Agricultural and environmental benefits from Biochar use in ACP countries: The BEBI project

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The BEBI project aims to reduce the pressure of ACP population on their forested area and, in the meantime, to increase soil fertility of croplands and reduce health risks related to cooking activities in Togo, Sierra Leon and Ghana. In particular, the project is focused on the objective of using crop residues more efficiently by adopting a pyrolisis process in innovative, low cost, and no polluting biochar producing stoves. Partners will test different feedstocks with different types of stoves and choose the best one to be distributed among local users for households cooking. Furthermore, the biochar produced as a residue of the pyrolisis will be used as an amendment in soil. These two activities are supposed to reduce desertification and unmanaged deforestation, improve soil fertility, increase agricultural yields, reduce the health risks related to charring and cooking activities, contribute to GHG mitigation and reduce poverty. The cooperation between three local NGOs and the stove producers will help to adapt the stoves to the cooking traditional methods and local people needs. The cooperation between the local and the European academic partners will enable to study the impact of biochar on soil quality, microbial communities, soil nutrients, water balance, agricultural yields, and the relation between feedstock quality, energy outputs and biochar productivity. The BEBI partners will assess also the improvement of indoor quality air due to the use of the innovative stoves. If the new stoves and biochar will be accepted by the local people a small medium enterprise will be set up to produce locally the stoves in order to boost a local sustainable development. Due to the biochar carbon sink potential a voluntary carbon trade scheme will be launched at the end of the project. The BEBI project will allow to analyse the acceptability, usability and suitability of the stoves and biochar production and use from both environmental and socio-economical point of view. Furthermore, it will improve the local partners' competence level and support their process to become poles of attractions on these technologies.

The development of a toolkit for rapid assessment and prediction of biochar stability and agronomic utility

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Before the potential for pyrolysis–biochar systems can be realised, the production and sequestration processes must be correctly specified, designed and tested. It is important that biochar produced from different feedstock under different processes has no detrimental effects on the environment. The beneficial agronomic benefits of biochar additions to soils, as well as short and long-term stability of biochar in soils may need to be maximised before biochar-enhanced soil management can be widely adopted. If biochar is to be effectively used for carbon sequestration on a large-scale, its long-term stability (i.e. centuries to millennia) needs to be proven. In addition, biochar contains a small fraction of labile carbon (which is not eligible for carbon credit under current schemes) which may impact soil processes in the short term, perhaps compounded by available mineral nutrients in the added material. The effect of biochar additions on pre-existing soil carbon (priming) also needs to be assessed.
The objective of this work has been to define a toolkit for rapid screening of short-listed biochar products for these characteristics. Quantification of the labile carbon fraction in biochar was assessed using controlled incubations of biochar in sterilised sand. Long-term stability was tested by subjecting biochar to a novel oxidative ageing technique. Soil-specific priming for the loss of pre-existing soil carbon (and its magnitude) was determined using natural abundance isotope tracing and reference soils from a single site with contrasting organic matter status. The nutrient value of biochar was determined using a procedure to extract mineral ions determined to be imminently crop-available, whilst the soil structural value of biochar products was evaluated using an approach that assessed the effects of biochar on abiotic and biotic soil aggregation processes.

Application of activated carbons prepared from biochar for soil amendment and crop yield improvement

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The largest energy input into crop production is generally nitrogen fertilizer. Activated biochar has a porous structure and its surface chemistry can be tailored for particular applications. Activated biochar captures positively charged ions like NH_4^+, K^+, Ca^{2+}, and Mg^{2+} which are retained on the carbon surface and not lost through volatilization or leaching. The binding of NH_4^+ to carbon surface is of particular interest because it reduces rate of nitrification (NH_4^+ to NO_3^-) and hence the loss of N_2O and N_2 via denitrification. Then it can sequester nutrients and hold water that might otherwise be leached through the soil profile. Activated biochar is able to bind nitrogen so that less is lost to leaching and denitrification, leading to a reduced requirement for nitrogen fertilizer application, as well as reduced ground water contamination and reduced greenhouse gas emissions (via nitrous oxide from the soil).
Activated biochar is commercially produced from lignocellulosic materials (such as agricultural wastes or forest residues), especially because of low inorganic materials content. Physical (using steam or CO_2) and chemical (using H_3PO_4 or KOH) activation methods are used to develop the porosity of biochar.
Pyrolysis of biomass produces biochar with yield of 20-30 wt %. For this study, the biochar was produced from whitewood (Spruce) using fast pyrolysis (provided by Dynamotive Corporation). This biochar was used for production of activated biochars using physical (steam) and chemical (KOH) activation. Two correlations were developed for BET surface area and activation yield of processes as a function of operating conditions. Using these correlations, the optimum operating conditions were calculated. The BET surface area and activation yield of

optimum steam-activated biochar are, respectively, 643 m^2/g and 56.9 wt %, and those for KOH-activated biochar are, respectively, 783 m^2/g and 75.3 wt %.
In this study, performances of biochar (precursor), two optimum activated biochars, and treated-activated biochars (prepared by acid-treatment and nitrogen-modification) for NH_4^+ adsorption are investigated. Long-term performance of the best activated biochar will be determined by field test. Different techniques used to characterize the porous characteristics and chemical structure of original and activated biochars are as follows: Nitrogen adsorption isotherm, Boehm titration, Fourier transform infrared spectroscopy, Elemental analysis.

Effect of corn stover biochar on the growth and water relations of a bean crop

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The study was conducted in the experimental field of the Faculty of Agricultural Sciences, University of Tarapacá, Arica, Chile. The objective was to analyze the effect of biochar concentration on growth and water relations of bean cv Magnum F1. The experiment was conducted in 3 L pots in a sandy substrate with biochar corn. Irrigation was performed with a nutrient solution of Hoagland (1952) and was applied every other day when the humidity was reduced to 30% of field capacity. Before sowing, the substrate was washed three times with distilled water. The experiment considered the following treatments: 0%, 3%, 5% and 10% char. The parameters measured in plants of 20 days are for height, stem diameter, fresh and dry weight, relative water content (RWC), water potential, osmotic potential, turgor potential and stomatal conductance. The results indicate that growth factors pres entan little difference between treatments, however, the dry weight can be seen further development in plants controls without char. The CRA is very similar between treatments. The water potential tends to diminish in direct relation to increased concentration of biochar, however, these variations are rare and occur in a range of - 0.2 MPa and - 0.55 MPa. These results indicate that 10% of biochar in the substrate is more available water for the plant which could be explained by assuming that the char can act as a water retainer and maintain, therefore, a more stable saturated environment between each irrigation. This effect of biochar on the water potential, may be reflected in cell turgor (turgor potential) which also increases in direct relation to increased concentration of biochar which resulted in treatment with 10% of this char a turgor m ayor that the control without char. Stomatal conductance is a little variable factor between biochar concentrations tested, demonstrating that plants are not subject to water stress in any of the treatments the effect of char.
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Charcoal Powder and Sawdust on Nutrient Availabity in a degraded Amazonian Oxisol

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The use of charcoal as a soil amendment is being touted as a potentially effective technique for nutrient management in tropical soils. The objective of this study was investigate the effect of charcoal, sawdust and organic compost on the chemical properties of a representative, low fertility Amazonian soil in an attempt to reproduce the fertility of Dark Earth soils. The effect of treatment 13 (120 Mg ha^{-1} of charcoal powder and no sawdust) increased pH five units higher then control plot in the soil sample showed at 0-10 cm depth. Additionally the treatment 4 (120 Mg ha^{-1} of sawdust and no charcoal) presented the lower value of potential acidity ($H^+ + Al^{3+}$).

The "Sewchar" Concept – A Strategy for the Sustainable Treatment of Human Waste and Sewage Sludge?

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Biochar strategies evolve extra (socio) economic and environmental benefits when waste materials are used as feedstocks, that up to now have to be discharged into cost-intensive and non-sustainable treatment processes. In contrast to directly plant derived feedstocks, such as biomass from dedicated bioenergy crops or agricultural and silvicultural residues, carbonaceous materials from the wastewater sector do not face any relevant competitions by alternative utilization routes. In many developing countries human excreta are hardly treated at all and, thus, cause substantial harm to human beings and the environment. On the other hand, due to the risks of organic contaminants the reuse of sewage sludges from conventional wastewater treatment plants as soil amendments is a matter of debate in industrialized countries. Thermochemical conversion processes used in biochar production principally allow for both, the removal of pathogens and the degradation of xenobiotics. By this way, biochars from human waste and sewage sludges, so-called "sewchars", could offer benefits not only for climate change mitigation and soil amelioration but also for health and environmental protection.
In order to develop environmentally sound and economically viable sewchar strategies our long-term research program addresses aspects of conversion technology, the physico-chemical characteristics of the conversion products and the effect of these products on soil properties and plant growth under specific site conditions. Our ongoing work encompasses concepts based on i) low temperature conversion (LTC), a process for dried feedstocks related to low temperature pyrolysis and ii) hydrothermal carbonization (HTC), that enables the conversion of carbonaceous materials with high moisture contents. The HTC technology is still in its infancy and investigations of HTC products are scarce. To increase the knowledge particularly in this field we are currently comparing LTC sewchars of an activated sewage sludge with the solid and liquid conversion products of a primary