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Parameterization and sensitivity analysis of a physically based plot-scale erosion model to predict rill initiation

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Rill erosion is an accelerated form of erosion with high agricultural and environmental significance. A physically based plot scale erosion model was developed in an earlier project to predict runoff and soil loss from small plots irrigated with rainfall simulator. The novelty of the model has been the fine scale representation of the random surface roughness hence the non-uniform runoff pattern. This enables to simulate transition between sheet and rill erosion.

Rainfall simulation experiments were carried out at Somogybabod, Hungary in the watershed of Lake Balaton. Texture class of the soil was sandy loamy silt. It has been a highly eroded soil down to the calcareous sandy loess parent material with high erodibility and strong rill formation in the landscape. Simulated rainfall was applied at 60 mm.h-1 intensity for 4 plots of 2 by 5 m size and measurements were repeated three times on each plot. Irrigation was continued until steady state runoff rate was reached, runoff and erosion were measured in regular time intervals. The results were used to calibrate the model.

Exponential equations were fitted to the runoff data with SPSS program. Three parameters of the model were derived directly from the fitted equations (initial infiltration, equilibrium infiltration, water storage of the active layer). Other parameters were set according to the experimental conditions (rainfall intensity, slope, plot size) or they were derived from generally accepted literature data (particle size, particle density). The remaining parameters were calibrated by repeated iterations and model runs (maximal sediment concentration, hydraulic friction, soil erodibility etc). The resulting set of parameters was considered as base scenario.

After parameterization, sensitivity analysis has been performed. The calibrated values of the influencing variables were changed with plus and minus ten percent and the total runoff and erosion was compared to the base scenario. Differences in total erosion data between plus and minus runs have been calculated. The results have been influenced by the following parameters in sequence of the decreasing effects: rainfall intensity (38 %), erosion coefficient (24 %), cell size (20 %), hydraulic friction (16 %), water storage of the active layer (6 %), particle size density (5 %), equilibrium infiltration (5 %), slope (5 %), initial infiltration (4 %). Other parameters have had smaller effect.

The model has predicted rill formation reasonably good. The change of the model output was larger than the change of input parameters in case of the rainfall intensity and erosion coefficient, the changes were similar in case of the cell size and the changes of outputs were smaller than the input changes at the other parameters. Thus, our conclusion is that searching for reliable "physically based" erosion coefficients and accurate estimation of real rainfall intensities are the most promising ways to predict the risk of rill erosion.