Hydraulic Conductivity and Water Flow Characteristics of Moss Crust-Covered Soils on the Loess Plateau (Postprint)

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Abstract

Biological soil crusts possess unique hydrophysical properties. To investigate their effects on soil water infiltration and flow characteristics, this study examined three typical surface cover types (bare land, moss crust, and moss crust-herb mixture) on aeolian sandy soil and loessial soil in the Loess Plateau, using the ring infiltrometer method and dye tracer method to explore their hydraulic properties and water flow characteristics. The results showed that moss crusts significantly affected the soil physicochemical properties of the 0–5 cm soil layer in both soil types: compared with bare land, soil bulk density decreased by 9.85%–10.00%, soil clay content increased by 1.01–1.29 times, and surface organic matter content increased by 2.73–3.02 times. Moss crusts reduced the saturated hydraulic conductivity of the 0–5 cm soil layer by 61.32%–88.89%, while saturated hydraulic conductivity in the 5–10 cm layer increased significantly. Additionally, due to the influence of herbaceous plants, the saturated hydraulic conductivity in the 0–5 cm layer of moss crust-herb mixture increased by 1.32–6.43 times compared with moss crust soil. The dye coverage ratios of both moss crust and moss crust-herb mixture on loessial soil were higher than that of bare land, and water infiltration depth increased by 10 cm, whereas the difference in dye coverage ratio between moss crust and bare land on aeolian sandy soil was not significant. In summary, the presence of moss crusts and moss crust-herb mixtures altered surface soil water infiltration, water flow characteristics, and infiltration depth, influencing soil water retention and ecological restoration in the Loess Plateau.

Full Text

Study of Soil Water Permeability and Water Flow Characteristics Under Moss Crusts Covering the Loess Plateau

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Abstract

Biological soil crusts are assumed to greatly affect soil hydraulic conductivity and flow characteristics owing to their unique hydrophysical properties. Many studies have reported the effect of biocrust cover on soil water movement in arid and semi-arid areas, noting that the physicochemical properties (i.e., bulk density, organic matter, and soil particle distribution) of topsoil differ from those of bare soil, which may have positive or negative impacts on soil water infiltration, evaporation, and other properties that play important roles in the water and heat balance of arid and semi-arid regions. However, biocrust/grass mixed into soil is a common surface cover type in the Loess Plateau of China, whereas the differences between biocrust cover and biocrust/grass mixed into soil are unknown in terms of water infiltration and flow characteristics. In this study, three typical soil cover types (bare soil, soil with moss crusts, and soil with a mixture of moss crusts and grass) were selected for both aeolian sandy soil and loessal soil. Their hydraulic conductivity and water flow characteristics were measured using the constant-head method in undisturbed soil samples and the dye tracing method in the field. The results show that moss crusts had a marked influence on the physicochemical properties of surface soil. Compared with bare soil, the bulk density of the moss crust layer decreased by 9.85%–10.00%, while the clay content and organic matter content of the moss crust layer were 1.01–1.29 times and 2.72–3.02 times that of bare soil, respectively. Moreover, moss crusts reduced the saturated hydraulic conductivity of surface soil, especially for aeolian sandy soil where the value was only 88.89% that of bare soil. The moss crust/grass mix would reduce water loss; however, grass roots can create numerous preferential flow paths. This significant effect ultimately increased surface soil hydraulic conductivity by 1.32–6.43 times. The stained area ratios of both the moss crust cover type and moss crust/grass mix were higher than that of bare soil at the same soil depths for loessal soil. Moreover, soil water infiltration depth increased by 10 cm under moss crust cover. However, the stained area of moss crust cover and bare soil was similar for aeolian sandy soil. More importantly, soil cracks and macropores caused by the swelling and shrinking of moss

crusts and the penetration of grass roots served as important preferential flow channels for soil water infiltration and conduction; therefore, finger flow was clearly observed during soil water infiltration, promoting rapid water movement and ultimately affecting soil water flow characteristics. In conclusion, moss crust cover and moss crust/grass mix in the Loess Plateau significantly altered surface soil water permeability and flow characteristics. Therefore, their effects on soil water conservation and vegetation restoration should be considered in arid and semi-arid climate regions.

Keywords: moss crusts; saturated hydraulic conductivity; dye tracer; stained area ratio; aeolian sandy soil; loessal soil; Shenmu; Loess Plateau

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Note: Figure translations are in progress. See original paper for figures.