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Impact of root morphology, soil characteristics and flow shear stress on the erodibility of topsoils during concentrated flow

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Many studies focus on the effects of vegetation cover on water erosion rates, whereas little attention has been given to the effects of the below ground biomass. However, few studies indicate that roots can reduce concentrated flow erosion rates significantly. Roots become important when the above ground biomass disappears, which often occurs in semi arid environments in case of fire or overgrazing or in case of concentrated flow erosion. In order to predict this root effect more accurately, this research aims to gain more insight into the influence of root morphology, soil and flow characteristics on the effects of plant roots on the erosion resistance of topsoils during concentrated flow. Although not experimentally investigated, Wischmeier already assumed in 1975 that plant species with contrasting root morphologies have a different reducing effect on soil losses by interrill and rill erosion. In this study, the effects of roots of different root morphologies (tap roots vs. fine-branched roots) on concentrated flow erosion rates are studied experimentally. The impact of soil type, soil moisture conditions (saturated vs. dry topsoil samples) and flow shear stress on the erosion reducing effect of roots is also considered. Treatments were (1) bare, (2) grass (simulating fine-branched roots) and (3) carrots (simulating taproots). The soils used were a sandy loam and a silt loam. Next, laboratory experiments during which concentrated flow was simulated in a flume were conducted. Slope, flow discharge, mean velocity, water temperature and sediment concentration were measured. Root density (RD) and root length density (RLD) values were assessed. Relative soil detachment rates (RSD) and mean flow shear stresses (ranging between 9-45 Pa) were calculated. The results indicate a significant difference between the two tested soil types and between the two different

species (grass and carrots) tested. No significant differences could be observed between saturated and dry topsoil samples. For grasses, no significant differences could be found between the different flow shear stress levels tested. For carrots on the other hand, the erosion reducing effect due to the roots is less when tested at higher flow shear stresses. This can be explained by the occurrence of local turbulence and horseshoe vortex erosion scars around individual carrot roots, which form an obstacle to the flow. According to root diameter different equations could be established. Carrots with very fine roots ($<$ 2mm) show a similar negative exponential relation between RD and RSD as grass roots. With increasing root diameter (2 to 15 mm) the erosion reducing effect of carrot type roots is less pronounced compared to fine roots. However, differences in erosion resistance induced by different root diameters are less pronounced as suggested by Wischmeier.