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Effects of traffic-induced soil compaction on crop growth and soil properties

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Traffic-induced soil compaction on arable soils constitutes a major threat for agricultural productivity and the environmental quality of the soil, water and atmosphere. The objective of this work is to evaluate a set of prevention strategies for agricultural traffic under real farming conditions. To that end, a one-pass traffic experiment was conducted near Ghent, Belgium in winter 2015 on a sandy loam (haplic Luvisol; 43% sand, 47% silt, 10% clay). Winter rye (*Secale cereale* L.), which promotes the removal of residual soil nitrogen and thus reduces the potential for nitrogen leaching, was sown as cover crop using different tractor and weather settings on different field lanes: dry (D, 0.16 m^3 m^{-3}) or wet (W, 0.20-0.23 m^3 m^{-3}) conditions, normal (N, 65 cm width, axle load 8520 kg) or wide (W, 90 cm width, axle load 8520 kg) tires and high (HP, 1.4 bars for N, 1.0 bar for W) or low (LP, 1.0 bar for N, 0.5 bar for W) inflation pressure. Subsequently, crop biomass, root density and a set of hydrophysical properties (penetration resistance, saturated hydraulic conductivity and water retention at 15, 35 and 55 cm depth) were measured. Bulk density, soil quality indicators (such as air capacity) and the pore size distribution were also calculated. Results showed significant biomass reduction ($p < 0.01$) for trafficked plots compared to their control (un-trafficked): 40% reduction under dry conditions and ~80% under wet conditions. However, no differences were found between traffic treatments. A similar trend was observed for root density, though less significant. Under wet conditions, the rooting depth was also reduced (10 cm instead of 30 cm), and densities were very small. These results suggest a negative effect of compaction on crop growth, worse under wet conditions, but the choice of tires did not prove to have an effect. Observations on the hydrophysical properties were more mitigated, as expected: distinct differences are primarily found under controlled lab conditions or after several passes. Moreover, high moisture conditions could not be obtained for the wet experiment, which never exceeded field capacity, conceived as threshold. Nevertheless, penetration resistance profiles indicated a plough pan about 40 cm depth, witness of previous agricultural operations on the field, and high values (3.5 to 4 MPa) were found in the subsoil too. Moreover, bulk densities were higher for all treatments (up to 1.8 Mg m^{-3}) compared to the controls (~1.55 Mg m^{-3}). Saturated hydraulic conductivities were very small (<< 10 cm/d), especially for the treatments. The dry treatment also showed better values than the wet ones at 15 cm. Water retention curves tended to show decreased water content at low suctions for the treatments (mainly at 15 cm), which could reflect on a reduction of macropores and their continuity. Soil quality parameters also showed better values in the control plots. These observations support an overall compacted state and loss of structural quality, though no significant impact of the traffic experiment or prevention strategies could be drawn.