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Soil quality, crop productivity and soil organic matter (SOM) priming in biochar and wood ash amended soils

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The application of energy production by-products as soil amendments to agricultural land is rapidly growing in popularity, however the increasing body of literature on primarily biochar but also wood ash have yielded contrary evidence of the range of these soil amendments function sensitivity in soil. This study aims to assess the efficacy of two by-products; biochar and wood ash to provide nutrients to grassland as well as the potential to improve overall soil quality. The study of soil amendments at field scale are scarce, and the agronomic benefits of biochar and wood ash in temperate soils remain unclear. We used replicated field plots with three soil treatments (biochar, wood ash and control) to measure the soil and crop properties over twelve months, including PLFA analysis to quantify the total soil microbial biomass and community structure. After a soil residency of one year, there were no significant differences in soil EC, total N, dissolved organic N (DON), dissolved organic C (DOC), NO_3-N and NH_4-N concentrations, between biochar amended, wood ash amended and un-amended soil. In contrast, the application of biochar had a significant effect on soil moisture, pH, PO_4-P concentrations, soil organic carbon (SOC) and total organic carbon (TOC), whilst the wood ash amendment resulted in an increase in soil pH only. There were no significant treatment effects on the growth performance or nutrient uptake of the grass. In a parallel laboratory incubation study, the effects of biochar and wood ash on soil C priming was explored, in which soil with ^{14}C-labelled native SOC was amended with either biochar or wood ash at the same rate as the field trial. The rates of $^{14}CO_2$ (primed C) production was measured with a liquid scintillation counter over a 50 day period. The $^{14}CO_2$ that evolved during decomposition likely originated from conversions in the (microbial) biomass. The results indicated that biochar application did not prime for the loss of native SOC (i.e. there was no acceleration of the decomposition of stable soil organic matter), whilst wood ash had a negative priming effect (i.e. the decomposition of stable soil organic matter was decelerated).

These two complimentary studies confirm the ability of biochar application to sequester carbon even at relatively low application rates (10 t ha^{-1}), however this is likely due to the inherent carbon content of biochar rather than promoting negative soil C priming. The potential for wood ash to repress native SOC turnover at low application rates (571 kg ha^{-1}) in the long term requires further investigation as this may be an additional tool for promoting C sequestration in soil, whilst simultaneously generating greater quantities of energy from the combustion of biomass to wood ash, as opposed to the pyrolysis of biomass to biochar.