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www.biocharisma.es

Summary

The role of biochar (high-carbon biomass residue produced by thermal decomposition in the absence of oxygen) in carbon sequestration and improving soil fertility is increasingly being recognized. In addition, biochars offer a simple and sustainable tool for managing agricultural and urban waste by converting it into added value products. Despite some detailed studies describing short term effects of biochar and publications focusing on (sub)tropical regions, there is still a lack of knowledge with respect to the agronomic efficiency and the carbon sequestration potential of biochar amended soils under Mediterranean climate. Comparably, the role and potential environmental threat of polycyclic aromatic hydrocarbons (PAHs) which may be formed during the charring process, are not very well understood. Thus, prior to sharpen this mitigation and waste management tool "Biochar systems", these issues need to be addressed in more detail.

Therefore, we produced isotopically enriched (13C and 15N) and unlabeled sewage sludge and carbonized organic carbon (biochar and hydrochar) in collaboration with The Foundation Centre for New Water Technologies (CENTA, Spain) and the Leibniz-Institut für Agrartechnik Potsdam-Bornim e.V. (ATB-Potsdam, Germany). Subsequently, the chars, obtained after heating at different temperatures (from 200ºC to 600ºC) and for 30 min to 3 hours, were characterized for their chemical and physical properties (C,H,N, heavy metals, pH, isotopic δ13C and δ15N and surface area). A more detailed analysis was performed by using scanning electron microscopy (SEM), FT-IR and 13C and15N NMR spectroscopy and GC-MS and Py-GC/MS.

Our results confirmed increasing aromaticity of the charred residues with higher production temperatures, although the carbonization time had no major impact on the chemical composition. Higher contributions of furans and other phenols, which could affect germination, were not detected in the hydrochars. Comparison of the chemical and physical properties of the unlabeled and the isotopically enriched samples showed no considerable differences, which permitted the use of the stable isotope approach to study the relationship between biochar properties, agronomic response and plant physiology.

Subsequently, the produced material and four well characterized biochars of the European ring trail experiment (Bachmann et al., 2016) were mixed at different doses with a typical Mediterranean calcic Cambisol and used as substrate for a greenhouse pot experiments with Lolium perenne. The application of our biochars improved germination rates and soil fertility (except for a kiln wood biochar). None of the used mixtures affected the pH of the already alkaline soil. The highest biomass yields were obtained after application of biochars and hydrochars from sewage sludge, which is best explained with their high contents of minerals,

phosphor and nitrogen. Considering costs for production and transport, the application of 10 t ha-1 turned out to be the most efficient one.

Field experiments, using the same soil but Helianthus annuus (sunflower) and barley support an improvement of the development of the plant shoots by biochar and hydrochar amendment. However, although char application could not maintain the higher agronomic production until the end of the experiment, the plants on soils with biochar addition showed a better adaption to aridity. We were able to show that biochar amendment induced physiological changes of the plant which can be related to a better adaption to drought. They were indicated by a reduced stomatal conductance and decreased leaf transpiration. The first could not be related to a stress situation, but correlated with higher stability of the photosystem-II, probably as a consequence of lower water use in a dry environment.

As a contribution to the ongoing discussion of the effectiveness of biochars to reduce CO2 emissions, we tested the biochemical recalcitrance of our hydro/biochars during aging in soils, both in the laboratory and in the field. In contrast to common believes, our experiments could not confirm mean residence times in a centennial or even millennial timeframe. Preliminary results of hand-picked biochars collected from the soils after our field experiment revealed partial but quick oxidation of the aromatic framework leading to an increase of carboxylated ring structures. Of course this will further reduce their biochemical recalcitrance but may also be a key function for improving soil nutrient retentions or the potential of aged biochars in soil remediation strategies.

The assessment of PAHs concentrations in selected biochars underlined the importance of devises or strategies which allow the escape of syngas from the biochar system during their production to avoid accumulation and re-condensation of aromatic gases in their pore system. We could further show that PAH can be introduced into soils with biochars, but the extent of this process depends on matrix effects. During our study it became clear that the latter needs more research for a better prediction of the fate of biochar-born PAHs in soils (De la Rosa et al., 2016).

In summary, the results achieved in the present project highlight again the importance of a good understanding of the variability of chars and how this affects soil properties and plant growth in different climatic conditions. As a consequence, both user and producer have to be aware that efficient and sustainable application of biochar in agriculture requires biochars customized for each situation and purpose. In general all the used chars, especially the hydrochars, showed a lower C sequestration potential than previously assumed. Concerning the agronomic results, this project revealed that under field conditions, biochars with low water holding capacity are more appropriate under Mediterranean climate conditions.

A summary of the major results, scientific publications and outreach activities of Biocharisma project are shown at www.biocharisma.es.

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