 10) with 10 or 20 d between multiple blackouts. Increasing the number of blackout treatments resulted in lower RCD, lower DBB in the late winter/early spring, and higher PEF in the early fall. Later blackout start dates decreased PEF in the early fall, and increased overall height and late fall RGC as compared to earlier blackout start dates. Nurseries growing Douglas-fir seedlings from
coastal Pacific Northwest provenances should be aware that blackout regimes can decrease RGC in the late fall, and cause quicker dormancy release in the early spring. Coastal Douglas-fir can be lifted and planted in the early fall, when RGC and DBB are relatively high. If planting between February and April is necessary, seedlings given blackout should be cold stored in January to maintain an adequate level of dormancy, RGC and PEF.

OSU Link
Non-OSU Link

12. Woodruff, D.R., B.J. Bond, G.A. Ritchie and W. Scott. 2002. Effects of stand density on the growth of young Douglas-fir trees. Canadian-Journal-of-Forest-Research 32(3): 420-427.

Keywords: planting operations
growth
photosynthesis
tree physiology

Abstract: The objectives of this study were (i) to provide further evidence of a positive correlation of stand density with early growth of coastal Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco var. menziesii); (ii) to determine when after planting the positive growth response occurs and how long it lasts; and (iii) to use stable isotopes of carbon to test whether the mechanism(s) responsible for the positive growth response to density are related to variables affecting photosynthesis, such as nutrient or moisture availability. We measured annual height (h) and diameter (d) growth (retrospectively) of 8- and 12-year-old trees in initial planting densities of 300, 1360, and 2960 trees/ha. Both height and diameter growth increased with density through the fifth year after planting and decreased with density by year 7. Diameter squared x height (d2h) was used as a volume index to assess increase in tree volume. Second-year increase in d2h for the high-density treatments was 300% of that in the low-density treatments. The delta 13C values of wood cellulose from annual rings of the second and third years after planting were not significantly different among densities, suggesting either (i) no significant differences in the effects of water availability, nutrient availability, or source air on photosynthesis in the three density treatments or (ii) differences that produced no net effect on delta 13C.

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Non-OSU Link

13. Zhang, J.W., J.D. Marshall and B.C. Jaquish. 1993. Genetic differentiation in carbon isotope discrimination and gas exchange in Pseudotsuga menziesii. A common garden experiment. Oecologia 93(1): 80-87.

Keywords: genetic tree improvement
photosynthesis
tree physiology

Abstract: Seeds were collected in 1966 from 25 naturally regenerated Douglas fir (Pseudotsuga menziesii) stands across its range in the USA and Canada (from 33 degrees 30' N to 53 degrees 12' N), from 170 m to 2930 m altitude, and from coastal and interior sites. Seeds were sown in spring 1972, and at 3 yr old seedlings were transplanted to the Trinity Valley tree breeding site, British Columbia. Photosynthesis (A), stomatal conductance to water vapour (g) and the ratio of intercellular to ambient CO2 (ci/ca) were measured between 09.00 and 16.00 h on 30 May, 18 July and 1 September 1990. Light levels were above saturation for photosynthesis on these days. The relative abundance of 13C and 12C (carbon isotope discrimination; Delta) ranged from 19.7o/oo to 22.43o/oo and was closely related to geographic location of seed source. There were no significant differences in Delta between the coastal and interior varieties. Most variation occurred within the interior variety; populations from the southern Rocky Mountains had the greatest discrimination (21.53%) and the lowest water use efficiency. Delta , g, ci/ca and intrinsic water use efficiency (A/g) were all correlated with altitude of origin and height and diameter at 15 yr. Observed patterns in the common garden did not conform to

expectations of higher water use efficiency (measured by both A/g and Delta) in trees from the drier habitats of the interior, nor did they agree with published in situ observations of decreasing g and Delta with altitude. The genetic effect counteracts the altitudinal effect, leading to some degree of homeostasis in physiological characteristics in situ.

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