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Improving predictions of root biomechanical properties, is age a better determinant than diameter?

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Roots mechanically reinforce many soils. Root tensile strength and stiffness is critical for soil stabilisation with plants potentially providing civil engineers a 'green' alternative for soil stabilisation. Relatively little is known on factors influencing root tensile strength. Through a better understanding of these factors the adoption of 'green engineering' techniques by civil engineers will improve. Existing models are limited in their accuracy due to simplistic assumptions to derive root contributions to the resistance of soil to failure. Current models typically use relationships between strength and diameter, however, there are a number of other factors potentially influencing root biomechanical properties. The effects of root age on biomechanical properties have largely been overlooked.

Barley (Hordeum vulgare) was grown under differing soil conditions, waterlogged, moderate mechanical impedance and in unimpeded, control, conditions. The root system was excavated and tensile tests performed on root sections along the length of each root axis. Root tensile strength increased with increasing distance along the root axes in control soil from 0.5 MPa to 7.0 MPa at a distance of 800mm from the root tip and from 1.0 Mpa to 8.0 MPa, 500mm from the root tip when under moderate mechanical impedance. Increases in strength were also observed when plants were subjected to waterlogging with tensile strength increasing from 1.0 MPa to 3.0 MPa, 200mm from the root tip. Young's modulus increased from $\sim$10 MPa at the root tip to $\sim$60 MPa 400mm and 800mm from the root tip in mechanically impeded and control treatments respectively. Distance from root tip explained over 47% of the variance in root tensile strength and 34% of root stiffness. Including root diameter in the model led to further improvements in predicting root properties, explaining $\sim$54% of root strength variance and $\sim$49% of root stiffness.

Root age has been shown to improve predictions of root tensile strength and modulus with the inclusion of root diameter improving predictions further. Laser sectioning of maize (Zea mays) roots demonstrate the damage caused during biomechanical testing and help explain potential reasons for poor relationships between diameter and strength due to stress localisation within the stele. Furthermore, changes in biomechanical root properties associated with age maybe as a result of lignin deposition but this remains to be established.