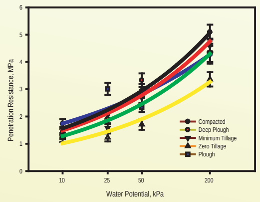
Genetic variation and interactions of root traits involved in plant:soil physical interactions.

Valentine T.A., Karley A.J., Hallett P.D., McKenzie B.M., Bengough A.G.
Environment Plant Interactions, Scottish Crop Research Institute, Invergowrie, Dundee, DD2 5DA
T.Valentine@scri.ac.uk

Background

Root growth is often constrained by soil physical conditions. Breeding crops to overcome these root constraints could make higher yields sustainable under variable rainfall patterns.



The main physical constraints to root growth are mechanical impedance, hypoxia, and water stress. The constraints experienced depend on soil compaction and water content. Soil strength increases as soil dries, and is greatest in compacted soils. Soil strength and structure are influenced by tillage.

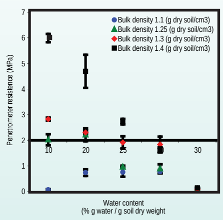
Plants respond to these varied rooting conditions by changes in overall root structure and by changes at the individual meristem level such as increasing border cell production.

Aims

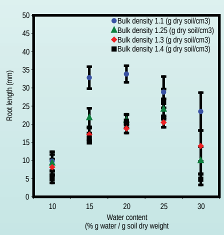
To quantify root trait variation in a selection of barley germplasm (inc. winter and spring cultivars with a range of introduction dates; two sets of spring cultivar mutants).

To investigate how root traits interact to overcome specific soil physical constraints.

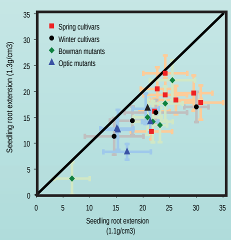
Barley seedling responses to soil physical constraints



Soil strength (penetrometer resistance) of repacked soil increased with compaction and drying.



Seedling (Cv. Optic) root elongation slows in more compact soil and extremes of soil water content.

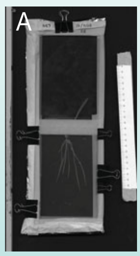


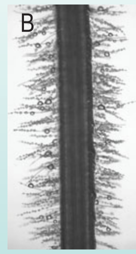
Barley seedlings exhibited different levels of growth inhibition due to soil compaction (soil water content 20%).

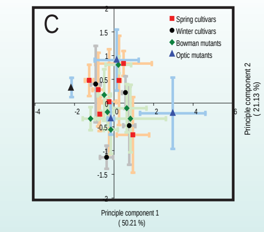
Acknowledgments: This work is supported by Scottish Executive Environment and Rural Affairs Department.
Barley cultivars and mutants were obtained from collections of Barley maintained by Genomics Programme SCRI. - See also reference Caldwell, D., McCallum, N., Shaw, P., Muehlbauer, G.J. & Waugh, R. (2004) A structured mutant population for forward and reverse genetics in barley (Hordeium vulgare L.). Plant Journal 40, 143-150.
Thanks also to Kirsty Binnie, Nicola Dale, John Post, Mark Young, Gladys Wright.

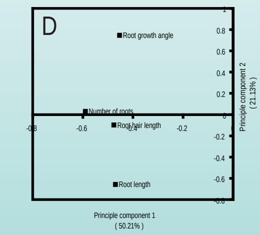
Root trait variation in barley cultivars and mutants

Barley cultivars and mutants were grown in sterile thin gel culture plates (Fig. A). Root phenotypes measured include number of seminal roots, root length, root growth angle and root hair length (Fig. B).

A


B


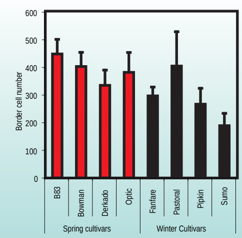
C


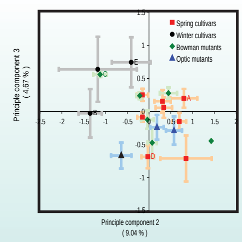
D


Significant variation between root phenotypes (Fig. C), mainly associated with size. Suggestion of opposing effects of root length and root growth angle on principle component 2 (Fig. D).

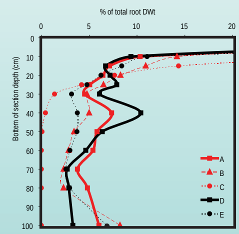
Border cell number: Significant variation was found between cultivars.

Border cells detach from the root cap as the root pushes through soil, decreasing root-soil friction, and helping root penetration.





Root depth distribution: Overall root mass dominated the variation found (PC1), but variation in root depth distribution was also found - separated mainly on the relative amount of roots at lower depths (e.g. PC2 Fig. A-C). PC3 - separated mainly on relative root mass at 35-40 cm depth.



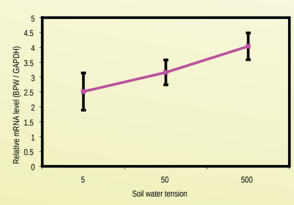
Conclusions and future work

Significant variation in root traits was found between barley cultivars and mutants (root mass, root distribution with depth, root length, and border cells produced). Genotypes differed in the ability of their roots to extend in compacted soil, suggesting some genotypes are more vulnerable to these constraints.

Plants with specific combinations of root traits are being assessed to elucidate the relative importance of these traits in overcoming soil physical constraints.

Plants are being assessed in differerent soil types, densities and water availability.

Expression of genes linked to responses of plants to soil conditions will be explored.



mRNA levels of BPW obtained by quantitative RT-PCR in plant roots grown under different water availability, in soil cores. BPW is involved in water uptake