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Do stones modify the spatial distribution of fire-induced soil water repellency? Preliminary data

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Keywords

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Abstract

Water repellency is a property of many fire-affected soils that contributes to delayed wetting rates and shows many hydrological and geomorphological consequences. Fire-induced soil water repellency (SWR) may be modulated by pre-fire soil and vegetation properties. Many studies have been carried out to investigate the relationship between SWR and these properties. But, to our knowledge, no studies have considered the effect of surface stones in the spatial distribution of fire-induced SWR. In this research, we study the occurrence and spatial and vertical distribution of SWR and its consequences on soil structure after experimental burning in a previously wettable soil under different stone covers (0, 15, 30, 45 and 60%). In our experiment, burning induced critical or subcritical SWR in the upper millimetres of previously wettable soil. Fire-induced SWR did not vary with stone cover, but critical SWR was reached in inter-stone soil areas. At stone-covered soil areas, SWR was increased, but WDPTs remained mostly below the 5 s threshold.

1 Introduction

Increased or induced soil water repellency (SWR) has been reported in many fire-affected soils (DeBano, 2000; Doerr et al., 2000) Although wildfires are considered one of the main causes of SWR, they are not the only origin. But fire can be considered as a water repellency-triggering factor in soils where plant species, microorganisms, or organic matter act as sources of hydrophobic substances (Doerr et al., 2000). SWR is a property of many soils that is getting more and more interesting for the scientific community, because of its consequences on soil erosion risk, runoff or infiltration rates and even plant ecology. Although the occurrence and consequences of fire-induced SWR have been deeply studied, some gaps still exist, as the influence of stone cover. Stones on the soil surface may affect the distribution of heat during burning, and, consequently, may change the expected spatial distribution of SWR. In

Figure 1. Some details of the experimental work: (a) soil plots with 0, 15, 30, 45 and 60% stone cover; (b) soil plot after addition of fuel; (c) soil plot during burning.

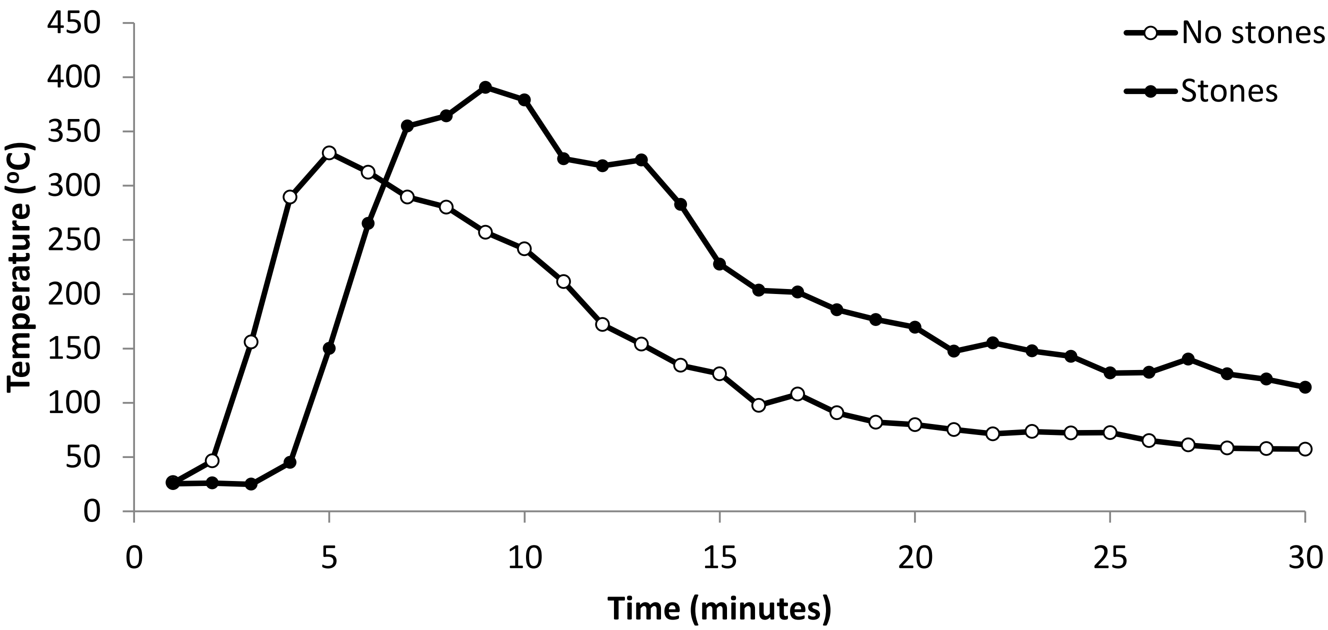

Figure 2. Temperature recorded 1 cm under the soil surface in areas uncovered and covered by stones by two selected thermopar probes.

this research, we study the effect of the stone cover on the occurrence of fire-induced SWR in a previously hydrophilic soil after experimental burning.

2 OBJECTIVES

The objective of this research is to study occurrence and spatial distribution of SWR after experimental burning in a previously hydrophilic soil under different stone covers (0, 15, 30, 45 and 60%).

3 METHODOLOGY

Experiments were carried out in the Blanco White experimental farm (Sevilla). Soil at the experimental area is clay-sandy loam (sand 64.1%, silt 15.3% and clay 19.6%), pH is 7.5 and CO_3Ca content is 18.3%. Soil plots (1.0 × 1.5 m^2) were marked with vertical metal bars and stones (8-10 cm in diameter) were regularly arranged at each plot in order to get 0, 15, 30, 45 and 60% stone cover, as shown in Figure 1-a. Stones were kept on the soil surface during three months before experimental burning. A series of

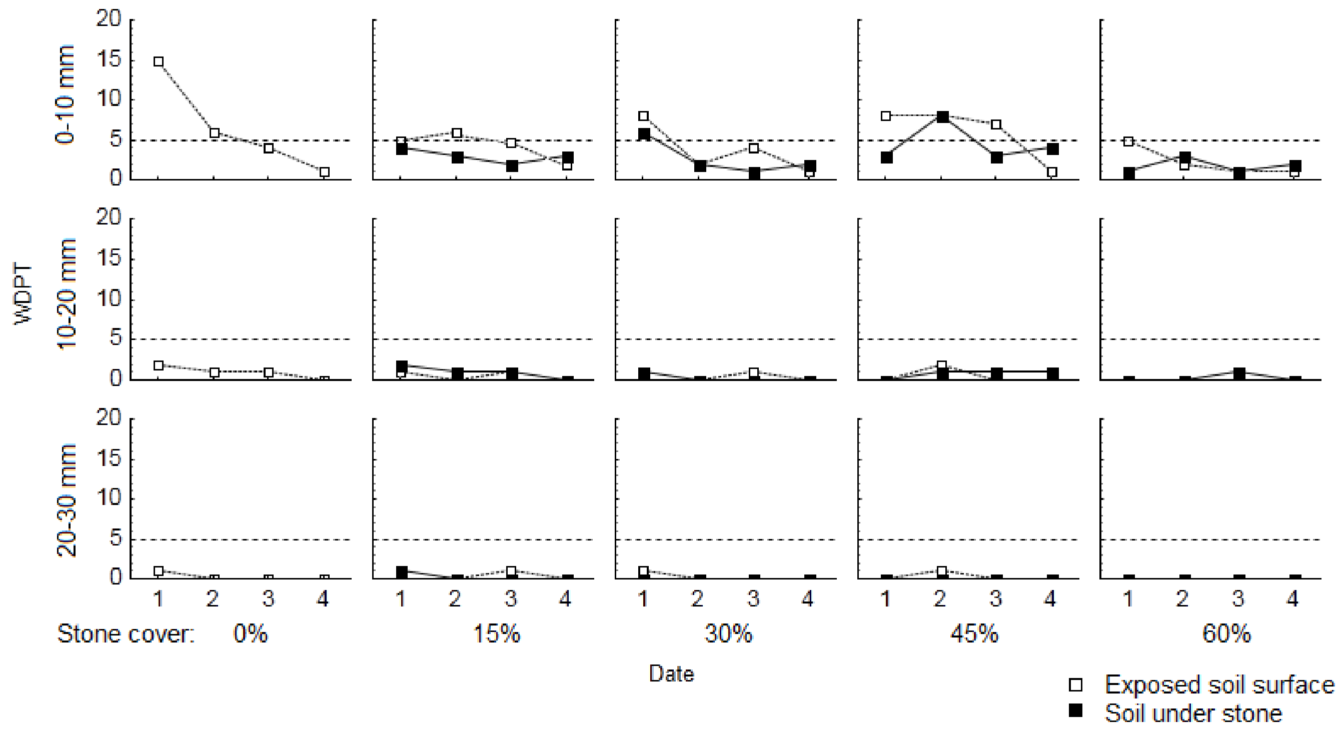

Figure 3. Soil water repellency (WDPT) for different stone cover classes, soil depth and dates (months after burning).

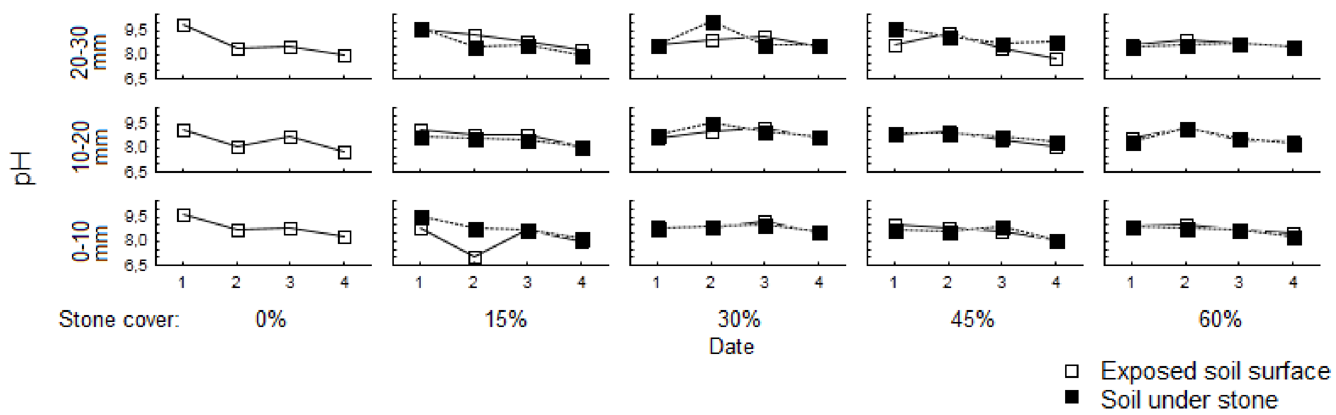

Figure 4. Soil acidity (pH) for different stone cover classes, soil depth and dates (months after burning).

thermopar probes were inserted 1 cm below the soil surface and soil temperature was recorded every 60 seconds under stones and under no stones.

Fuel was added to soil plots in order to simulate natural shrubs (Figure 1-b). Fuel density was 6.5-7.5 kg m-2. Fuel structure was 50% fine branches (<5 mm) and 50% thick branches (>15 mm). Experimental burning was carried out on February 14th 2012 until fire extinguished spontaneously (Figure 1-c), after full consumption of fuel after 15 minutes.

Soil samples (0-10 cm) were collected 2 days after burning and monthly during a 7-month period later. Soil samples for laboratory analyses were collected using a cylindrical core (4.8 cm in diameter) inserted 10 cm in soil and were transported to laboratory, air dried and homogenized. Part of the soil samples were sieved (<2 mm) and reserved for

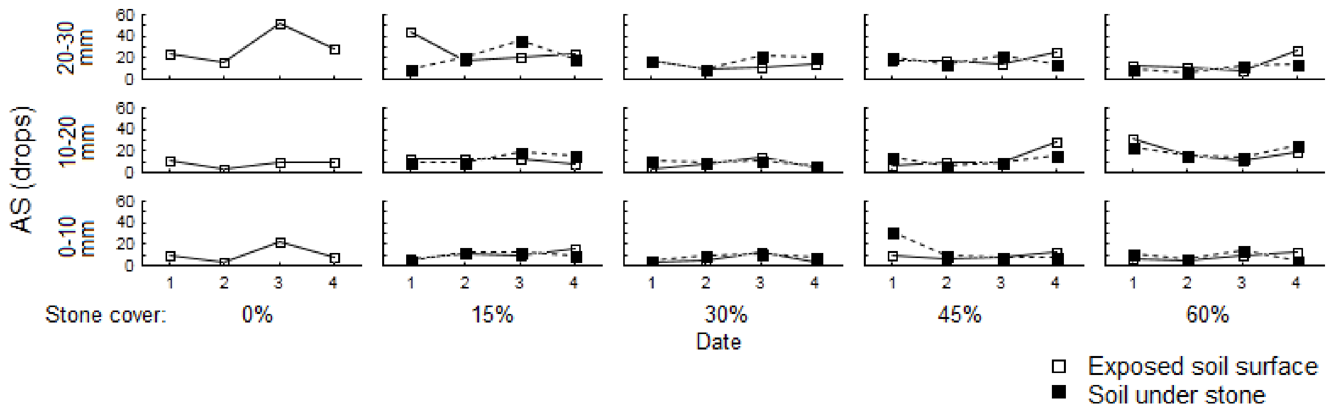

Figure 5. Aggregate stability (AS) for different stone cover classes, soil depth and dates (months after burning).

pH determination (1:5) and analysis of soil organic C content (titration with $K_2Cr_2O_7$ and determination of organic C using UV-Vis spectrophotometry). Aggregate stability was assessed using the counting the number of drop impacts method (CND; Mataix-Solera et al., 2011). SWR was assessed under field conditions using the water drop penetration time method, WDTP (Jordán et al., 2011) at 0, 10 and 20 mm depth.

4 Results and discussion

Temperature recorded at 1 cm under the soil surface is shown in Figure 2. Temperature reached in uncovered soil areas reached 300-350 ^{o}C, with short-time peaks. In contrast, temperature at stone-covered soil areas reached 350-400 ^{o}C peaks. In addition, peaks were delayed approximately 5 minutes and were longer in time, with temperatures above 300 ^{o}C over 14 minutes.

Wettable character was stable below 10 mm, with SWR remaining unaffected by burning. In contrast, soil areas under stones and no stones showed different behaviours. SWR was triggered at 0-10 mm depth in plots under 0% stone cover immediately after burning, and decreased progressively until soil material became wettable two monts after burning. Slight SWR (average WDTP between 5 and 10 s) was observed by sampling dates 1 and 3 at exposed inter-stone areas from soil plots under 15, 30 and 45% stone cover. Stone-covered areas remained wettable or slightly water repellent (average WDPT ranging between 1 and 6 s) character. SWR was not observed at 60% stone cover soil plots.

5 Conclusions

- Both pH and AS at different depths did not show significant differences between soil plots with different soil cover.
- Burning temperature induced critical or subcritical SWR in the upper layer (0-10 mm) of previously wettable soil.
- Fire-induced SWR did not vary with stone cover, but critical SWR was reached in inter-stone soil areas. At stone-covered soil areas, SWR was increased, but WDPTs remained mostly below the 5 s threshold.
- Research is being carried out in order to study further evolution of properties, wettability at the surface and the effect and dynamics of ashes.

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