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Contrasting agronomic response of biochar amendment to a Mediterranean Cambisol: Incubation vs. field experiment

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The application of biochar to soil is being proposed as a novel approach to establish a significant long-term sink for atmospheric carbon dioxide in terrestrial ecosystems. In addition, biochars offer a simple, sustainable tool for managing organic wastes and to produce added value products. Numerous research studies pointed out that biochar can act as a soil conditioner enhancing plant growth by supplying and, more importantly, retaining nutrients and by providing other services such as improving soil physical and biological properties [1].

However, the effectiveness of biochar in enhancing plant fertility is a function of soil type, climate, and type of crop [2] but also of the biochar properties. The inherent variability of biochars due to different feedstock and production conditions implies a high variability of their effect on soil properties and productivity. Furthermore, due to the irreversibility of biochar application, it is necessary to perform detailed studies to achieve a high level of certainty that adding biochar to agricultural soils, for whatever reason, will not negatively affect soil health and productivity.
The major goals of this research were: i) understanding how the properties of 5 different biochars produced by using different feedstock and pyrolysis conditions are related to their agronomic response, and ii) assessing the agronomic effect of biochar amendment under field conditions of a typical Mediterranean non-irrigated plantation. Four of the used biochars were produced by pyrolysis from wood (2), paper sludge (1) and sewage sludge (1), at temperatures up to 620 ºC. The fifth biochar was produced from old grapevine wood by applying the traditional kiln method.
Biochars were analysed for elemental composition (C, H, N), pH, WHC and ash contents. The H/C and O/C atomic ratios suggested high aromaticity of all biochars, which was confirmed by 13C solid-state NMR spectroscopy. The FT-IR spectra indicated the presence of lignin residues in wood biochars. The FESEM-EDS distinguished compositional and structural differences of the studied biochars such as macropores on the surface of pyrolysis wood biochars.

In the frame of a pot experiment, the biochar characteristics (physical properties and chemical composition) were related to the germination rates and to the plant biomass production of a Lolium perenne. Incubation was carried out in 300 mL pots during 79 days in which a calcic Cambisol [3] was amended with 10, 20 and 40 t ha-1 biochar. After adjusting the soil humidity to 60Biochar amendment improved significantly germination rates and soil fertility (excepting kiln wood biochar), and had no negative pH impact on the already alkaline soil. Application of sewage sludge biochar, the richest in minerals and nitrogen, resulted in the highest soil fertility. In this case, increase of the dose went along with an enhancement of plant production. Considering further costs due to production and transport of biochar, the application of 10 t ha-1 turned out as the most efficient for the crop and soil used in the incubation experiment [further details in 5].
The field study was performed with seeds of Helianthus annuus, at the experimental station “La Hampa”, located in the Guadalquivir river valley (SW Spain; 37º 21.32’ N, 6º 4.07’ W), Seville. The calcic Cambisol which was also used as matrix for the pot experiments was amended with doses equivalent to 0 (control), 1.5 and 15 t ha-1 of the five biochars, making a total of 12 different treatments. Soil properties and composition were monitored during the growing time including elemental composition, pH, water holding capacity and soil microbial biomass. After 6 months of growth, sunflower plants were harvested. Plant height, chlorophyll content and sunflower seeds production were recorded. Results of this field experiment are still being processed. Nevertheless, preliminary results indicated that addition of biochar did not alter negatively physical properties (pH, EC) or composition of this alkaline soil, on the contrary biochar addition caused a slight improvement of the WHC and soil porosity. Those changes produced a faster development of plant shoots. However, at the end of the experiment, biochar amendment caused no significant increase on the agronomic production for any of the tested biochars.

From these preliminary results, we conclude that biochar amendment improved physical-surficial characteristics of the calcic Cambisol from an agronomic point of view, but under the typical Mediterranean climate those changes seem to leave the harvested seed yields unaffected.

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