EGU2020-7424
https://doi.org/10.5194/egusphere-egu2020-7424
EGU General Assembly 2020
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Plot-scale experiments to assess the effects of surface spatial heterogeneity on runoff and soil loss

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Topsoils on the arable fields are usually considered as spatially uniform layers, especially just after the cultivation when the seedbed conditions are present. Nevertheless, there are features, resulting from the agricultural machinery operations or memory effects from the previous growing season, that cause spatially non-uniform soil infiltration characteristics even on a small scale. Examples of such features are the wheel tracks, wrinkles from the ploughing or the non-uniform morphology of the compacted subsoil. Surface runoff and soil loss are affected by the direction of the agro-operations. Wheel tracks act as an obstacle for the surface flow if the orientation is perpendicular to the slope and as the main draining flow path if the orientation is in slope wise direction. Ploughing changes the soil structure in the shallow part of the soil profile, creates sharp delineation between topsoil and compacted subsoil and subsequently alters the natural infiltration and may create lateral subsurface runoff. Plot scale artificial rainfall / runoff experiments were designed to study the ploughing and wheel track compaction effect on the surface runoff and soil loss. Several experiments were carried out at mildly declined slopes (slope ca 10 %) at 16 m2 plots located at an experimental site in the central part of the Czech Republic utilizing Norton Ladder Rainfall Simulator. Experiments were replicated at (1) a plot without wheel track (noWT), (2) a plot with wheel track oriented slope wise (swWT) and (3) a plot with wheel track oriented perpendicularly to the slope (psWT). Artificial rainfall experiments were supplemented with a detailed soil water regime monitoring, geophysical measurement and measurement of penetration resistance. Wheel track at the swWT plot caused faster runoff and soil loss response to the rainfall and increased the total runoff volume and soil loss mass. Wheel track at the psWT plot disconnected the upper and lower part of the plot. The psWT plot was entirely connected when surface depressions were connected which increased the time lag of the runoff and soil loss response. It was concluded that the surface topography and possibly impact of raindrops are the first order control factors of the surface runoff and soil loss formation. Filling and consequent interconnection of the surface depressions together, to the bottom of the plot or to the wheel track, triggers the surface runoff and soil loss. The compacted subsoil, which exhibited high penetration resistance and electrical resistivity, did not exhibit any lateral subsurface runoff in the shallow soil profile suggesting high hydraulic conductivity of both the topsoil and the subsoil when the soil is fully saturated. The experiments were carried out within a scope of projects 773903 “SHui - Soil Hydrology research platform underpinning innovation to manage water scarcity in European and Chinese cropping systems” and LTC18030 “The effect of land-use changes on soil erosion, sediment transport, water quality and rainfall-runoff balance”.