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Runoff generation and flow paths on an inclined cultivated soil

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The hydrology of cultivated catchments has its specific features due to the temporary variable topsoil properties and a sharp divide between topsoil and compacted subsoil. Under various conditions (actual topsoil physical properties, initial soil saturation, rainfall characteristics, surface roughness or vegetation stage) the prevailing runoff mechanisms may vary from surface runoff to subsurface runoff or deep percolation.
To investigate the runoff generation and flow pathways and to quantify the runoff components on an inclined cultivated field under various rainfall and field conditions we conducted plot scale rainfall simulations. The experiments were done on the experimental plots Bykovice in Central Bohemia (Czech Republic), where the soil is classified as Cambisol with a clear divide between the topsoil and compacted subsoil at a depth of approximately 14 cm.
We used a mobile rainfall simulator (designed at the CTU in Prague) equipped with four solenoid-controlled nozzles positioned 2.65 m above the soil. An inclined experimental plot (8 x 2 m, 9% slope) was successively exposed to uniform simulated rainfall with intensity ranging from 23 to 64 mm h-1 and duration ranging from 1 h to 2.5 h. These simulated rainfall parameters were selected to represent intensive rainfall events observed in the study locality, to generate surface runoff and to initiate soil erosion. The dynamics of surface and shallow subsurface runoff and the soil water regime at three soil depths were monitored. Various initial soil moisture conditions, and vegetation stages; from cultivated fallow to stubble, delimited the simulations. Variable proportions of both monitored runoff components were observed in relation to rainfall intensity and duration, ranging from zero surface runoff to a distinct dominance of surface runoff. Both components reacted very dynamically to the precipitation: shallow subsurface runoff was formed first under all tested conditions on the given soil profile. Even with the highest tested precipitation intensities, surface runoff always formed due to saturation excess of the topsoil, irrespective of the topsoil properties and crops.
The experiments were numerically modelled and analysed to understand the effect of temporal variability in the macropores and intra-aggregate voids ratio within the topsoil. We used a combination of physically based macroscopic models S1D and HYPO. In the S1D the dual permeability approach with two coupled Richards equations is used, the simultaneously operating HYPO code is based on a diffusion wave (Boussinesq eq.).
Additional comparison of the experiments results with whole experimental catchment runoff regime (Nucice, Czech Republic) proves that lateral runoff through the shallow topsoil can easily cause a very quick increase of stream discharge.
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