Root plasticity to water and its relevance for drought tolerance

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ABSTRACT

The manner in which roots explore the soil is a key ability for plants to survive and compete. Root plasticity to exploit nutrient patches is well documented, however the responses to localised water is less well understood. Compacted layers in the soil, either natural e.g. at horizon boundaries or resulting from compaction associated with the passage of machinery, often impedes the access of roots to the subsoil. In these cases access to subsoil water is controlled by the numbers of roots that find and follow a crack or biopore through the compacted layer and then have the plasticity to exploit the water resource. Recently we have used field experiments controlling the access of roots to water in the subsoil as a way to screen a limited number of barley genotypes for their ability to cope with drought stress.

We have modified our technique of controlling access to the subsoil and applied it in controlled growing conditions with dry surface soil and water available at depth. Measurements of root length, mass and branching are obtained after washing the roots from fixed depths in the soil. This enables us to measure the proliferation of roots of different barley genotypes and to compare them with control samples and thus quantify their plasticity to subsoil water.

Key words (max 6): Barley, Root Plasticity, Drought tolerance, Biopores, Subsoil water.

1. INTRODUCTION

In this paper we study the behaviour of roots of barley plants grown in tubes of soil. The roots of crops grown in the field can be prevented from accessing the subsoil burying a horizontal layer of mesh in the subsoil prior to planting the crop (Beyrouty and Oosterhuis 1989). Our recent work (McKenzie *et al.* 2009) has shown that access of crop roots to the subsoil can be controlled and varied by puncturing these layers of mesh to provide a limited number of opportunities for the roots to find a way through the mesh. Crop parameters such as leaf area and plant height show response this access. The technique mimics the way roots access subsoil by following biopores created by soil fauna or left from previous crops. We are comparing the response of different barley genotypes to this limited access. Any differences must arise from differences in root number or plasticity.

2. METHODS

Individual barley plants from a range of genotypes are grown in tubes packed with soil. The tubes (50mm diameter, 0.5m long) have a layer of mesh placed at 0.1m depth. The mesh prevents root penetration but allows the movement of fluids. The mesh is punctured with a 2mm diameter hole in the centre. This permits individual roots that find the hole to access the subsoil.

A pre-germinated barley seed is planted into the soil at the top of each tube. The base of the tubes is left open and immersed in water. This provides a water gradient – from a wet base to a dry top soil. The barley is allowed to grow in controlled environment chambers for 28 days and then harvested. At harvest the above ground parts of the plant are measured. The tubes containing soil and roots are sectioned in 0.1m lengths. The top 0.1m is above the mesh, the other sections are below the mesh. The water content of the layers is determined. The number of roots (if any) that have penetrated the hole is determined. All roots are then washed from each layer of the soil and scanned. Parameters such as root length, diameter and mass are determined.

3. RESULTS

Differences in the root systems of different genotypes have been observed. It appears that there are differences in both the number of roots penetrating the hole and the root parameters in each layer. Experiments are continuing and statistical analysis being conducted.

4. DISCUSSION

Our field based method provides a new method to screen for differences in crop production and root growth at the plot scale (McKenzie *et al.* 2009). To fully exploit the information obtained from the field assessments we need to identify and quantify specific root parameters that relate efficient exploitation of soil resources, particularly water.

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