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Overland flow generation mechanisms affected by topsoil treatment: Application to soil conservation

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Hortonian overland-flow is responsible for significant amounts of soil loss in Mediterranean geomorphological systems. Restoring the native vegetation is the most effective way to control runoff and sediment yield. During the seeding and plant establishment, vegetation cover may be better sustained if soil is amended with an external source. Four amendments were applied in an experimental set of plots: straw mulching (SM); mulch with chipped branches of Aleppo Pine (Pinus halepensis L.) (PM); TerraCotten hydroabsobent polymers (HP); sewage sludge (RU); and control (C). Plots were afforested following the same spatial pattern, and amendments were mixed with the soil at the rate 10 Mg ha-1. This research demonstrates the role played by the treatments in overland flow generation mechanism (runoff, overland flow and soil moisture along the soil profile).

The general overland flow characteristics showed that in the C plots the average overland flow was 8.0 $\pm$ 22.0 l per event, and the HP plots produced a similar mean value (8.1 $\pm$ 20.1 l). The average overland flow per event was significantly less for soil amended with SM, PM or RU (2.7 $\pm$ 8.3 l; 1.3 $\pm$ 3.5 l and 2.2 $\pm$ 5.9 l, respectively). There was a similar trend with respect to the maximum overland flow. The mean sediment yield per event was relatively high in the C and HP plots (8.6 $\pm$ 27.8 kg and 14.8 $\pm$ 43.4 kg, respectively), while significantly lower values were registered in the SM, PM and RU plots (0.4 $\pm$ 1.0 kg; 0.2 $\pm$ 0.3 kg and 0.2 $\pm$ 0.3 kg, respectively). Very similar trends were found for the maximum sediment yield. Regarding to the soil moisture values, there was a difference in the trends between the C and HP plots and the SM, PM and RU plots. In the C and HP plots the general trend was for a decrease in soil moisture downward through the soil profile, while in the SM, PM and RU plots the soil moisture remained relatively constant or increased, except for the RU treatment in which the soil moisture decreased from 5 to 10 cm depth.

According to the results, the hydrological and erosive response in the five treatments showed dissimilarities, despite having similar rainfall exposure and the same original soil properties. This means that the differences between the treatments play a key role in the soil moisture, overland flow and sediment yield values.

The study has demonstrated the effects of various treatments on the generation of overland flow, and hence the sediment yield. In the C and HP plots, relatively large amounts of overland flow rapidly developed. This cannot be explained by saturation conditions, as the soil moisture content was highest near the surface and decreased with depth in the profile. This, together with the relatively low macro-porosity, proved that the mechanism of overland flow generation was of the Hortonian type.

On the other hand, in the SM and PM plots, the high level of macro-porosity, together with the increase in soil moisture content with depth, explained the small quantities of overland flow and sediment yield. In the rare case that overland flow developed in these plots, it was minor in amount, and yielded little sediment because of saturation conditions. The processes in the RU plots were more complicated; from 10 cm depth the soil moisture content always increased with further depth, usually rapidly. Thus, water infiltrated continuously and there was no rainfall excess. Therefore, in terms of overland flow and sediment yield, the RU plots behaved in a similar way to the SM and PM plots. The fact that the soil moisture content was low at depths of 10 cm is because of the uptake of water at these depths by the roots of Carlina hispanica Lam.

From a land management standpoint, the SM, PM and RU treatments were the most effective in reducing overland flow and sediment yield following afforestation. In addition, the soil profile became more wettable, which provided more water to support plant survival. However, when afforestation was combined with RU

treatment, the vegetation cover resulting from the amendment treatment was the main factor controlling the hydrological processes. Application of the HP treatment caused a decrease in soil moisture content with depth in the soil profile, and overland flow and sediment yield were maximum in this treatment.