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Effect of micro-topography and undrained shear strength on soil erosion

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An experiment to evaluate the effect of the pre-event soil surface conditions on the dynamics of the interrill erosion process was performed at the Masse experimental station (Italy) in a replicated 1mx1m plot, located in a 16% slope in a silt-clay-loam soil equipped with a nozzle-type rainfall simulator. Two experiments was performed, each experiment started from a just ploughed bare surface and included 3 simulations (I, II and III in the first experiment and IV, V and VI in the second experiment) carried out in the range of few days. A 30 min pre-wetting phase ensures almost constant initial soil moisture (mean=31%, CV=5%) and bulk density (mean=1.3 g/cm3, CV=3%). Rainfall intensity was maintained constant (mean=67mm/h, CV=2.7%). The independent variables were the initial soil surface conditions that, progressively modified by the rainfall runoff process, were different for the three subsequent simulations. The soil surface initial and final micro-topography and undrained shear strength, T, were monitored through photogrammetric surveys (with I-Phone 6plus) and Torvane test (with pocket-torvane, obliged shear surface at 0.5 cm from soil surface, plate diameter 5 cm, 0.2186 full scale complete revolution 360°, test done on saturated soil surface, with water standing at the surface). Runoff, Q, runoff coefficient, Qr, soil loss, SL and sediment concentration, C, were measured every 5 min. The particle size distribution were also determined.

During the simulations Q increases monotonically with typically concave trend. Almost similar consideration can be made for the other variables. A higher frequency of the roughness, RR, (i.e. vertical distance between the surface and a reference horizontal plane, obtained by removing the slope effect) lower than a fixed amount, was measured at the final than the initial step of each simulation and within the single experiment between successive simulations. Therefore, the roughness decreases along with the Q, SL and C increase. In general in the simulations equidistant from the plowing (I-IV, II-V, III-VI) the dynamic of Q, SL and C relative to the second experiment are slightly above that of the first experiment. Actually it is observed that although the frequency distributions of the initial RR of the first simulation of each experiment (I and IV) almost overlap, a higher frequency of the RR lower than a fixed amount was measured in the second experiment (the RR-V >RR-II and the RR-VI>RR-III). Higher T values were often measured at the final than the initial step of each simulation due to sealing and crusting processes associated with the surface smoothness.

These and other results open interesting scenarios in the study of the dynamics of the erosion process with particular reference to the relationship between the characteristics of the soil surface and the climatic and hydrological forcing both at event and intra-event time scale. In addition, some results offer discussion points relative to the dynamics of the soil erodibility, showing that the concentration behavior cannot be fully explained by the runoff dynamics.