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SOIL SURFACE PROPERTIES IN CENTRAL AUSTRALIA: THE EFFECTS OF FIRE ON WATER REPELLENCE

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ABSTRACT

Water infiltration into soil was studied before and after burning small plots of *Eragrostis eriopoda* and *Triodia basedowii* in central Australia. Fire had no statistically significant effect on sorptivity and did not induce water repellence.

INTRODUCTION

Fire is widely used in rangeland management. Research in the USA (Krammes and DeBano, 1965) indicates that fire can induce water repellence in semi-arid rangeland soils. Any induced water repellence would be an impediment to water infiltration during rainfall events, lowering soil moisture levels and possibly affecting seed germination.

Savage *et al.* (1969) proposed that soil conditions conducive to fungal growth were the most important factors in inducing water repellence and that fire may simply aggravate an existing condition. These workers were able to induce water repellence in sand fungal cultures by heating them at temperatures in the range 200-400°C. These appear to be the critical temperatures. Above 400°C soil organic matter is destroyed and water repellence lost.

Savage (1974) later put forward a two-step mechanism for heat-induced water repellence. Initially during fire, organic substances move from the burning litter layer into the underlying soil. Later the heat moves down through the soil "fixing" some of the more polar hydrophobic substances and revolatilizing the less polar ones. Hence the water-repellent layer becomes broader as it moves deeper. Most of the heat load imparted to the soil surface comes from the smouldering litter layer (Scholl, 1975) and significantly affects the extent of the induced water repellence.

In this study we used sorptivity as the main indicator of water repellence. Sorptivity depends on the capacity of soil to adsorb water onto surfaces and to absorb water into capillaries and should therefore be reduced by water repellence. No previous measurements of this soil property have been reported in the literature after fire in central Australia.

METHODS

Sites: The two sites in woollybutt (*Eragrostis eriopoda*) grassland (Mt Riddock Station, NT; 134°40'E, 23°02'S) had been unburnt for at least four years (R. Cadzow, pers. comm.). The two sites in hard spinifex (*Triodia basedowii*) grassland (Indiana Station, NT; 135°26'E, 23°20'S) had been unburnt for at least 40 years (F. Bird, pers. comm). Both stations are located north-east of Alice Springs, NT. These species were chosen because they are low and compact, occur in relatively uniform stands and were locally abundant.

Soils at all sites were uniform, coarse, siliceous red-brown sands.

Treatments: Infiltration measurements were carried out on bare ground between plants, beneath single plants (the above ground parts of which had been removed) and beneath single plants burnt *in situ*. Ten replicate plots were recorded at each site.

The objective of the burn treatment was to simulate wildfire conditions. An area of approximately 1 m^2 was burnt. Biomass density varied between 3.4-3.6 kg/m^2 dwt. Where necessary additional plant material of the same species was added to achieve uniform fuel loads.

Infiltration Measurements: These were carried out using a disc permeameter (Perroux and White, 1988). This device allows water to infiltrate into the soil at controlled positive and negative pressures. In this study the pressure potential was nominally zero. Where necessary the soil surface was levelled using sieved surface soil (0-2 cm depth) from an area adjacent and equivalent to the infiltration site. For these coarse soils a recording time of 6-9 minutes was found to be sufficient. Sorptivity was estimated using an infiltration model proposed by Philip (1975).

Surface Temperature: There was a single additional burn conducted at each site to measure the soil surface temperature dynamics during fire. Temperatures were recorded every minute for 15 minutes using a buried thermocouple probe. The probe tip was within 3 mm of the soil surface at the centre of the plant.

Soil Samples: A sample from each plot was analysed in the laboratory for moisture content (drying at 105°C for 48 hours) and water repellence using the Molar Ethanol Droplet (MED) Test (King, 1981). A fifth of the samples, chosen at random, were quantitatively analysed for clay and silt content.

RESULTS

There was no statistically significant difference ($P<0.05$) in sorptivity beneath plants before or after fire. Sorptivity values between plants were slightly higher than those below plants. The difference however was not significant.

The mean soil moisture content of samples was less than 0.5%. Clay and silt contents were typically less than 3%. Soil moisture and the clay/silt content were both too low to influence infiltration appreciably.

Only in soil exposed to fire was water repellence induced (MED test). Of these samples only 40% had this condition. The extent of repellence ranged from low to severe based on the scale of King (1981).

DISCUSSION

No widespread or significant water repellence was observed despite the fact that the lower specific surface area of coarse soils requires only small amounts of hydrophobic materials to induce repellence. Tongway and Hodgkinson (1992), using lower fuel loads and repeated fires, also found no evidence of fire-induced water repellence.

Soil temperatures sufficient to induce repellence were only transient. In both grassland communities there was rapid cooling resulting in low heat loads. It appears that at least 10 minutes heating at or above 200°C may be necessary to induce or aggravate water repellence (DeBano and Krammes, 1966). Fuel loads of perhaps 5-10 kg/m^2 are probably necessary to achieve this level of heating.

Some burnt samples did, however, develop a degree of water repellence (MED Test). Results were not consistent throughout the whole soil sample indicating that the hydrophobic materials present were localised. On a landscape scale the repellence observed would be insignificant and should have no serious effect on seed germination.

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