Aeration as influenced by soil structure dynamics– a contribution to improve the acquisition of nutrients from the subsoil.

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Soil structure influence on aeration can be analyzed at various scales. At plot scale, crop sequences are a valid alternative to improve subsoil structure due to the generation of enhanced biopore networks and inter-aggregate pores (cracks). These secondary pores can be used by future crops to take advantage of a better substrate. In a millimeter scale, great variability in oxygen content is found, especially related to the proximity to roots and microbial hotspots. We hypothesized that root driven soil structure formation has a significant impact on aeration.

Two plot scale studies examined how far three crops of (i) *Festuca arundinacea*, (fescue - shallow roots), (ii) *Cichorium intybus* (chicory - taproot-herringbone-roots) and (iii) *Medicago sativa* (alfalfa – taproot-depth-multibranched) and their different root architectures influenced soil structure and aeration. The field experiment was located near Bonn (Germany) with soil type Haplic Luvisol derived from loess. Air diffusion, air permeability, air-filled porosity and hydraulic conductivity were analyzed as a function of crop type, crop duration (one, two and three years of continuous cultivation) and soil depth (45, 60, 75 and 90 cm). Continuity and tortuosity indices were also calculated. In a third experiment, oxygen content and redox potential in the rhizosphere of alfalfa was monitored at a millimeter scale by means of miniaturized oxygen and redox sensors under various matric potential ranges. Respiratory activity, content of available carbon and pH profiles were determined near the root surface.

In the plot scale, after three years, alfalfa generated more macropores than chicory and fescue at 75cm (means of 13.6 %, 2.5 % and 3.4 % respectively) and 90 cm depth (means of 17.8 %, 2.3 % and 4.4 % respectively). A greater structuration effect under alfalfa was interpreted via a higher tortuosity index. Measurements showed decreasing gas diffusion with depth under chicory and fescue cultivation, whereas increased with depth under alfalfa. Under chicory, higher continuity and lower tortuosity of pores influenced the advective transport. Significant effects of the three treatments on soil aeration parameters were observed after three years of cultivation suggesting the need of three years biological tillage for structure changes. Measured VWC showed critical water contents during summer. Simulated air permeability in dependence of VWC showed almost no aeration problems for the studied field up to 75 cm. The structure changes observed are promising to extend these results to other soils with swell/shrink potential. In the rhizosphere scale, gradients in oxygen concentration and anoxic zones were found in the proximity of roots due to a higher respiratory activity compared to the bulk soil. Under saturated and near field capacity up to -200 hPa, oxygen transport was limited, ranging pO_2 from 0 to 3 kPa at the root surface. Aerobic respiration decreased about 100 times in comparison to a dryer status. 9—12 % air-filled porosity was found optimal for O_2 transport. This was confirmed by redox potential patterns, which showed values around +300 mV in aerated conditions, while reached +100 mV on the root surface under near water saturated conditions. From the perspective of aeration, the rhizosphere extension was 1-2 cm from the root surface.