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Water depression storage under different tillage conditions: measuring and modelling

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Water storage in surface depressions (DS) is an important process which affects infiltration, runoff and erosion. Since DS is driven by micro relief, in agricultural soils DS is much affected by tillage and by the direction of tillage rows in relation to the main slope. A direct and accurate measurement of DS requires making the soil surface waterproof -soil is very permeable especially under tillage- but preserving all details of the soil roughness including aggregates over the soil surface (micro-roughness). All this is a very laborious and time-consuming task. That is why hydrological and erosion models for DS estimation normally use either empirical relationships based on some roughness index or numerical approaches. The aim of this work was (i) to measure directly in the field the DS of a soil under different tillage conditions and (ii) to assess the performance of existing empirical 2D models and of a numerical 2D algorithm for DS estimation.
Three types of tillage classes (mouldbard+roller, roller compacted and chisel) in 2 tillage directions (parallel and perpendicular to the main slope) were assessed in an experimental hillslope (10% slope) which defines then 6 treatments. Experiments were carried out in 12, 1-m2 micro-plots delimited by metal sheets; that is, a pair of repetitions for each treatment. In each plot, soil surface was gently impregnated with a waterproof, white paint but without altering micro-roughness. A known amount of water (stained with a blue dye) was poured all over the surface with a measuring cup. The excess water was captured in a gutter and measured. Soon after finishing the experiment, pictures of the surface was taken in order to analyze water storage pattern (from stained water) by image processing. Besides, longitudinal height profiles were measured using a laser profilemeter. Finally, infiltration rate was measured near the plot using a double ring infiltrometer.
For all the treatments, DS ranged from 2 mm to 17 mm. For the same tillage direction, clear differences in DS were observed among tillage types. Besides and as expected, DS much increased (up to 3 times) in those treatments were tillage rows were perpendicular to the main slope. The performance of the models in DS prediction was in general rather limited with deviations from reference values ranging from 45% to over 100%. The results suggest the inadequacy of 2D approaches to depict the complexity of the water surface storage pattern. On the other hand, some tillage operations lead to a rather small DS but with a relative high infiltration rate (up to 3 times that of the non-tilled soil); whereas in others the opposite was true. This fact should be taken into account in hydrological management of agricultural soils.