AGING OF BIOCHARS UNDER MEDITERRANEAN CLIMATE CONDITIONS: A FIELD STUDY

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Introduction

Biochar (BC) is the carbonaceous solid residue produced through the pyrolysis of organic residues with the objective to be used as soil ameliorants. Numerous research studies pointed out that BC can act as a soil conditioner enhancing plant growth by supplying and, more importantly, retaining nutrients and by improving soil physical and biological properties (Lehmann and Joseph, 2015). In addition, the application of BC to soil is being proposed as a novel strategy to mitigate the emissions of carbon dioxide (CO_2) to the atmosphere. Although BC is increasingly used as soil amendment and the properties of freshly produced BCs are well documented (De la Rosa et al., 2014) its biochemical stability and alteration during aging in the soil environment are still unclear (Ameloot et al., 2013).
Therefore, we investigated the decomposition of BC and the changes of its characteristics during a 2-years field experiment under Mediterranean climate conditions. Here, five different BCs were mixed with a calcic Cambisol located at the experimental farm "*La Hampa*" (Coria del Río, Seville). Seeds of sunflower plants (*Hellianthus annus*) were planted and harvested after 5 months. After 6, 12 and 24 months soil samples were taken and biochar particles were carefully separated by hand. See further details of field conditions at Paneque et al, (2016).
Biochar alterations were analyzed by measuring its elemental composition (C, N contents), pH, electrical conductivity (EC) and fragmentation degree. In addition, Field Emission Scanning Electron Microscopy (FESEM) and ^{13}C Solid State Nuclear Magnetic Resonance (NMR) were used to assess biochar alterations.
The biochemical recalcitrance of the BCs were assessed through a laboratory-based respiration experiment in which the BCs were mixed with soil and incubated for four months (25ºC, 60% water holding capacity) using an automatic respirometer.

Results

The characterization of fresh BCs showed their heterogeneity, which is attributed to the different nature of the feedstock and different pyrolysis conditions. After 24 months of aging in the soil under Mediterranean climate conditions, BCs exhibited a sharp decrease of the OC content and aromaticity (measured by ^{13}C NMR spectroscopy). In contrast, the N content of the BCs increased slightly due to the accumulation of microbial communities and soil organic matter as a result of the high porosity of the BCs.
The physical fragmentation (disintegration) of all BCs increased significantly during the time span of the field experiment. FESEM images showed the collapse of BC structures and pores with aging (evident after 24 months at field). They also revealed organic mineral associations, microbial remains and the distribution of BC-pores, which were consistent with their specific surface area. These data pointed out that BCs are providing additional niches for microbiota, which would contribute to an enhancement of the soil quality from an agronomic point of view.

Respiration experiments under laboratory conditions (respicond experiment) evidenced that the tested BCs were less recalcitrant than previously assumed by other authors. Wood-derived BCs were the most stable ones, exhibiting mean residence time of the stable C pool (MRT_2) approximately four to five times longer than the MRT_2 of the bulk soil.

Conclusions

Our results clearly evidenced lower physical and biochemical recalcitrance of the BCs than commonly assumed. This was not only confirmed by the degradation study under laboratory settings, but also by the more realistic experiment under field conditions. Based on our findings we suggest that microbial communities used BCs not only as habitats but also as C-source. This puts into question the role of BC for long-term C sequestration strategies and underlines the need for a deeper understanding on the degradation pattern occurring during BC aging in soil environments.

References

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Acknowledgements

J.M. De la Rosa thanks The Spanish Ministry of Economy and Competitiveness (MINECO) for his “Ramón y Cajal” post-doctoral contract. The study was carried out with the support of the Marie Skłodowska-Curie actions of the European Union's FP7 People Programme (PCIG12-GA-2012-333784-Biocharisma project) and of the BIOREMEC project (CGL2016-76498-R) funded by MINECO.