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Charcoal produced by prescribed fire increases dissolved organic carbon and soil microbial activity

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In Australian forests fire is an important driver of carbon (C) storage. When biomass C is combusted it is transformed into vegetation residue (charcoal) and deposited in varying amounts and forms onto soil surfaces. The C content of charcoal is high but is largely in a chemically stable form of C, which is highly resistance to microbial decomposition.

We conducted two laboratory incubations to examine the influence of charcoal on soil microbial activity as indicated by microbial respiration. Seven sites were chosen in mixed species eucalypt forest in Victoria, Australia. Soil was sampled prior to burning to minimise the effects of heating or addition of charcoal during the prescribed burn. Charcoal samples were collected from each site after the burn, homogenised and divided into two size fractions. Prior to incubation, soils were amended with the two size fractions (<1 and 1-4.75 mm) and at two rates of amount (2.5 and 5% by soil dry weight). Charcoal-amended soils were incubated in the laboratory for 86 d, microbial respiration was measured nine times at day 1, 3, 8, 15, 23, 30, 45, 59 and 86 d. We found that addition of charcoal resulted in faster rates of microbial respiration compared to unamended soil. Fastest rates of microbial respiration in all four treatments were measured 1 d after addition of charcoal (up to 12 times greater than unamended soil). From 3 to 8 d, respiration rates in all four treatments decreased and only treatments with greater charcoal addition (5%) remained significantly faster than unamended soil. From 15 d to 86 d, all treatments had respiration rates similar to unamended soil. Overall, adding greater amount of charcoal (5%) resulted in a larger cumulative amount of CO_2 released over the incubation period when compared to unamended soil.

The second laboratory incubation focused on the initial changes in soil nutrient and microbial respiration after addition of charcoal over a 72 h period. Charcoal (<2 mm) was added at rate of 5% to soil with differing moisture content (55 and 70% water holding capacity). Microbial respiration was measured continuously and dissolved organic C (DOC), nitrogen (DON), extractable phosphorus (P), and microbial C, N and P were measured at four time points during the 72 h incubation. Our data showed that the initial spike in microbial respiration was highly correlated to the amount of DOC in the soil. Soil moisture did not significantly change the microbial response or soil nutrient availability after addition of charcoal.

This study outlines one of the processes of carbon cycling that occurs immediately after fire. Charcoal deposition resulting from prescribed burning provides a transitory yet important source of C for soil microbes and stimulates microbial activity.