

Research report

- Project title:** Report of the 3rd year of the project: The use of biochar as a soil amendment for degraded soils and studies on function and community structure of fungi decomposers of organic residues contrasting in quality continuously in the long term.
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Abstract

The first part of the studies is the investigation of the use of biochar as a soil amendment. Two soils which had contrasting textures and mineralogies, were employed including Korat series (isohyperthermic, Typic (oxyaquic) Kandiusults) a loamy-sand textured soil, and Wahiawa series (clayey, kaolinitic, isohyperthermic, Tropeptic Eustrtox) a clayey textured soil. The two types of biochar used were made from eucalyptus (*Eucalyptus camaldulensis*) wood which was the part not used as feedstock for paper making, i.e. top 3 meter end of a eucalyptus tree. The two biochar types had different pyrolysis methods. One was produced in traditional method of Northeast Thailand, i.e. traditional kiln (TK), designated as TK-biochar, and the other employed flash carbonization (FC) techniques designated as FC biochar. The FC technique based on rapid temperature increase 25⁰C/min during pyrolysis to the highest temperature of 350⁰C which was maintained for 1.4 minutes. This technique was developed by Hawaii Natural Energy Institute, University of Hawaii. The experiment was factorial with 3 factors including 2 soils types, 2 biochar types and 5 rates of biochar and chemical fertilizers, i.e. No biochar and no fertilizers, no biochar+fertilizers, 1% soil weight+, 2%+, and 4% + fertilizers. The second part of the studies involves a long-term experiment in a research station (Office of Agriculture in the Northeast, Tha Phra subdistrict, Muang district, Khon Kaen province) which organic residues were applied yearly. There were 5 organic residue treatments of different residue quality (biochemical composition): Control (no residue application), groundnut stover (high quality residue with high contents of N but low lignin and polyphenols; tamarind leaf(+

petiole) litter (intermediate quality with medium contents of N, lignin and polyphenols), dipterocarp leaf litter (low quality with low N but high lignin and polyphenol contents), and rice straw which had different quality, i.e., it had low contents of all the three biochemical components but it had the highest cellulose content. The residues were applied at the rate 10 t/ha yearly. The studies of microbial functions through enzyme analyses and microbial (fungal) community structure, performing decomposition of the contrasting quality residues, reported herein, made use of soils from year 16 of the long-term experiment.

The study on the use of biochar as a soil amendment showed that after harvesting of corn of both crop 1 and 2, soils treated with FC-BC showed significant increases in pH over the control. Meanwhile, soils treated with TK-BC showed soil pH increases over the control only in crop 2. However, pH decreased under treatments with added fertilizer. Phosphorus (P) contents increased while bulk density of soils decreased with increasing biochar rates. Corn heights in crop 1 in both Korat and Wahiawa soils were not significantly affected by types and rates of biochars, but in crop 2 both soils treated with TK- and FC-BC at 1, 2, and 4% had higher heights than the controls. Corn biomass or dry weight in crop 1 in both soils did not significantly respond to types and rates of biochars. In addition, biochars did not significantly affect properties of both soils as indicated by soil pH and P contents which were not significantly different between those treated with biochars and the control. This was with the exception of the 4% rate of crop 2. In crop 2, both soils treated with TK- and FC-BC at various rates resulted in higher corn biomass than the control. This was likely due to changes in soil properties be it physical, such as bulk density, chemical (pH, CEC, and nutrient availability) and biological (changes in microbial biomass and population), as a result of BC application. However, influence of BC types and rates on properties of both Korat and Wahiawa soils were not seen in crop 1 but it was clearly shown in crop 2.

Studies on microbial function in decomposition of organic residues contrasting in quality under incubation experiment conditions were through investigations of 4 enzymes including invertase, β -glucosidase, peroxidase and phenoloxidase. These are enzymes involved in degrading organic compounds varying in resistance to decomposition. These organic compounds were constituents of either newly added organic residues or indigenous soil organic matter. It was found that invertase activity tended to increase in all newly applied organic residues treatments, i.e., in C-

soil (soil without organic residue inputs) and N-soil (soil with 16 years application of organic residues). NTM (the soil treated with tamarind leaf(+petiole) litter for 16 years) had the highest invertase activity followed by NTM+TM treatment (soil treated with tamarind leaf(+petiole) litter for 16 years plus newly added litter). In C-soil treatment which received newly added organic residues, it was found that C+GN (soil without organic residue application for 16 years but with newly added groundnut stover residue) had higher invertase activity compared with those that received the other organic residues. Similarly, β -glucosidase activity increased in all treatments receiving newly added organic residues in both C-soil and N-soil relative to those without newly added residues. This was with the exception of NTM treatment which had the highest activity of the enzyme but it decreased when new residue was applied. Meanwhile, C-soil treatment had the lowest β -glucosidase activity. Peroxidase activity increased in C-soil treatments that received newly added residues. The highest activity was found in C+TM treatment (soil that had never received organic residues before new tamarind litter was applied) followed by C+RS (soil that had never received organic residues before new rice straw residue was applied), C+GN and C+DP (soil that had never received organic residues before new dipterocarp leaf litter was applied). Addition of fresh residues into the N-soil brought about decreases in peroxidase activities with the exception of NRS+RS. Meanwhile, phenoloxidase activities in C soil receiving newly added residues increased and the highest increase was found in C+DP followed by C+GN, C+TM, and C+RS. As for the N-soils receiving newly added residues, NGN+GN (soil that had been receiving GN residues continuously for 16 years + newly added residues) had the highest phenoloxidase activities followed by NDP+DP (soil that had been receiving DP residues continuously for 16 years + newly added residues), NTM+TM (soil that had been receiving TM residues continuously for 16 years + newly added residues), and NRS+RS (soil that had been receiving RS residues continuously for 16 years + newly added residues). As for the N soil treatments (those that had been receiving residues continuously for 16 years without newly added residues), the NDP had the highest phenoloxidase activity followed by NGN, NTM, and NRS.

Microbial community studies emphasizing on fungal communities which decompose contrasting quality organic residues in a sandy soil treated with organic residues continuously for 16 years, employed molecular techniques including real time-polymerase chain reaction (RT-PCR) and conventional PCR in order to multiply gene copies. It was found that applications of contrasting

quality organic residues continuously for 16 years led to changes in fungal community structure. This is especially so under NTM treatment which showed significant differences in fungal species and fungal abundance relative to the other treatments. This was determined by employing the technique “terminal restriction fragment length polymorphism (T-RFLP)” which employed two kinds of enzymes, MSP I and HAE III digestion-based T-RFLP. Analysis of similarity by Bray-Curtis combined with non-metric multidimensional scaling (nMDS) based on two enzymes digestion confirmed the clear separation of fungal community structure in C- and N-soils. The digestion of MSP I revealed a clearest separation of fungal community structure in NTM soil followed by NDP soil as compared to control soil. Meanwhile, the digestion of HAE III showed the clearest separation of fungal community structure under NDP soil followed by NTM soil as compared to control soil.