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Effects of compaction and water content on lodgepole pine seedling growth

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Abstract

Soil disturbance by heavy machinery usually causes a decrease in porosity and an increase in soil strength, which may limit access to nutrients and compromise seedling survival and growth. This study used a soil strength and a greenhouse experiment to assess the impact of compaction on lodgepole pine (*Pinus contorta* Dougl. Ex. Loud. var. *latifolia* Engelm.) seedling growth and the degree to which soil water influences the effects of compaction. A silt loam soil was collected from a forest landing in the central interior of British Columbia (BC) in the Sub-Boreal Spruce Biogeoclimatic zone. The silt loam soil was used in a soil strength experiment where soil with four water content levels (0.10, 0.18, 0.27, and 0.36 $cm^3\ cm^{-3}$) was packed into 0.21 cm^3 cores with three levels of compaction (74, 79, and 84% of maximum bulk density (MBD)). Soil strength was strongly affected by compaction and water content. In the greenhouse experiment, three water content levels (0.10–0.15, 0.20–0.30, and 0.30–0.35 $cm^3\ cm^{-3}$) and three levels of compaction (67, 72, and 76% of MBD) were applied to soil in pots and 1-year old lodgepole pine seedlings were grown in the pots. Soil strength was highest (1275 kPa) for the high compaction and dry water content treatment in the greenhouse experiment. Though the soil strength for this treatment did not exceed 2500 kPa, the effect of compaction on growth was noticeable, with a decrease in diameter growth, total shoot mass, and new root mass as compaction increased at the dry water content. At dry water content and high compaction, foliar nutrient concentrations were greatest. Generally, water content had a greater impact on seedling growth than did compaction, at the levels of compaction used in this study. This study indicates that if there is a critical value for mechanical impedance of the conifer roots, it likely occurs below 2500 kPa. Our results are consistent with the explanation that soil strength incrementally affects root growth below 2500 kPa for this soil type. Expensive rehabilitation techniques may not be needed on lightly disturbed soils similar to that used in this study if soil water content is high enough throughout the conifer growing season to alleviate the effects of compaction on soil strength.

Keywords: Soil compaction; Soil water content; Soil bulk density; Lodgepole pine seedlings

1. Introduction

Excessive soil disturbance by harvesting machinery may displace topsoil and compact underlying soil (McNabb, 1994) leading to a decrease in long-term site productivity. Soil of temporary access areas such as forest landings (areas of cutblocks where harvested trees are processed and loaded onto trucks) and skid trails may become so degraded that these areas are lost from the productive forest. Soil rehabilitation practices in British Columbia (BC) are carried out on excessively disturbed sites to improve soil conditions so that these sites may be replanted and that tree growth may increase. Since soil rehabilitation practices are expensive to apply, information is needed to better understand the factors that control seedling establishment and growth on degraded soils.

Compaction causes a decrease in porosity and an increase in soil bulk density and consequently in soil strength. Poor aeration, and reduced permeability to water (and therefore available soil water), may cause decreased tree growth (Rab, 1996; Grigal, 2000), but detrimental effects are not universal, and are affected by soil type (Gomez et al., 2002), climate (Miller et al., 1996), and the level of compaction (Jansson and Wästerlund, 1999; Kabzems and Haeussler, 2005; Sanchez et al., 2006). Research by da Silva et al. (1994) has attempted to

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