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Microbial dynamics in hierarchical aggregates of tropical soil amended with bambara groundnut seed residue biochar

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Abstract

Application of Bambara groundnut seed residue biochar (BSB) in vegetable production has shown to affect soil fertility, especially carbon (C) and nitrogen (N). However, there is a lack of knowledge on the microbial responses to repeated applications of BSB and NPK fertilisers in different soil aggregates. For this purpose, three replicates of four-treated soil samples (control, NPK, BSB, and NPK+BSB) arranged in Randomised Complete Block Design were taken after four years of continuous cultivation of cucumber crops at Nsukka Nigeria. The samples were mechanically separated into four dry-stable aggregate fractions of 4.75–2.00, 1.00–2.00, < 0.25–1.00, and < 0.25 mm. In addition to bulk soil < 2.00 mm, these five soil aggregate hierarchies were evaluated, with the aim of determining the effect of treatments on soil microbial nutrient cycling in a 20-day incubation experiment. The cumulative CO_2 emission in soil hierarchies at day 20 was relatively low in the control and BSB soils, ranging from 0.10 to 0.21 and 0.14 to 0.26 mg CO_2-C soil^{-1}, respectively. In general, increased labile C utilisation was significantly higher in the < 0.25 mm aggregate than in other soil fractions in all the amended soils. Nonetheless, cumulative CO_2 respiration in all the soil hierarchies increased significantly in the NPK and NPK+BSB amended soils compared to the BSB and control soils. There is a small pool of labile C that explains the insignificant effect of the BSB application on the basal respiration of the soil aggregates. The NPK+BSB amendment increased microbial C in 1.00–2.00 mm aggregate and < 2.00 mm soil by 40 % and 70 %, respectively, and microbial biomass N in 4.75–2.00 and 1.00–2.00 mm aggregates, and in < 2.00 mm soil by 106 %, 89 % and 341 %, respectively. The β-glucosidase activity was significantly reduced in the NPK and NPK + BSB amended soils compared to the BSB soil, whereas the reverse was the case with the reduced N-acetyl-β-glucosaminidase enzyme. Increased tyrosine aminopeptidase enzyme activity was evident in the NPK and NPK+BSB amended soils and in all aggregate hierarchies, but the C-cycle enzyme activities were mostly maximal in the < 0.25 mm aggregate fraction. The study highlights that NPK+BSB amendment can induce greater C mineralisation in < 0.25 mm aggregate fractions. Moreover, the substantial increase in microbial C and N with the NPK+BSB amendment indicates the significant association of the > 1.00 mm macro-aggregates to the improvement of soil quality.

Keywords: Biochar amendment, C mineralisation, dry-stable aggregates, enzyme activity, microbial biomass

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