Beneficial Use of Biochar To Correct Soil Acidity

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Summary: *Soil acidity is a serious constraint for crop production in many regions of the world, Hawaii included. Liming is the conventional remedy, yet lime is costly and may not be available in some places. Our research showed that biochar, a by-product of bio-fuels production, could replace lime, at least partially, in alleviating soil acidity. A combination of moderate application rates of biochar (e.g., 2 to 4%) with lime (an equivalent of exchangeable acidity or about 2 tons/ha for most Hawaii acid soils) could significantly improve soil quality and increase crop growth.*

Soil acidity, characterized by low pH and high aluminum (Al), is a serious constraint for crop production in many regions of the world. In Hawaii, many agricultural lands are acidic, particularly soils of the Oxisol, Ultisol and Andisol orders. To correct soil acidity, additions of lime (conventional method) or bio-residuals, such as compost or crop residues (recent method) have resulted in reduced Al toxicity and increased crop yields.

Derived from natural organic materials (woody debris, corn stalks, macadamia shell, etc.) biochar is a stable form of charcoal produced in a high temperature, low oxygen process, such as controlled pyrolysis or even natural forest fire. Due to its molecular structure, biochar is chemically and biologically more stable than the original carbon form it comes from, making it more difficult to be converted back to CO2, meaning it can store carbon for a long time (carbon sequestration). On the other hand, the surface of biochar can contain many chemically reactive groups, such as COOH, OH, ketone, that give biochar a great potential to adsorb toxic substances, such as aluminum (Al) and manganese (Mn) in acid soils, and arsenic (As) and cadmium (Cd) in heavy metal contaminated soils. Thus, biochar could be used to rehabilitate environments that may be hostile to plant growth (acid soils) or harmful to human health (heavy metal contaminated soils).

The addition of biochar to agricultural soils has recently received much attention due to the apparent benefits to soil quality and enhanced crop yields, as well as the potential of gaining carbon credits by carbon sequestration. With that in mind, we explored the possibility of using biochar to alleviate Al toxicity in an acid soil of Hawaii.

Fig. 1. Desmodium intortum growth in an experiment having a factorial design (3 biochar rates x 3 lime rates).

The soil (Leilehua series, Ultisol order) was from Waiawa, Oahu. In its unamended state, the soil has a pH of 4.6, 1.9 cmolc/kg acidity, and 1.3 cmolc/kg exchangeable Al, and can hardly support the growth of *Desmodium intortum*, a tropical forage legume, highly sensitive to soil acidity. A greenhouse experiment was set up, using this acid soil and this legume as the test plant. Treatments included: 3 lime rates (0, 3 and 6 tons/ha of CaCO3 equivalent) and 3 rates (0, 2.5, and 5%) of a finely ground (60 mesh) biochar made of local kiawe wood (pH of the biochar was 8.5 when measured in 1:10 char:water solution). The experiment had a factorial design (9 treatments) with 3 replicates per treatment. Basal fertilizer (added to all treatments, in mg/kg) was 160 N, 160 P2O5, and 160 K2O from a 16-16-16 commercial fertilizer (Fig. 1).

The additions of lime predictably increased the plant growth by increasing soil pH and lowering Al (Al was precipitated out of solution, thus becoming non-toxic to crops) (Fig. 2).

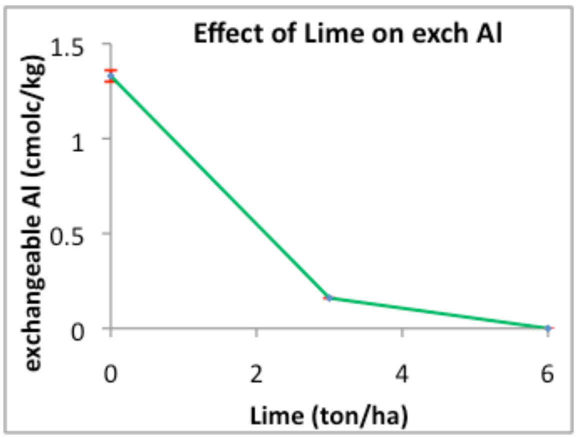


Fig. 2. Effect of lime on soil Al

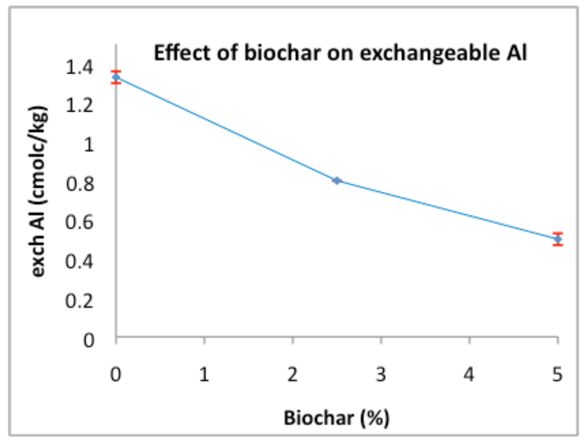


Fig. 3. Effect of biochar on soil Al.

What was more interesting (at least to us) was the positive effect of biochar on soil property and plant growth. In fact, the additions of 2.5 and 5% biochar, without lime, raised soil pH slightly from 4.6 to 5.1 and 5.2 and lowered exchangeable Al from 1.3 to 0.8 and 0.5 cmolc/kg, respectively (Fig. 3). Consequently, the plant growth was increased visibly and significantly (Fig. 4). It appears that biochar could partially substitute for lime.

The best growth (dry matter weight) was obtained where 3 tons/ha of lime was applied along with 5% biochar, which was 2.5 g/plant as compared to 0.4 g/plant in the control and 1.0 g/plant in the highest lime without biochar: a 6-fold and 2.5-fold increase, respectively (Fig. 5).

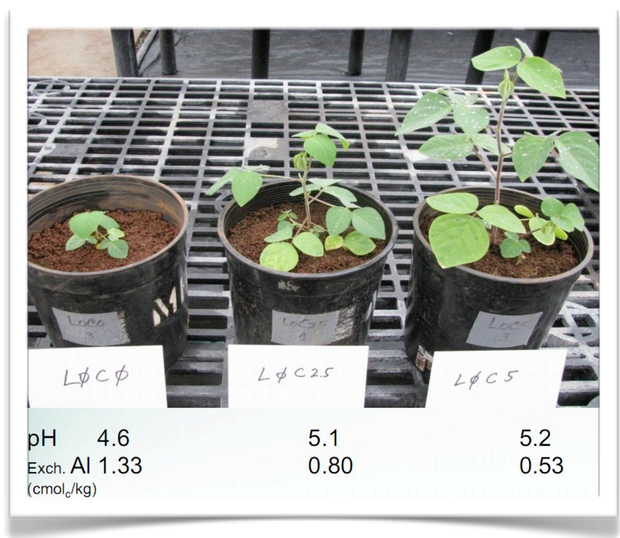
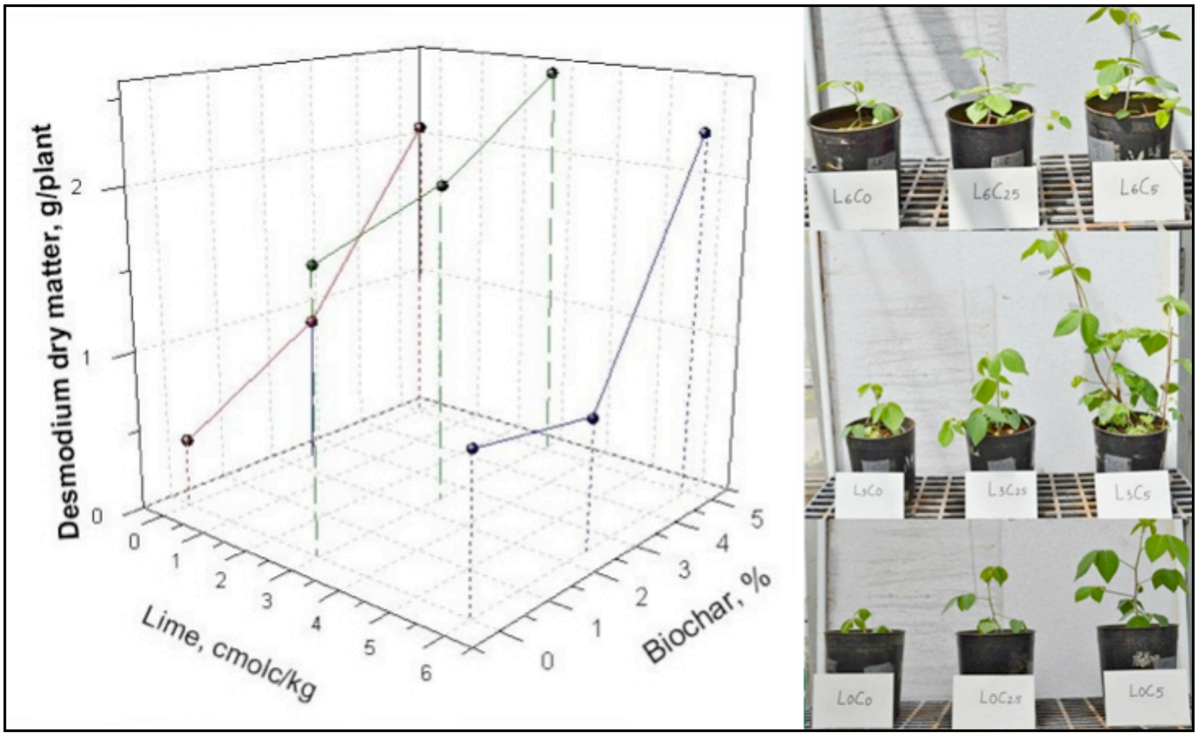


Fig. 4. Effect of biochar on plant growth.

Fig. 5. Effects of biochar and lime on Desmodium intortum growth.



Aluminum concentrations in shoot also indicated the beneficial effects of biochar applications. Across all three lime levels (0, 3, and 6 tons/ha), shoot Al averaged 129 ppm (or µg/g) without biochar as compared to 85 ppm and 70 ppm at 2.5% and 5.0% biochar (Fig. 6). For each percent biochar added, shoot Al was reduced by about 12 ppm [Shoot Al (ppm) = 125 – 11.84*biochar (%)]. Such Al reductions in shoot help explain the increased growth of *D. intortum* upon biochar additions.

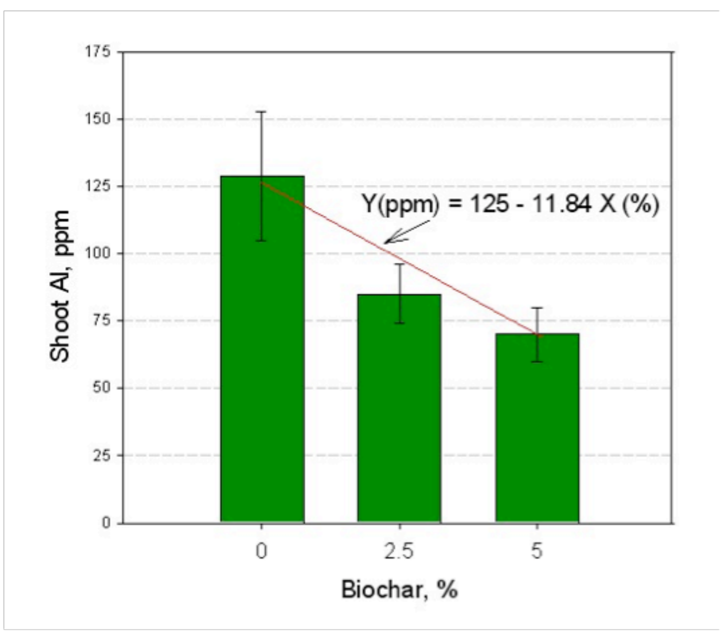


Fig. 6. Shoot Al as a function of biochar application rates.