Plant and Soil **185**: 293–304, 1996.

Applications of minirhizotrons to understand root function in forests and other natural ecosystems

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Key words: decomposition, minirhizotron, production, soil biota, turnover

Abstract

Minirhizotrons have proved useful to understand the dynamics and function of fine roots. However, they have been used comparatively infrequently in forests and other natural plant communities. Several factors have contributed to this situation, including anomalous root distributions along the minirhizotron surface and the difficulty of extracting data from minirhizotron images. Technical and methodological advances have ameliorated some of these difficulties, and minirhizotrons have considerable potential to address some questions of long standing interest. These questions include more fully understanding the role of roots in carbon and nutrient cycling, rates of root decomposition, responses to resource availability and the functional significance of interactions between plant roots and soil organisms. Maximizing the potential for minirhizotrons to help us better understand the functional importance of fine roots in natural plant communities depends upon using them to answer only those questions appropriate to both their inherent strengths and limitations.

Introduction

Since first described by Bates (1937), minirhizotrons have emerged as useful tools to understand root system form and function. They have helped improve our understanding of many aspects of root ecology, including production, longevity, phenology and distribution in a wide array of ecosystems (Aerts et al., 1992; Dubach and Russelle, 1995; Eissenstat and Caldwell, 1988; Hendrick and Pregitzer, 1992a, 1993a,b; Hooker et al., 1995; Kosola et al., 1995; Taylor, 1987; Upchurch and Ritchie, 1983). Within the past few years, the technology associated with minirhizotrons has advanced considerably. In particular, developments in optics and electronics have greatly increased both the amount and detail of data that can be collected with minirhizotrons. Early minirhizotron studies were comparatively primitive and the level of resolution and degree of quantitative data collected were low, but it is now possible to resolve and measure structural and ultra-structural root features at scales of 10 microns or less.

Root systems in most plant communities are poorly understood, and few have been studied with minirhizotrons. Data from natural plant communities are especially scarce, as the minirhizotron technique has been most readily accepted and refined by agronomic scientists (Taylor, 1987; Upchurch and Ritchie, 1983, 1984). However, minirhizotrons are well suited for field research in natural plant communities. They are small in size (typically 2-5 cm in diameter and up to 2 m in length), image acquisition technology is of high quality and they are easily installed in remote field locations. Moreover, they permit the in situ study of fine root dynamics in a continuous, non-destructive manner. Minirhizotron studies from non-agronomic ecosystems are appearing in the scientific literature with increasing regularity, but several difficulties, both real and perceived, have contributed to their still infrequent use. These include frequently observed anomalous root length or number distributions along the soil profile, the relatively high cost of acquiring state-of the-art technology, and the difficulty of extracting data from minirhizotron images. The small number of studies that have used minirhizotrons to sequentially track the growth and fate of individual roots is disappointing.

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