Determining the phenotypic basis of differential cultivar response to soil physical constraints in winter and spring barley

Supervisors: Glyn Bengough, Paul Hallett, Blair McKenzie, Tracy Valentine and Adrian Newton

Background:
Barley growth was studied on an established site under five different cultivation practices: zero cultivation, minimum tillage, 'conventional' plough, compaction (plough then tractor wheeling), and 'deep plough' (30cm plough depth). The plots are on a South-facing well drained sandy loam soil, at SCRI. In 2008 we grew 64 different winter barley cultivars and 56 spring barley cultivars on the treatments to study their relative performance. These treatments produced very different root-zone soil physical environments and, in 2008, there was a large difference between cultivar yield under the high and low soil disturbance regimes. Certain cultivars out-yielded others by up to 30% on the plough treatments, with the higher-yielding cultivars in high disturbance regimes often performing relatively more poorly on the low-disturbance systems.

The aim of this study, during 2009, was to obtain more detailed information on crop growth for a smaller range of winter and spring barley genotypes, selected to span the range of relative yield on the high and low disturbance treatments. We wanted to see if the original cultivar rankings were repeatable, and to obtain preliminary information to focus future research direction in understanding interactions between genotype and cultivation practices. Strong interactions between cultivar and cultivation practice could indicate a need to carry out breeding selection under such conditions for adapted cultivars.

Experiments performed:
Twenty winter and ten spring barley cultivars were sown in six replicate plots in each of the five soil cultivation treatments, making a total of >900 plots. Half of the plots were monitored from April through to harvest for: emergence, plant density, habit, canopy morphology, growth stage, disease, height, light interception, root capacitance, root pullout strength, and grain yield. Due to the large number of plots involved, not all parameters could be measured on all treatments and so we concentrated effort on the minimum tillage and plough treatments.

Results:
Cultivar-yield variation between the treatments was much less in 2009 compared with the previous year. For the winter barley cultivars, the minimum tillage plots yielding consistently more than the plough treatment for most of the cultivars. There was some consistency of cultivar ranking, with many of the cultivars that performed relatively better (than on plough) on the minimum tillage treatment in 2008, also doing so in 2009. The leaf area index, as estimated from light interception in May 2009, followed a similar pattern to yield in most of the cultivars.

The spring barley plots on the plough treatment generally out-yielded the minimum tillage in 2009, but the yield under plough treatment appeared relatively unrelated to their yield under minimum tillage.

Root pull-out force was investigated as a rapid measure of nodal (crown) root number and strength. It was related to plant size and yield, probably because of an increase in the number of tillers present. Root capacitance was also found to be a potentially valuable method for root system assessment, but depends strongly on soil water content.

Conclusions:
Cultivar yield performance on minimum versus plough treatments depended strongly on seasonal variation, presumably due to consequences of variations in soil water regime in the rooting zone. Cultivar yield was positively related to leaf area index and root pullout force. There was some consistency of ranking of relative cultivar performance on minimum tillage compared with ploughed between seasons, and root characteristics were strongly implicated as the basis for these differences. Root traits were therefore clearly identified as a key priority for developing barley cultivars resilient to soil cultivation differences and likely abiotic stresses in general. To progress such research we will focus on improving our ability to study root systems in the field on large numbers of plots.

Acknowledgements
We are very grateful to Dr C. Hackett (BioSS) for statistical analysis, to Mr M. Skiba for performing the measurements, and to the SSCR for contributing to the funding of this study.