Effects of biological soil crusts on surface roughness and implications for runoff and erosion

Emilio Rodríguez-Caballero a,⁎, Yolanda Cantón a, Sonia Chamizo b, Ashraf Afana b, Albert Solé-Benet b

⁎ Corresponding author. Tel.: +34 950 14068.
E-mail address: rce9599@ual.es (E. Rodríguez-Caballero).

1. Introduction

Microtopography plays an important role in controlling exchanges of matter and energy between the soil and the atmosphere, and its effect is known to be extended from the plot to the hillslope scale and even to larger scales. It modifies the contact surface between the two systems and affects vertical (evapotranspiration and infiltration) and horizontal (runoff) water flows, conditioning soil water availability (Allmaras et al., 1966; Dunkerley, 2004). Its effect on runoff generation and erosion has been widely studied, especially in agricultural soils (Covers et al., 2000; Kamphorst et al., 2000), and is considered a key parameter governing these processes (Kirkby, 2002; Gaur and Mathur, 2003). Microtopography modifies overland flow, affects water storage in surface depressions, modifies the fraction of soil covered by water, regulates the amount of excess rainfall needed for runoff to start and affects hydraulic resistance which controls the flow velocity (Allmaras et al., 1966; Solé-Benet et al., 1997; Dunkerley, 2004; Sun et al., 2009; Smith et al., 2011). The presence or absence of soil surface roughness can also strongly influence water retention times at a given site (Dunkerley, 2004), modifying the connectivity of water sources (Armstrong et al., 2011). Moreover, it has been reported that rough surfaces absorb raindrop impact on the soil surface, and modifies significantly water flow and soil surface interactions (Dunkerley, 2004), reducing the shear effect and the speed and transport capacity of water flow (Helming et al., 1998; Planchon et al., 2000; Gaur and Mathur, 2003; Liu and Singh, 2004), and consequently, sediment yield.

Geomorphologic evolution of arid and semiarid systems is highly dependent on the interactions and feedback-dominated processes at the fine and intermediate scales (Cammeraat, 2002). At these scales, dynamic processes are controlled by the hydrological and erosion behavior of the different surface covers, their spatial distribution in the landscape and all interactions among them (Cammeraat, 2002; Puigdefábregas, 2005; Boer and Puigdefábregas, 2005). In these systems, characterized by sparse vegetation cover, runoff and sediment yield are mainly generated in the intershrub spaces, while plants act as sinks of these resources (Ludwig and Tongway, 1995; Puigdefábregas, 2005). In most arid and semiarid ecosystems around the world, up to 70% of these inter-plant areas may be covered by biological soil crusts (BSCs) (Belnap et al., 2005), which are...