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Does biochar live up to its environmental expectations? -An in-depth study of biochar alteration of pH and nutrient availability in tropical acidic soils

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A great proportion of the agricultural lands in tropical countries around the world are severely affected by soil acidification, nutrient depletion and poor cation exchange capacity (CEC). Biochar has been suggested as an amelioration agent to solve these problems. To explore this, we have studied the effect of biochar amelioration on pH, CEC and nutrient availability in soils from Zambia and Indonesia.

The effects of different amounts (0-30%; w:w) of three types of locally produced biochar (cacao shell, oil palm shell and rice husk) were tested in 31 acidic mineral soils from Indonesia. To cause a significant increase in mean soil pH (from 4.7 to 5), the addition of 0.6% cacao shell biochar, 6% oil palm biochar and 7 % rice husk biochar was needed.). After 30% biochar addition the estimated soil pH was 8.95 for the cacao shell biochar and 5.52 and 5.47 for the oil palm shell- and rice husk biochars, respectively. Assuming a maximum realistic biochars addition of 1 to 3%, these findings clearly show the different potentials of the biochars as liming agents; cacao shell biochar clearly has a large potential to act as a liming agent, whereas oil palm shell and rice husk biochars have not. The increase in soil pH due the addition of all three biochars happened faster when the initial soil pH was high and CEC was low. Addition of biochar resulted in a significant increase in the amount of exchangeable base cations (cacao shell » oil palm and rice husk) and a significant increase in CEC.

Further, the effect of biochar on nutrient retention in soil was tested. The adsorption of PO4-P, NH4-N and NO_3-N to cacao shell and corn cob biochars produced at 300 - 350 °C was first quantified. The results showed no adsorption of PO4-P to washed biochars, and some leakage of PO4-P from unwashed biochars. NH4-N was adsorbed by both unwashed and washed biochars. The binding was weak, with Kd values around 102 Lkg-1 and this suggests that biochar could retain N fertilizers and then release them when needed. There was no significant release or adsorption of NO_3-N from, or to, either of the biochars.

Three Indonesian soils, including one peat soil and four Zambian soils, were amended with 0, 1 5 and 10% (w:w) of Zambian produced corn cob biochar. The results showed that the available NH4-N decreased slightly, associated with the increased CEC from the biochar. Available NO_3-N increased slightly in the Zambian soils but not in the Indonesian, and the available PO4-P only increased in two soils. The other soils had concentrations of PO4-P below the detection limit in all treatments, indicating that the binding of PO4-P to these acidic soils seem to be too strong to be changed by biochar.

Overall, biochar addition to acidic tropical agricultural soils may increase soil pH and CEC, and increase nutrient availability; but the response is highly dependent on type, quality and amount of the added biochar in addition to intrinsic soil properties.