Geophysical Research Abstracts
Vol. 14, EGU2012-9966, 2012
EGU General Assembly 2012

Set-up and calibration of an indoor nozzle-type rainfall simulator for soil erosion studies

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Rainfall simulation is one of the most prevalent methods used in soil erosion studies on agricultural land. In-situ simulators have been used to relate soil surface characteristics and management to runoff generation, infiltration and erosion, eg. the influence of different cultivation systems, and to parameterise erosion models. Laboratory rainfall simulators have been used to determine the impact of the soil surface characteristics such as micro-topography, surface roughness, and soil chemistry on infiltration and erosion rates, and to elucidate the processes involved.

The purpose of the following study is to demonstrate the set-up and the calibration of a large indoor, nozzle-type rainfall simulator (RS) for soil erosion, surface runoff and rill development studies. This RS is part of the Kraijenhoff van de Leur Laboratory for Water and Sediment Dynamics in Wageningen University.

The rainfall simulator consists from a 6 m long and 2,5 m wide plot, with metal lateral frame and one open side. Infiltration can be collected in different segments. The plot can be inclined up to 15.5° slope. From 3,85 m height above the plot 2 Lechler nozzles 460.788 are sprinkling the water onto the surface with constant intensity. A Zehnder HMP 450 pump provides the constant water supply. An automatic pressure switch on the pump keeps the pressure constant during the experiments. The flow rate is controlled for each nozzle by independent valves. Additionally, solenoid valves are mounted at each nozzle to interrupt water flow. The flow is monitored for each nozzle with flow meters and can be recorded within the computer network.

For calibration of the RS we measured the rainfall distribution with 60 gauges equally distributed over the plot during 15 minutes for each nozzle independently and for a combination of 2 identical nozzles. The rainfall energy was recorded on the same grid by measuring drop size distribution and fall velocity with a laser disdrometer. We applied 2 different flow rates (4,5 l/min and 5,5 l/min), resulting in different rainfall intensities and made 2 repetitions each.

The average rainfall intensity was 36,8 mm/h at the first and 37,6 mm/h at the second repetition with the lower flow rate (4,5 l/min). With the higher flow rate (5,5 l/min) at the first repetition it was 44,4 mm/h and 46 mm/h at the second one. The maximum and minimum values were 22 mm and 2 mm at the lower (4,5 l/min) flow rate, respectively 26 mm and 4 mm at the higher one (5,5 l/min). In this latter case, the resulting average kinetic energy reached 7 J m-2 mm-1, with a maximum 31,3 J m-2 mm-1 of and a minimum of 2,9 J m-2 mm-1.

The Christiansen Uniformity coefficient (CU) for the lower intensities was 66% and 69%, respectively, with the higher intensities slightly better (70% and 72%).

The data of the rainfall simulator in Wageningen make it a promising tool for research in soil erosion processes.