Applications of Minirhizotrons for the Study of Root Dynamics

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Introduction

Minirhizotrons were originally proposed by Bates in 1937. The minirhizotron technique involves installing a clear tube in the soil and lowering a device into the tube to observe the roots at the soil-tube interface (Taylor et at., 1990). Bates (1937) originally used a mirror and a lamp mounted on the end of a stick to see roots intersecting a glass tube. Recent applications have been improved through the use of a miniature color video camera and a right-angle viewing head (Upchurch and Ritchie, 1984). The new technology has greatly improved the quality of the soil images (Taylor et al., 1990).

Roots and their rhizosphere organisms can be observed at the soil-wall boundary (Taylor et al., 1990). Estimation of plant root activities by the minirhizotron technique is a non-destructive approach for observing root responses to the soil environment (Box et al., 1989). The minirhizotron technique allows the in situ study of the relationships of the entire range of soil biota: roots, microorganisms, protozoa and invertebrates (Lussenhop and Fogel, 1993).

Materials and Methods

Materials

The minirhizotron system is a multicomponent assembly that visually or photographically records root growth (Brown and Upchurch, 1987). The various components include: (1) a transparent observation tube that is often made of acrylic; (2) a scope with a viewing eyepiece or a camera that is produced by either the Circon Corporation or Bartz Technology and is specifically made for use in minirhizotrons; (3) recording equipment for permanently storing the images; and (4) a device for transporting the equipment.

Installation

Proper installation is critical. Hydraulic soil probes are often used for quick and accurate placement. The tube must contact the soil enough to minimize voids at the soil-tube interface. As well, the walls of the minirhizotron tubes cannot be smeared with soil. The angle of installation depends on the observation desired, however vertical tube placement is not recommenced as roots tend to grow down the tube interface. After installation, the above-ground portion of the tube is painted and capped to prevent moisture and light from entering the tube (Brown and Upchurch, 1987).

Viewing and Recording

The Circon Corporation, or the Bartz Technology, camera and optics system is designed to be lowered into the tube and to transmit a video image to a monitor or video camera (Brown and Upchurch, 1987). The images can then be recorded permanently and analyzed using computer software, such as **RooTracker™**, which was developed specifically for minirhizotron images (Brown and Upchurch, 1987).

Discussion

Applications

Applications of the minirhizotron system involve quantitative and qualitative root measurements such as color, branching, length, density, diameters, dynamics and lateral root spread (McMicheal and Taylor, 1987). Minirhizotrons have been used to contrast root response to different tillage, crop and community types (Aerts et al., 1989). Infrared lighting emphasizes contrast allowing dark roots, roots of legumes, cereals and native grasses to be seen more easily (Lussenhop and Fogel, 1993).

Macroscopic fungal structures may be counted, allowing density estimates of ectomycorrhizae, rhizomorphs, and colonies of saprophytic fungi. Periodic observations of microorganisms allow determination of survivorship and productivity (Lussenhop and Fogel, 1993).

Benefits of minirhizotrons

Minirhizotrons can be installed among crops or in natural communities (Lussenhop and Fogel, 1993). Nutrients or inoculum can be added to the surface of minirhizotron tubes through cannulae (Lussenhop and Fogel, 1993). Frequent measurements can be done ***in situ*** with little disturbance to the natural environment (Cheng et al., 1990). As well, minirhizotrons can be used to observe microfaunal and mesofaunal activities in the rhizosphere (Box et al., 1989). Estimates of increases in root length can be made rapidly (Taylor et al., 1990) and the dynamics of plant root growth can be studied directly (Samson and Sinclair, 1994).

Various interesting aspects of soil activity can be studied over time, such as: the spread of fungal hyphae, the death of an individual root as it experiences an oxygen deficit, the swelling and shrinking of a root as the soil water potential changes, the bulging of a root as it encounters an impeding object (Taylor et al., 1990).

Limitations of minirhizotrons

The minirhizotron tubes may fail to maintain close contact at the soil-tube interface (Brown and Upchurch, 1987), which can influence root growth and distribution (Brown and Upchurch, 1987). As well, root densities, when estimated using the minirhizotron technique, may not correspond well with the estimates from soil cores (Samson and Sinclair, 1994). Consequently, a major limitation of the minirhizotron system is the number of tubes required to accurately estimate rooting (Taylor et al., 1990). The initial costs are also a concern, as the equipment costs are approximately $25,000.

Conclusion

Minirhizotrons offer the unique opportunity of continuously observing roots in situ. They also allow for the direct observation of interactions between roots and the surrounding biota.

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