FARMING PRACTICE
SOIL AMENDMENT WITH BIOCHAR

IMPACT: SOIL BIOLOGICAL QUALITY

Reference 29

Zhang, LY; Jing, YM; Xiang, YZ; Zhang, RD; Lu, HB 2018 Responses of soil microbial community structure changes and activities to biochar addition: A meta-analysis Sci Total Environ. 643:926–35. 10.1016/j.scitotenv.2018.06.231

Background and objective

Effects of biochar application on soil microbial community structure changes and activities remain controversial under different biochar characteristics, soil properties, and experiment conditions. It is critical to determine responses of soil microbial community structure changes and activities to biochar addition with different biochar characteristics, soil properties, and experiment conditions. Answer the following questions: How do soil microbial community structure changes and activities change with different biochar characteristics under different soil properties and experiment conditions? What are the main influencing factors on soil microbial community structure shifts and activities under biochar addition?

Search strategy and selection criteria

The peer-reviewed articles reporting effects of biochar addition on soil microorganisms with different biochars under different soil and experiment conditions were collected globally using Web of Science (http://apps.webofknowledge.com) and China National Knowledge Infrastructure (CNKI, http://www.cnki.net). Keywords and terms used for the literature online-searching were "biochar" and "soil microbial biomass, or soil microbial activity, or microbial community structure, or total PLFA, fungi, bacteria and actinomycetes" and "phospholipid fatty acids or PLFAs". Articles satisfying the following criteria were included for the meta-analysis: at least three replicates per treatment, biochar and control treatments in the same experimental site (i.e., the same experimental conditions), clearly reported biochar addition rates, and analyzed data of soil microbial activities (bacteria, fungi and actinomycetes), total microbial biomass and activities (total PLFA), and microbial community structure changes (fungi to bacteria ratios and Gram-positive bacteria to Gram-negative bacteria ratios) using the PLFA method.

Data and analysis

Values of the mean (i.e., Pc) and 95% CI of the overall effect of biochars on soil microorganisms were calculated using the random-effect models in the Meta-Win software and the datasets. The Pearson correlation and regression analyses were conducted to examine relationships of the responses of microbial community structure changes and activities vs. the various factors. The chi-square test was applied to determine significant difference between groups at $P < 0.05$.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
49	Lab incubations, Pot trials, field trials	Soil amendment with biochar	No amendment	Metric: Soil total microbial biomass (Bacterial and fungal phospholipid fatty acids, PLFAs); Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	0.9375

Results

- Biochar addition overall increased soil F/B ratios by 6.4% under different conditions. An increased F/B ratio indicates a more sustainable agricultural system, in which C decomposition and N mineralization mediated by fungi result in more efficient plant nutrient uptake, thus promoting crop growth. Especially low pyrolysis temperature biochars increased soil F/B ratios by 37%.
- Biochar addition increased soil G+/G− by 10%. Medium temperatures (350–600 °C) and residue biochars enhanced G+/G− values by 8.5% and 23%, respectively
- Across all the studies, biochar addition significantly increased activities of the total soil microorganisms (total PLFA), bacteria, fungi, actinomycetes, G+ bacteria, and G− bacteria by 8.3%, 20%, 19%, 9.1%, 11%, and 13%, respectively.

Factors influencing effect sizes

- Soil type : The response ratios of soil F/B were negatively correlated with soil pH ($P < 0.05$). Nutrient supply (by biochars and soils) and soil pH interactively influenced the F/B ratios. The SOC was negatively correlated with the response ratios of activities of fungi ($P < 0.05$) and actinomycetes ($P < 0.01$).
- Biochar application rate : Response ratios of soil G+/G− were positively correlated with biochar load ($P < 0.001$). Biochar load were positively correlated with the response ratios of activities of bacteria ($P < 0.01$), the total soil microorganisms (total PLFA), fungi, and actinomycetes ($P < 0.001$).
- Fertilisation : Biochar addition combined with fertilization greatly increased soil G+/G− by 17%
- Biochar pyrolysis temperature : The response ratios of bacteria and fungi were negatively correlated with biochar pyrolysis temperature ($P < 0.01$)
- Biochar specific surface area : Biochar SSA were positively correlated with the response ratios of the total PLFA ($P < 0.01$).

Conclusion

Results showed that biochar addition significantly increased the ratios of soil fungi to bacteria (F/B) and the ratios of Gram-positive bacteria to Gram-negative bacteria (G+/G−), and microbial biomass and activities.