IWYP International Wheat Yield Partnership
Research to Deliver Wheat for the Future

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Root System Architecture and Function Influences Wheat Yields

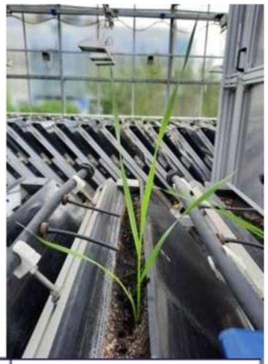

Fig 1. Screening roots in glasshouse

Fig 2. Difference in rhizosheath attached to roots in cv. *Avalon* (left) vs. *Cadenza* (right)

Roots are often the ignored "invisible half" of a crop, but an optimized root system is a critical component of crop growth and development and thus a prime target for improving wheat genetic yield potential.

Variation affecting root phenotypes is rarely selected directly by breeders because of the difficulties in phenotyping root structures. Roots are important for many features of plant growth including scavenging for and uptake of nutrients and minerals. They also exude phytochemicals that attract or repel classes of microbes that have a major influence on root function. The structures and phytochemicals also influence the portfolio of endophytes that enter the plants and influence their abilities to withstand stresses, including diseases, amongst other things.

Poor root growth limits the uptake of nutrients, minerals and water. The latter leads to reduced transpiration and thereby higher canopy temperatures. This inverse relationship between root mass and canopy temperature provides a useful proxy assessment of root biomass/activity.

Root mass reflects the amounts of carbon that are exported from shoots to enable root growth and this is under genetic control. In an IWYP project, "**Root^y: A Root Ideotype Toolbox to Support Improved Wheat Yields**", led by Eric Ober at NIAB, UK, along with colleagues in Italy, Germany, Australia, Mexico and the UK, a range of parameters such as root biomass distribution and growth angle were investigated in the field, and in specialised 'rhizoboxes' in the glasshouse (**Figure 1**). The experiments contribute to the physiological and genetic understanding of root growth and development, but also aid development of techniques for higher-throughput root phenotyping to characterize genetic variation for root traits to aid their exploitation by breeders (see also IWYP Science Brief No. 21 https://iwyp.org/iwyp-science-briefs/). After backcrossing genes known to influence root biomass and angle into different elite lines, field trials revealed that the genes affected biomass at different depths. In a parallel project at the IWYP Hub at CIMMYT, remote sensing protocols were developed that predict root mass with high accuracy at different soil depths using canopy thermography (Moreno, 2024. PhD thesis). One trait that correlated with yield was the apparent uniformity of root distribution in upper soil layers, suggesting that root systems that leave areas of the soil unexplored are disadvantageous. Roots of two cultivars (*Avalon* vs. *Cadenza*) were also found to have very different amounts of rhizosheath attached to the roots (**Figure 2**). Using monoclonal antibodies against different types of carbohydrates in root exudate, heteroxylan contents of the rhizosheaths of different cultivars were found to correlate with rhizosheath size. Interestingly, differences in fungal community composition were found between lines with either high or low xyloglucan levels in their exudate (**Figure 3**). Furthermore, certain groups of fungal species in exudates correlated with yield in field trials.

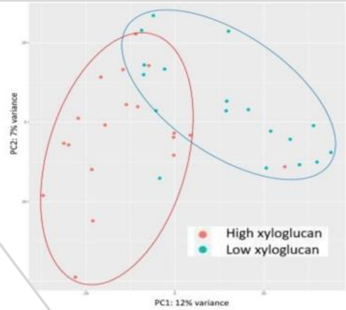

Fig 3. Fungal community types group relative to xyloglucan level in exudate

These observations emphasize the importance of root-rhizosphere interactions based on root exudate chemistry and microbiome composition, in addition to root size, angle and shape and their effect on grain yield in wheat.

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