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Experimental rill erosion research vs. model concepts – quantification of the hydraulic and erosional efficiency of rills

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In soil erosion research, rills are believed to be one of the most efficient forms. They act as preferential flow paths for overland flow and hence become the most efficient sediment sources in a catchment. However their fraction of the overall detachment in a certain area compared to other soil erosion processes is contentious. The requirement for handling this subject is the standardization of the used measurement methods for rill erosion quantification. Only by using a standardized method, the results of different studies become comparable and can be synthesized to one overall statement. In rill erosion research, such a standardized field method was missing until now. Hence, the first aim of this study is to present an experimental setup that enables us to obtain comparable data about process dynamics in eroding rills under standardized conditions in the field. Using this rill experiment, the runoff efficiency of rills (second aim) and the fraction of rill erosion on total soil loss (third aim) in a catchment are quantified. The erosion rate [g m-2] in the rills is between twenty- and sixty-times higher compared to the interrill areas, the specific discharge [L s-1 m-2] in the rills is about 2000 times higher. The identification and quantification of different rill erosion processes are the fourth aim within this project. Gravitative processes like side wall failure, headcut- and knickpoint retreat provide up to 94 % of the detached sediment quantity. In soil erosion models, only the incision into the rill's bottom is considered, hence the modelled results are unsatisfactorily. Due to the low quality of soil erosion model results, the fifth aim of the study is to review two physical basic assumptions using the rill experiments. Contrasting with the model assumptions, there is no clear linear correlation between any hydraulic parameter and the detachment rate and the transport rate is capable of exceeding the transport capacity. In conclusion, the results clearly show the need of experimental field data obtained under conditions as close as possible to reality. This is the only way to improve the fundamental knowledge about the function and the impact of the different processes in rill erosion. A better understanding of the process combinations is a fundamental request for developing a really functioning soil erosion model. In such a model, spatial and temporal variability as well as the combination of different sub-processes must be considered. Regarding the experimental results of this study, the simulation of natural processes using simple, static mathematical equations seems not to be possible.