Effects of Biochar on Soil Microbial Community Composition using PLFA Profiling - A Review

Nivya Mariam Paul[1*], Variampally Sankar Harikumar[2]

[1] Research and Development Centre, Bharathiar University, Coimbatore, Tamil Nadu, India
[2] Department of Post Graduate Studies and Research in Botany, Sanatana Dharma College, Alappuzha, Kerala, India
*Corresponding Author: nivyamariampaul@gmail.com

Abstract. Biochar is a charcoal like substance produced from organic biomass after pyrolysis. Biochar act as a good soil conditioner by increasing microbial activities, soil nutrition and soil structure. Soil microorganisms are involved in litter decomposition and soil nutrient mineralization which is important in the sustainable development of plants and trees. The functioning of an ecosystem is controlled by biogeochemical cycles driven by microorganisms. The cell membrane of all microorganisms is composed of phospholipids that are easily metabolized after the cell death. Hence, phospholipid fatty acid (PLFA) analysis of microorganisms can be used for the characterization of living microbial communities. PLFA analysis is a lipid based, culture independent biochemical technique. Therefore, PLFAs can be used for the characterization of soil microbial community structure that are not able to cultivated by the conventional methods. This profiling act as a biological register of soil health, and as an indicator of soil response to different field management systems like biochar.

Index Terms: Biochar, pyrolysis, PLFA, microbial communities

I. INTRODUCTION

Biochar is a highly porous substance produced by the pyrolysis of biomasses and inoculated into soil which helps to increase the fertility. It also stores carbon for many years and helps in its sequestration and mitigate climate change [1]. Biochar increases the properties of soil which increase the nutritional value of soil and thus the number of plant growth promoting organisms [2]. Soil microorganisms helps in the shaping of humus, modification of soil minerals and biogeochemical cycles [3,4]. The microorganisms in soil shows the quality of soil and it undergo alterations according to the changes in their environment [5]. Soil health can be analyzed using the microbial structure in soil [6]. Effect of biochar on soil properties are shown in Figure 1.

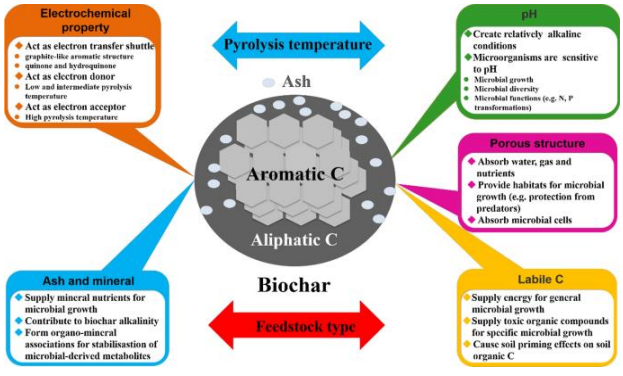

Figure 1. Effect of biochar on the properties of soil [7].

1.1. Phospholipid Fatty Acids

Bacterial and eukaryotic cell membranes mainly contain phospholipids. The cell membranes of all the three domains of life are composed of these phospholipids [8]. Each phospholipid molecule consists of a single glycerol backbone, a hydrophilic polar head and two hydrophobic fatty acid tails. Phospholipids are formed by replacing two OH groups in glycerol by two fatty acid chains (non polar tail) and the third OH group by a phosphate group (polar head). The membrane fatty acids vary in their chain length, microbial fatty acids are of length between 12 -24 C long. Commonly occurring fatty acids have a chin length between 14-20 C long [9].

1.2. Phospholipid fatty acids as biomarkers

PLFAs act as markers for specific communities of microorganisms. In other words, lipids of a particular group of organisms will be same at a particular concentration. But the specificity level is rare [10]. Even though most of the lipids are common among different organisms, some microbial groups contain a characteristic PLFAs and are used as a biomarker. For example, 18:2 ɯ 6 is used as a biomarker for fungus biomass and number [11]. 18:2 ɯ 5c is used as a biomarker for arbuscular mycorrhizal fungi [12].

1.3. Nomenclature

PLFA naming was done in a common manner, in which the total number of carbon atoms in the fatty acid chain was written followed by the number of double bonds, which are separated with the punctuation mark:. The symbol Ш was used to denote the position of double bond in the fatty acid followed by the number of ‘C’ atoms from the aliphatic end of the fatty acid chain. By custom, for example, it is written as 24:1 Ш6c [13]. The

Nivya Mariam Paul, Variampally Sankar Harikumar – “Effects of Biochar on Soil Microbial Community Composition using PLFA Profiling - A Review”, Pg no: 24 – 25. 2022
doi.org/10.36647/978-93-92106-02-6.5

prefix ‘a’ indicates anteiso branching and the prefix ‘i’ denotes iso branching. Methyl position, if it is not iso or anteiso, is written with the prefix ‘Me’ (10Me 22:0). ‘Cyclo’ represent cyclopropyl PLFAs. ‘OH’ indicates hydroxyl groups. DMA denotes dimethyl acetal [14,15].

II. CONCLUSION

The profile of PLFA analysis helps in determining the microbial community structure and biomass content of environmental samples. Phospholipid fatty acid analysis helps in the calculation of alterations in the microbial communities than molecular methods. Biochar application into soil increase the microbial diversity and PLFA is a good tool for the calculation of biomass content and microbial diversity after the application of different types of biochar.

REFERENCES

1. P. Conte, R. Bertani, P. Sgarbossa, P. Bambina, H. P. Schmidt, R. Raga, R., ... & P. Lo Meo. Recent Developments in Understanding Biochar’s Physical–Chemistry. *Agronomy*, *11*(4), 615, 2021.
2. N. Ullah, A. Ditta, M. Imtiaz, X. Li, A.U. Jan, S. Mehmood,... & M. Rizwan. Appraisal for organic amendments and plant growth-promoting rhizobacteria to enhance crop productivity under drought stress: A review. *Journal of Agronomy and Crop Science*, 2021.
3. K. Denef, D. Roobroeck, M. C. M. Wadu, P. Lootens, P. Boeckx. Microbial community composition and rhizodeposit-carbon assimilation in differently managed temperate grassland soils. *Soil Biology and Biochemistry*, *41*(1), 144-153, 2009.
4. B. F. Brockett, C. E. Prescott, S. J. Grayston. Soil moisture is the major factor influencing microbial community structure and enzyme activities across seven biogeoclimatic zones in western Canada. *Soil biology and biochemistry*, *44*(1), 9-20, 2012.
5. O. A. Hewedy, K. S. Abdel Lateif, M. F. Seleiman, A. Shami, F. M. Albarakaty, R. M El-Meihy. Phylogenetic diversity of Trichoderma strains and their antagonistic potential against soil-borne pathogens under stress conditions. *Biology*, *9*(8), 189, 2020.
6. B. P. Degens, L. A. Schipper, G. P. Sparling, M. Vojvodic-Vukovic. Decreases in organic C reserves in soils can reduce the catabolic diversity of soil microbial communities. *Soil Biology and Biochemistry*, *32*(2), 189-196, 2000.
7. Z. Dai, X. Xiong, H. Zhu, H. Xu, P. Leng, P., J. Li, ... J. Xu. Association of biochar properties with changes in soil bacterial, fungal and fauna communities and nutrient cycling processes. *Biochar*, *3*(3), 239-254, 2021.
8. K. O. Konhauser. Introduction to Geomicrobiology; John Wiley & Sons, 2009.
9. J.A.W. Morgan and C. Winstanley. Microbial biomarkers. In: Modern soil microbiology (Eds). J.D van Elsas, J.T. Trevors., E.M.H. Wellington., Marcel Dekker. Inc., New York, 1997, pp 331-348.
10. H. T. S. Boschker, & J. J. Middelburg. Stable isotopes and biomarkers in microbial ecology. FEMS Microbiology Ecology. Volume 40. Issue. Pp. 85-95, 2002.
11. A. Frostegård and E. Bååth, E. The use of phospholipid fatty acid to estimate bacterial and fungal biomass in soil. Biol. Fertil. Soils. 22, pp. 59-65, 1996.
12. S.J.M. Dicken, E.B. Allen, L.S. Santiago, and D. Crowley. Exotic annuals reduce soil heterogeneity in coastal sage scrub soil chemical and biological characteristics. Soil Biol. Biochem. 58, pp. 70-81, 2013.
13. D. C. White, H. C. Pinkart, and D. B. Ringelberg. Biomass measurements; Biochemical approaches. In: Manual of environmental microbiology (Eds). C. J. Hurst and G. R. Knudsen ASM Press, Washington, DC, pp. 91-101, 1997.
14. E. Baath and T. H. Anderson. Comparison of soil fungal/bacterial ratios in a pH gradient using physiological and PLFA based techniques, Soil Biol Biochem, vol. 35, pp. 955-963, 2003.
15. K. L. Steenwerth, L. E. Jackson and F. J. Calderon. Soil microbial community composition and land use history in cultivated and grassland ecosystems of coastal California, Soil Biol Biochem, vol. 35, pp. 489-500, 2003.