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Influence of Soil Compaction on the Dynamics of Root Growth and Mortality in Spring Barley

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ABSTRACT

A controlled environment experiment was conducted to investigate the effect of soil compaction on the dynamics of root growth and mortality in spring barley. Plants were grown in soil packed to a dry bulk density of 1.10 (loose soil) or 1.45 g cm^{-3} (compacted soil) and the appearance and disappearance of roots recorded at an observation window. Compaction reduced the total length of root produced, but did not alter the dynamics of root death and decay following removal of the shoot during grain filling, nor the proportion of root length that died and decayed before shoot excision. The results suggest that models of C and N cycling should consider the effects of soil compaction on root production, but not specifically those on root death and decay.

KEYWORDS: Barley, root mortality, decomposition, C and N cycling, soil compaction

INTRODUCTION

The effects of soil physical properties on root growth are well documented. Compacted or dry soil exerts a greater mechanical impedance to root growth than lose or moist soil. A large mechanical impedance reduces the rate of root extension, increases their radial thickening and alters the pattern of branching so that lateral roots emerge closer to the main root apex compared to roots grown in soil of low impedance (Bingham and Bengough, 2003). By comparison less is known about the effects of soil compaction on root death and decay, yet compaction has been found to alter root tissue composition in a way that could potentially slow tissue degradation (Bingham et al., unpublished data). As root turnover is an important process in below-ground carbon (C) and nitrogen (N) cycling, a better understanding of the effects of soil physical properties on root death and decay would establish whether these factors need to be accounted for in models of C sequestration and N cycling. The objective of experiments reported here was to determine the effects of soil compaction on the temporal dynamics of root production, death and decay in spring barley plants.

MATERIALS & METHODS

Plants were grown in plastic piping 750 mm long and rectangular in cross section (Bingham, 2007) packed with a sandy loam soil to a uniform dry bulk density of either 1.10 g cm^{-3} (loose) or 1.45 g cm^{-3} (compacted). One face of the pipe was constructed of transparent acrylic sheet to facilitate observation of the root system. Seedlings of spring barley (*Hordeum vulgare* L., cv Prisma) were transplanted one per culture vessel and grown under controlled environment conditions. The length of roots appearing and disappearing from the observation window at different depth intervals was recorded weekly commencing at planting and continuing until after

shoots were excised during grain filling (56 days after planting). The data were used to estimate the total length of root produced, the cumulative length that died and disappeared (dead root) and the current visible root length.

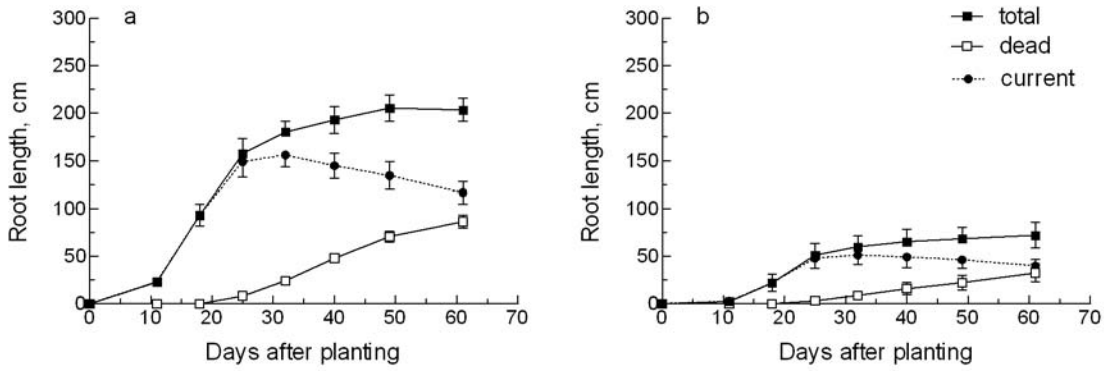

Figure 1. Visible root length (current), cumulative total length produced and length of dead and decayed root at the observation window 20-28 cm below the soil surface in loose (a) and compacted (b) soil.

RESULTS & DISCUSSION

Roots of plants grown in compacted soil first appeared at the observation window later than those grown in loose soil and the total length produced was smaller (Fig. 1). These results are consistent with the effects of soil compaction on the rate of root extension (Bingham et al., 2003). In addition, total root and shoot biomass was reduced significantly by compaction when measured on a duplicate set of plants mid way through the period of stem extension and during grain filling (data not shown) indicating that the compaction treatment was severe enough to restrict plant growth. Nevertheless compaction had no effect on the temporal dynamics of root death and decay. The onset and proportion of the total root length that disappeared prior to removing shoots during grain filling was similar in compacted and loose soil (Fig. 1). After removing the shoot there was an exponential decline in root length visible at the observation window (data not shown), but the half-life for visible root length did not differ significantly between soil bulk density treatments. The results suggest that models of C and N cycling should account for the effects of soil bulk density on root production, but not specifically those on subsequent root death and decay.

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