Investigation on the effect of biochar addition and the use of pasture species with different rooting systems on soil fertility and carbon storage

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Erwin Ismu Wisnubroto

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Abstract

There is a potential to increase soil carbon (C) sequestration in New Zealand pastoral soils, especially in the subsoils where the soil C stocks have been reported to have a greater C saturation deficit than the topsoils. Selecting pasture species with deeper root systems will enhance soil formation at depth and mineral weathering, thus enhancing the potential for soils to stabilize organic matter (OM). Moreover, the addition of biochar may increase the stable C pool of soils and provide other additional benefits. Up to the present time few studies have investigated the potential of biochar to promote root growth and allocation of plant C to the subsoil. A glasshouse study was carried out to examine the effect of adding a nutrient-rich biochar at various dose (0, 1.5, 5 and 10 Mg ha^{-1} without nitrogen (N) fertiliser; 0, 1.5, 10 and 20 Mg ha^{-1} with N fertiliser at a dose of 113 kg N ha^{-1}) to a sandy soil on plant growth (above- and below-ground). The results indicated that, in the absence of N limiting conditions, biosolids-derived biochar could improve plant biomass yield as a result of the addition of available P and K. This amendment also caused an increase in plant root length. Subsequently, a 2-year lysimeter trial was set up to compare changes in C stocks of soils under deep- or shallow-growing pastures as well as to investigate whether biochar addition below the top 10 cm could promote root growth at depth. For this: i) soil ploughing at cultivation for pasture establishment was simulated in two different soils (a silt loam soil and a sandy soil) by inverting the 0–10 and 10–20 cm depth soil layers, and biochar was mixed at a rate of 10 Mg ha^{-1} in the buried soil layer, where appropriate; and ii) three pasture types with contrasting root systems were grown. Distinctive biochars were selected for these two soils so that soil-specific plant growth limitations could be overcome. In the silt loam, soil inversion resulted in a net loss of native organic C in the buried horizon under shallow-rooted species, but not under deep-rooted species. The addition of a C-rich pine biochar (equivalent to 7.6 Mg C ha^{-1}) to this soil resulted in a net C gain (6–16% over the non-biochar treatment, calculated up to 30 cm; $P < 0.05$) in the buried soil layer under all pasture treatments; this overcame the net loss of native organic C in this horizon under shallow-rooted pastures. In the sandy soil all pasture species were able to maintain soil C stocks at 10–20 cm depth over time. In this soil, the exposure of a skeletal and nutrient-depleted soil layer at the surface may have fostered root growth at depth. The addition of a nutrient-rich biosolids biochar (equivalent to 3.6 Mg C ha^{-1}) to this soil had no apparent effect on total C stocks. In this 2-year study, none of the biochar amendments affected either pasture yield or root growth. More research is needed to understand the mechanisms through which soil C stocks at depth are preserved.

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