BIOCHAR IMPROVES NITROGEN FERTILIZER EFFICIENCY ON A HIGHLY WEATHERED CENTRAL AMAZONIAN FERRALSOL

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Leaching losses of nitrogen (N) are a major limitation of crop production on permeable soils and under heavy rainfalls as in the humid tropics [1]. Inspired by the sustained fertility of anthropogenic Terra Preta soils in the central Amazon and by its recreation we studied the effect of charcoal as soil amendment (biochar). The use of biochar as a carbon (C) rich and recalcitrant soil amendment can have important implications for sustainable land use in the humid tropics and the earth's carbon budget [2].

We established a field trial in the central Amazon (near Manaus, Brazil) in order to study the influence of charcoal and compost on the retention of N. The soil was classified as a highly weathered Xanthic Ferralsol [3], fine textured with high clay content. It is strongly aggregated and has medium contents of organic C (24 g kg–1), low pH values of 4.7(in H_2O), low CEC of 1.6 cmolc kg^{-1}, and low base saturation of 11% [4]. Two previous harvests on the 4 m^2 plots proved that biochar can sustain fertility but the mechanisms could not be fully discerned [4]. Therefore fifteen months after organic matter admixing (0 – 0.1 m soil depth) and two harvests, we added ^{15}N labelled ammonium sulphate (27.5 kg N ha^{-1} $(NH_4)_2SO_4$ at 10 atom% excess). Total mineral fertilization was 55, 40, 50 and 430 kg ha^{-1}, for N, P, K and lime respectively. For this study, five mineral-fertilized (F) treatments were chosen, four of them with compost (CO + F) and/or biochar (CC + F) application. Compost was applied at a rate of 67 Mg ha^{-1} and biochar at a rate of 11 Mg ha^{-1}. Compost contained 10.1, 0.73, 2.85, 3.27, and 1.51 g kg^{-1} N, P, K, Ca, and Mg, respectively; and biochar contained 5.39, 0.03, 0.23, 0.82, and 0.17 g kg^{-1} N, P, K, Ca, and Mg, respectively. The charcoal derived from secondary forest wood and was considered rather as soil conditioner than fertilizer due to the charcoal's low nutrient contents. It was manually crushed to particle sizes <2 mm. The treatment receiving compost only (CO) served to provide a reference value for N isotope composition in soil and plants. The tracer was measured in top soil (0 – 0.1 m) and plant samples taken at two successive sorghum (*Sorghum bicolor* L. Moench) harvests (HI and HII).

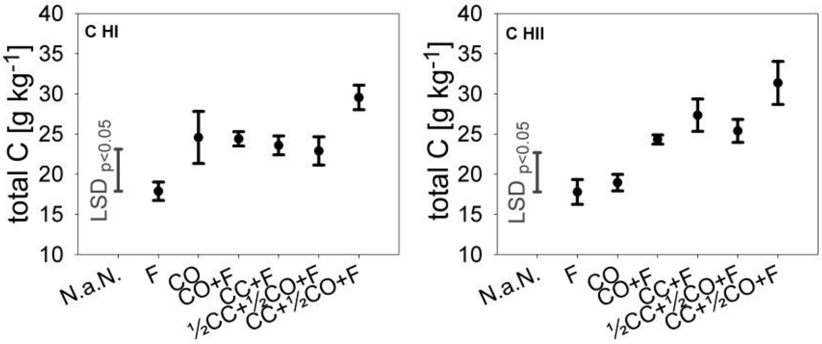

FIG. 1. Total soil carbon contents after the first (HI) and second harvest (HII).

The Lower biomass input and less recalcitrance of the unfertilized compost treatment (CO) compared to biochar (CC) caused a marked decrease in total soil organic C (Fig. 1). The N recovery in biomass was significantly higher when the soil contained compost (14.7 % of applied N) in comparison to only mineral fertilized plots (5.7 %) due to significantly higher crop production during the first growth period. After the second harvest, the retention in soil was significantly higher in the charcoal amended plots (15.6 %) in comparison to only mineral fertilized plots (9.7 %) due to higher retention in soil. The total N recovery in soil, crop residues and grains was significantly ($P < 0.05$) higher on compost (16.5%), charcoal (18.1%) and charcoal plus compost treatments (17.4%) in comparison to only mineral fertilized plots (10.9%). Organic amendments increased the retention of applied fertilizer N. One process in this retention was found to be the recycling of N taken up by the crop (Fig. 2).

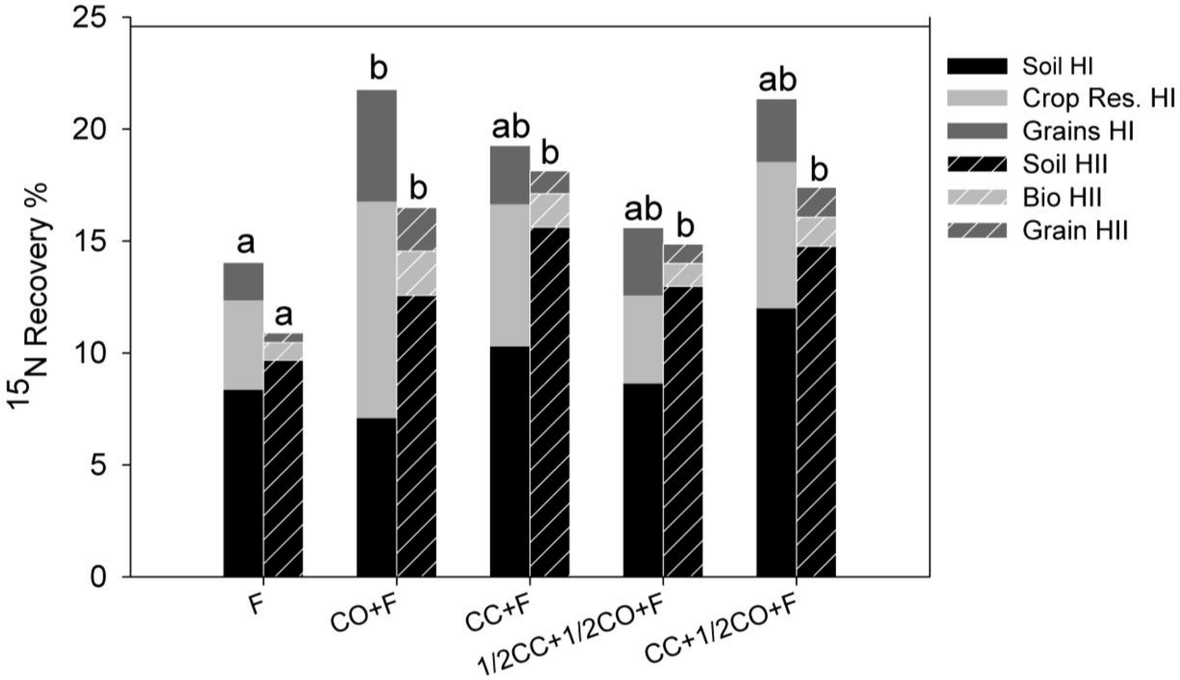

FIG. 2. N recovery in plants and soil, n=5, letters indicate significant differences, p<0.05 [5].

The use of biochar received global interest as its use as soil amendment under the described environmental conditions may not only improve soil fertility but also facilitate long-term carbon sequestration. Modern pyrolysis systems can generate renewable energy from biomass and produce biochar as a by-product [6]. Thus, biochar can help improve agricultural productivity, provide renewable energy, mitigate climate change and reduce vulnerability to global warming, and help to balance the competing choices around cultivating crops for different purposes—such as for energy or for carbon sequestration or for food.

References

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