

Assessment of grass root effects on soil piping in sandy soils using the pinhole test

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Soil piping is a complex land degradation process, which involves the hydraulic removal of soil particles by sub-surface flow. This process is frequently underestimated and omitted in most soil erosion studies. However, during the last decades several studies reported the importance of soil piping in various climatic zones and for a wide range of soil types. Compared to sheet, rill and gully erosion, very few studies focused on the factors controlling piping and, so far, there is no research study dealing with the effects of plant roots on piping susceptibility of soils having a low cohesion. The objective of this study is therefore to assess the impact of grass root density (RD) on soil piping in sandy soils using the pinhole test.

The pinhole test involves a water flow passing through a hole of 1 mm diameter in a soil specimen (sampled using a metal ring with a diameter of 5 cm and a length of 8 cm), under varying hydraulic heads (50 mm, 180 mm, 380 mm and 1020 mm; Nadal-Romero et al., 2011). To provide a quantitative assessment piping susceptibility of the soil sample, the pipeflow discharge ($\text{cm}^3 \text{s}^{-1}$) and the sediment discharge (g s^{-1}) were measured every minute during a five minute test. Bare and root-permeated samples were tested, using a sandy soil with a sand, silt, clay content of respectively, 94%, 4% and 2%. The root-permeated topsoil samples were taken in field plots sown with a mixture of grasses with fibrous roots. All soil samples were placed on a sandbox with a 100 mm head for 24 hours to ensure a similar water content for all samples. In total, 67 pinhole tests (lasting 5 minutes each) were conducted, i.e. 43 root-permeated soil samples with RD ranging from 0.01 to 0.93 kg m^{-3} and 24 root-free soil samples as a reference.

Clear piping erosion could be observed in 65% of the root-free soil samples, whereas only 17% of rooted soil samples revealed clear piping erosion during the tests. Statistical analyses show that there is a negative correlation (-0.41 , $p < 0.05$) between RD and sediment discharge. Mean pipeflow discharge was 1.4 times larger for the root-free samples compared to the root-permeated samples, while mean sediment discharge was 3 times higher for the root-free samples compared to the rooted samples. This indicates that the presence of fibrous roots in topsoils decreases the susceptibility to soil piping significantly. Furthermore, a positive correlation between the hydraulic head (50–1020 mm) and sediment discharge was observed. Overall, our results suggest that root density is a highly relevant factor for decreasing the soil piping erosion rates in the sandy topsoils. The presence of even very low root densities ($< 1 \text{ kg m}^{-3}$) decrease pipeflow and sediment discharge.

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Reference:

Nadal-Romero, E., Verachtert, E., Maes, R., Poesen, J., 2011. Quantitative assessment of the piping erosion susceptibility of loess-derived soil horizons using the pinhole test. *Geomorphology* 135, 66–79.