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Rooting out soil structure

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Soil has a spatially heterogeneous mix of weaker and stronger elements, and larger and smaller pores. When studying physical constraints to root growth, however, most studies use sieved, repacked soil to create a more homogeneous environment that is far from conditions observed in field soils. Sieved, repacked soil gives the advantage of careful manipulation of physical properties, such as density or penetration resistance, and also removes differences in carbon and microbial properties that could affect structurally different soils sampled from tillage or compaction field experiments. To overcome unrealistic homogeneity of repacked soils, but remove soil structure treatment impacts on other soil properties that could confound interpretation, we have explored root growth in laboratory cores carefully packed to provide different soil structures.

In one set of experiments, sieved soil was compacted then broken apart to form aggregates. Treatments were formed by packing either the sieved soil (unstructured) or much denser aggregates (structured) to a range of bulk densities, producing a 50% increase in macroporosity at 1.55 g/cm^3 density and more variable penetration resistances for structured soils. Plant growth of barley, peas and Arabidopsis, including shoot and root properties, was affected less by bulk density in structured than unstructured soils. For instance, root length of barley and peas decreased less between 1.25 g/cm^3 and 1.55 g/cm^3 for structured compared to unstructured soils, as roots could exploit macropores.

Another experiment explored how the shape of macropores in the plough pan affected deep rooting of rice. Round holes simulating biopores and straight pores simulating cracks were inserted through a simulated plough pan, packed to the Proctor Density of 1.53 g cm^{-3} and penetration resistance of 2.80 MPa at – 20 kPa water potential. Not only did macropores improve root growth in the plough pan and through to the subsoil, but the shape of the macropore had a large impact. Cracks compared to biopores produced 55% more root length density in the plough pan, but 26% less root length density in the subsoil. Many other root properties in the plough pan and subsoil were affected by macropore shape.

With increased use of shallow or zero tillage, and constraints from diminishing water for irrigation and the stresses of climate change, the capacity of roots to take advantage of the heterogenous structure of field soil to grow deep and wide is extremely important. Laboratory approaches with

controlled soil structure will help to unravel the underlying processes by providing careful control, which can supplement understanding obtained from structured field soils.