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Responses of Soil Microorganisms under Different Soil Amendment Practices

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Abstract

Soil microorganisms play an important role in soil biogeochemical processes, such as decomposition of organic material, nutrient cycling, pedogenesis and biotransformation of organic pollutants. The efficient and ability of microorganism activity depends on the different nutrient management practices. The aim of this review work is to identify how microorganisms respond for different soil nutrient management practices. Application of integrated manure composts; especially manure compost + bacterial fertilizer, consistently resulted in higher levels of soil respiration rate, cultivable microorganisms, and soil enzyme activities while N fertilizers showed no significant influence or negative results. Biochar application could affect microorganisms in the soil by changing in nutrient availability; changes alterations in plant-microbe signaling; and habitat formation and refuge from hyphal grazers. Addition of straw at different rate of application showed variation in bacterial population. Substrate quality can affect the micro-organisms community composition and structure, give positive or negative response to the addition of substrate either organic or in organic. Further characterization of long-term manure effects on multiple aspects of soil microbial communities in different agro-ecological systems is required as Ethiopian context. Additionally, further study to bring the contradicting ideas on long term application of mineral fertilizer will be needed.

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Healthy soil, Soil microbial activity, Soil microenvironments, Soil microorganisms, Substrates.

Introduction

Soil microorganisms play an important role in soil biogeochemical processes, such as decomposition of organic material, nutrient cycling, pedogenesis and biotransformation of organic pollutants (Geisseler *et al.*, 2017). They also improve soil physical properties such as structure, porosity, aeration, and water infiltration by forming and stabilizing soil aggregates. While the growth and activity of microorganisms are functions of soil properties, such as nutrition, texture, pH, temperature, soil water content (Zhong and Cai, 2007). These soil properties are determined by soil nutrient management practices. The soil microbial community is an important component of a healthy soil; it is considered as a sensitive indicator of soil health and quality (Doran and Zeiss, 2000). This is due to the fact that microbes are responsible for the circulation of nutrient transformation, organic matter decomposing, humus formation, and system stability in the soil ecological function (Schmidt *et al.*, 2019).

The applications of soil nutrients from different sources affect soil microorganisms in different ways. The application of mineral fertilizer directly or indirectly influences the soil quality and productive capacity by induces changes in soil chemical, physical and biological properties (Schmidt *et al.,* 2019; Geisseler and Scow, 2014). Zhong and Cai, (2007) reported that nitrogen (N) and phosphate (P) fertilizers had no significant effects on soil microbial populations.

Biochar as a soil amendment can increase microbial biomass and motivate soil microbial activity, as well as change microbial community in soil (Domene *et al.,* 2015). It increases the sorption and degradation of soil contaminants and reduces their bioavailability and toxicity to microbes (Ajema, 2018). According to Ajema, (2018) cited, biochar has also been shown to enhance nutrient availability over longer time scales by enhancing N mineralization or nitrification (Ameloot, 2013)as a result, the microbial growth and activity enhanced and by reducing soil nutrient losses due to its high ion exchange capacity (Tanzito *et al.,* 2020)

Microorganism response positively for the application of manure compost. According to (Zhen *et al.,* 2014) the application of manure compost enhances soil microbial activities that improve the crop growth, compared with chemical fertilizers. It has been comprehensively tested as effective in rising nutrient availability to crops by improving grain yield in a cost-effective and environmentally friendly manner (Ahmad *et al.,* 2007; Zhen *et al.,* 2014). The addition of manure compost can also enhance the content of organic matter and improve soil porosity, structural stability, moisture, and nutrient availability, as well as biological activity (Francis *et al.,* 2010; Wang *et al.,* 2019). Hence, it is becoming a more popular practice to add manure compost to the soils if the degraded cropland is considered to be restored. Bio-fertilizers is another kind of soil amendment and have identified as an alternative to chemical fertilizers to increase soil fertility and crop production in sustainable farming. Bio-fertilizer as a substance contains living microorganisms, when applied to seed colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the availability of primary nutrients to the host plant (Javoreková *et al.,* 2015).

Generally soil microorganisms have responded positively and negatively for the applied soil amendments. However, there is no sufficient literatures and clear information in the area. Understanding how soil microbial properties respond to different substrate may help to strengthen soil ecosystem health practices. Various studies were give emphasize to increase production and productivity of agriculture; by adding different substrates to the soil. However, giving attention to the effect of different substrate used on microbial community and their activities are rarely reported. Therefore, the aim of this review work isto identify the effect of organic and inorganic soil amendments on soil microbial composition and activities and its response for various soil amendments.

Effect of Soil Amendment Techniques on Soil Microorganisms

Effect of mineral fertilizer application on microorganisms

Geisseler *et al.,* (2017)reported that, the effects of mineral fertilizer application on microbial biomass carbon contents (MBC) and soil organic carbon content (SOC) are small when compared with the effect of organic fertilizers. Mineral fertilizer increased MBC content by 29%, whereas organic fertilizer led to an increase of 61%. The biomass of bacteria, actinomycetes and fungi tended to increase also with addition of organic fertilizer than with mineral fertilizer. The response, varied considerably among the microorganisms; small increase in fungi with mineral fertilizer treatment compared to compost/manure the increase in bacteria biomass and actinomycete in treatments with manure and compost than mineral fertilizer. According to Treseder, (2008) microbial biomass declined significantly under nitrogen fertilization, by an average of 15.4% across all studies in his meta-analysis. However, fungal biomass declined more strongly as the total N fertilization increased and bacterial biomass did not indicate a significant change.

The response of microbial community composition to fertilization treatments was correlated with soil properties, such as SOC, total P and pH (Zhao *et al.,* 2014). That nutrient amendment affects microbial community composition through changes in soil properties. Most soil physicochemical properties related to microbial activity are determined by soil nutrient amendments. Simultaneously, soil microorganisms improve soil physical properties such as structure, porosity, aeration, and water infiltration by forming and stabilizing soil aggregates. Since the growth and activity of microorganisms are functions of soil properties, such as nutrition, texture, pH, temperature, soil water content (Zhong and Cai, 2007). The effect of fertilization on soil properties in turn highly depends on the initial soil characteristics, which may explain why the response of the microbial community is so variable and site specific (Geisseler *et al.,* 2017).

The growth and activities of microorganisms are constrained by different factors in different soils and different management. For instance, Yan *et al.,* (2000) found that there existed a threshold effect in regard to soil organic matter content. When the soil organic matter content was larger than the threshold, there was no significant correlation between soil microbial diversity and soil organic matter content while a positive relationship was observed at soil organic matter content below this level. Therefore, in order to maintain and improve microbial diversity, it is important to determine the critical factors controlling the growth and activities of soil microorganisms.

Effect of manure/compost application on microorganisms

According to Zhen *et al.,* (2014) findings, cattle compost changes the soil bacteria and fungi community structure by increasing exogenous microorganisms, which can directly influence the soil microorganism community structure. Zhen *et al.,* (2014) confirmed that, animal compost increased bacteria and fungi diversity by increasing the carbon pool of the soil; (Dai *et al.,* 2017) that it is conducive to the establishment of a diverse microbial community structure. Thus improves the living conditions for indigenous microbial populations.

According to Zhang *et al.,* (2018), an 8-month field trial showed that application of manure increases microbial biomass carbon (C), N mineralization, soil respiration, and enzyme activities and a 3-month trial showed that the relative abundance of soil Gram-negative bacteria increased more by applying manure than inorganic fertilizer (Lazcano *et al.,* 2013).

Effect of biochar soil amended on microorganisms

Application biochar affects the soil microbial abundance and activities by improving nutrient availability and pH, CEC, total N and C (Geissseler*et al.,* 2017). The pH value has also been found to affect the soil microbial population and enzymatic activities; indeed, a high pH might enhance bacteria abundance, whereas it did not change fungi total biomass or dramatically reduce their growth (Trupiano *et al.,* 2017). Beneficial effects of biochar were found to increase more in sandy than in loamy substrates (Trupiano *et al.,* 2017).

Kolton *et al.,* (2011)the relative abundance of the *Bacteroidetes* phylum was significantly higher in the biochar-amended root-associated community. Biochar improves the physical and chemical soil quality, including increased organic carbon content, Ca content, pH and resulting lower content of exchangeable Al (Liu *et al.,* 2016); but also improves soil biological properties (Sheng and Zhu, 2018). Ding *et al.,* (2016) reported that biochar had increased soil biological community composition and microbial biomass by 125 % and basal respiration increased by 30.1 % CO_2 in 35 h after substrate addition. Despite the resistance nature of biochar, several studies have reported increased soil respiration rates when biochar was added to soils (Liu *et al.,* 2016; Ameloot, 2013). The addition of biochar may provoke an increase in soil pH, through the negative charge on the surface that buffers acidity in soils and the presence of mineral ashes in the biochar, which has a positive effect on soil microbial activity in acidic soils (Ameloot, 2013). Biochar application could affect microorganisms in the soil by changing in nutrient availability; changes alterations in plant-microbe signaling; and habitat formation and refuge from hyphal grazers (Ding *et al.,* (2016).

In contradictory, biochar amending sometimes exerts negative effects on microorganisms. Taylor *et al.,* (2012)reported that the decrease in microbial abundance and activities might be also expected with an enhanced retention of toxic substances, such as heavy metals and pesticides, and the release of pollutants from biochar, such as bio-oil and polycyclic aromatic hydrocarbons. According to Kolton *et al.,* (2011) discussed, no significant differences were observed in the levels of genus richness between the biochar-amended and non-amended (averages of 195 and 172 unique genera for duplicate samples, respectively), and the composition of selected genera significantly differed between the two treatments. Ameloot, (2013)reported that, a shift occurs in the chemical composition towards molecules that are more resistant to microbial decomposition such as highly condensed aromatic structures while carbonization of biomass.

Table.1 Effect of fertilization on microbial community composition in paddy rice systems.

Statistics	Number of observation and response ratio (RR)				
	SOC	Total biomass	Bacteria (B)	Actinomycetes	Fungi (F)
Mineral (N or NPK)					
Average RR	1.18	1.50	1.76	1.91	1.04
Range	0.98-1.84	0.8-4.47	0.80-7.90	0.89-6.50	0.67-1.72
Organic (manure or compost)					
Average RR	1.47	2.77	2.63	2.95	1.00
Range	1.06-2.48	0.76-10.2	0.74-10.2	1.48-5.87	0.37-2.22

RR=response ratio, N=nitrogen, NPK=nitrogen, phosphorus and potassium; SOC=Soil organic carbon. Source: (Geisseler *et al.*, 2017)

Table.2 Influence of application bio-fertilizer to the arable soil on the microbial carbon

Parameter	Treatment	Day of observation				
		1	15	30	64	105
C_{mic}	T1	123.37a	124.17a	141.29a	106.01a	49.88a
	T2	186.42b	185.43b	212.34b	120.60ab	62.30
	T3	250.27c	248.89c	283.37c	147.28b	98.04b
	T4	290.76d	267.86c	288.69c	189.75c	164.37c
C_{mic}/ C_{org}	T1	3.46a	3.48a	3.45a	3.39a	1.85a
	T2	4.94b	4.20ab	4.82b	3.35a	2.04ab
	T3	6.20c	5.23bc	5.42bc	3.77a	3.04b
	T4	6.77c	5.61c	5.78c	4.89a	4.21c

*means followed by the same letters within each column are not significantly different at $p \leq 0.05$, Cmic is microbial carbon, Corg is organic carbon. Sources: Javoreková *et al.*, (2015)

Effect of biofertilizer application on soil microorganisms

According to Javoreková *et al.*, (2015) are products containing arbuscular mycorhizal fungi, N-fixers (*Azotobacter chroococcum*), P-solubilizers (*Bacillus megaterium*) and K solubilizers (*Bacillus mucilaginous*), which improve chemical properties of the soil; for example content of organic matter and content of a total carbon. Javoreková *et al.*, (2015)conducted laboratory incubation experiment for 150 days and the result confirmed that increased values of microbial biomass especially on the early 30 days with the application of bio-fertilizer (Table 2). Applied organic fertilizers were a suitable source for the growth and reproduction of the soil microorganisms. Microbial biomass increased the highest about 230 % (in the first day) and 329 % (in the last day) after 150 days. Soil microorganisms give positive or negative response to the addition of substrate either organic or in organic. Substrate quality can affect the micro-organisms community composition and structure; although the quantity or amount of substrate added can affect their growth. The effects of mineral fertilizer on MBC and SOC contents are small when compared with the effect of organic fertilizers; mineral fertilizer increased MBC content by 29% relative to the unfertilized control, organic fertilization led to an increase of 61%. Organic materials affects the soil microbial activity and biomass, changes the soil bacteria to fungi ratio and soil enzyme activity, and reshapes the microbial community structure; through changing the soil pH and SOC.

Manure composts; especially manure compost + bacterial fertilizer, consistently resulted in higher levels of soil respiration rate, cultivable microorganisms, and soil enzyme activities, while N fertilizers showed no significant influence or negative results.

Fertilizers, especially manure compost, significantly enhanced soil microbial properties in response to the increase in soil physicochemical properties of soil organic matter and humus. From a soil microbial point of views, manure compost application can be used as an environmentally friendly and rapid measure for restoring degraded cropland.

Generally, the long-term application of chemical fertilizers affects the microbial community; consequently, the growth and activity of pathogenic fungal genera may be enhanced. In contrast, organic fertilizers tend to maintain a higher soil microbial biomass, fungal and bacterial diversity, mesofaunal abundance and enzyme activity. Organic amendments enhance the health of agricultural soils by reducing bulk density, promoting soil structural stability, biological activity and nutrient levels as well as providing nutrients in an organic form. Consequently, the combined application of organic amendments and inorganic fertilizers is likely to represent a more appropriate fertilizer practice for sustainable food production. Soil microorganisms are mostly heterotrophic and use organic carbon as carbon and energy sources. So the growth of microorganisms in the soil should be controlled by the supplies of organic carbon. Understanding the key roles of biochar properties on microbial activity in different soil types are essential to know the conditions of biochar to reach the desired benefits, and how can the trade-offs between various environmental and the biological effects of biochar.

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References

Ahmad, R. *et al.*, (2007) 'Bio-conversion of organic wastes for their recycling in agriculture : an overview of perspectives and prospects', 57(4), pp. 471–479.

Ajema, L. (2018) 'Effects of Biochar Application on Beneficial Soil Organism Review Effects of Biochar Application on Beneficial Soil Organism Review', (January). doi: 10.13140/RG.2.2.15186.66247.

Ameloot, N. (no date) Biochar additions to soils : effects on soil microorganisms and carbon stability.

Dai, H. *et al.*, (2017) 'The effect of different organic materials amendment on soil bacteria communities in barren sandy loam soil', pp. 24019–24028. doi: 10.1007/s11356-017-0031-1.

Ding, Y. *et al.*, (2016) 'Biochar to improve soil fertility. A review', Agronomy for Sustainable Development. doi: 10.1007/s13593-016-0372-z.

Domene, X. *et al.*, (2015) 'Short-term mesofauna responses to soil additions of corn stover biochar and the role of microbial biomass', Applied Soil Ecology, 89, pp. 10–17. doi: 10.1016/j.apsoil.2014.12.005.

Doran, J. W. and Zeiss, M. R. (2000) 'DigitalCommons @ University of Nebraska - Lincoln Soil health and sustainability : managing the biotic component of soil quality Soil health and sustainability : managing the biotic component of soil quality', Applied Soil Ecology, (June).

Francis, I., Holsters, M. and Vereecke, D. (2010) 'The Gram-positive side of plant-microbe interactions: Minireview', Environmental Microbiology, 12(1), pp. 1–12. doi: 10.1111/j.1462-2920.2009.01989.x.

Geisseler, D., Linquist, B. A. and Lazicki, P. A. (2017) 'Soil Biology & Biochemistry Effect of fertilization on soil microorganisms in paddy rice systems e A', Soil Biology and Biochemistry, 115, pp. 452–460. doi: 10.1016/j.soilbio.2017.09.018.

Geisseler, D. and Scow, K. M. (2014) 'Soil Biology & Biochemistry Long-term effects of mineral fertilizers on soil microorganisms e A review', Soil Biology and Biochemistry, 75, pp. 54–63. doi: 10.1016/j.soilbio.2014.03.023.

Javoreková, S. *et al.*, (2015) 'Effect of bio-fertilizers application on microbial diversity and physiological profiling of microorganisms in arable soil', 4, pp. 54–61.

Kolton, M. *et al.*, (2011) 'Impact of Biochar Application to Soil on the Root-Associated Bacterial Community Structure of Fully Developed Greenhouse Pepper Plants □ ', 77(14), pp. 4924–4930. doi: 10.1128/AEM.00148-11.

Lazcano, C. *et al.*, (2013) 'Short-term effects of organic and inorganic fertilizers on soil microbial community structure and function', pp. 723–733. doi: 10.1007/s00374-012-0761-7.

Liu, S. *et al.*, (2016) 'Response of soil carbon dioxide fluxes, soil organic carbon and microbial biomass carbon to biochar amendment : a meta-analysis', pp. 392–406. doi: 10.1111/gcbb.12265.

Schmidt, J. E. *et al.*, (2019) 'Agricultural management and plant selection interactively affect rhizosphere microbial community structure and nitrogen cycling', pp. 1–18.

Sheng, Y. and Zhu, L. (2018) 'Science of the Total Environment Biochar alters microbial community and carbon sequestration potential across different soil pH', Science of the Total Environment, 622–623, pp. 1391–1399. doi: 10.1016/j.scitotenv.2017.11.337.

Tanzito, G. *et al.*, (2020) 'Use of charcoal (biochar) to enhance tropical soil fertility : A case of Masako in Democratic Republic of Congo', 11(March), pp. 17–29. doi: 10.5897/JSSEM2019.0798.

Taylor, P. *et al.*, (no date) 'Critical Reviews in Environmental Science and Technology Biochar : Carbon Sequestration, Land Remediation, and Impacts on Soil Microbiology Biochar : Carbon Sequestration, Land Remediation, and Impacts on Soil Microbiology', (June 2013), pp. 37–41. doi: 10.1080/10643389.2011.574115.

Treseder, K. K. (2008) 'REVIEW AND Nitrogen additions and microbial biomass : a meta-analysis of ecosystem studies', Ecology Letters, 11, pp. 1111–1120. doi: 10.1111/j.1461-0248.2008.01230.x.

Trupiano, D. *et al.*, (2017) 'The Effects of Biochar and Its Combination with Compost on Lettuce (Lactuca sativa L.) Growth, Soil Properties, and Soil Microbial Activity and Abundance', 2017(i).

Wang, F. *et al.*, (2019) 'E ff ects of successive metalaxyl application on soil microorganisms and the residue dynamics', Ecological Indicators, 103(December 2018), pp. 194–201. doi: 10.1016/j.ecolind.2019.04.018.

Yan, F., McBratney, A. B. and Copeland, L. (2000) 'Functional substrate biodiversity of cultivated and uncultivated A horizons of vertisols in NW New South Wales', Geoderma, 96(4), pp. 321–343. doi: 10.1016/S0016-7061(00)00018-5.

Zhang, F. *et al.*, (2018) 'Trichoderma Biofertilizer Links to Altered Soil Chemistry, Altered Microbial Communities, and Improved Grassland Biomass', 9(April), pp. 1–11. doi: 10.3389/fmicb.2018.00848.

Zhao, J. *et al.*, (2014) 'Responses of Bacterial Communities in Arable Soils in a Rice-Wheat Cropping System to Different Fertilizer Regimes and Sampling Times', 9(1). doi: 10.1371/journal.pone.0085301.

Zhen, Z. *et al.*, (2014) 'Effects of Manure Compost Application on Soil Microbial Community Diversity and Soil Microenvironments in a Temperate Cropland in China', 9(10). doi: 10.1371/journal.pone.0108555.

Zhong, W. H. and Cai, Z. C. (2007) 'Long-term effects of inorganic fertilizers on microbial biomass and community functional diversity in a paddy soil derived from quaternary red clay', 36, pp. 84–91. doi: 10.1016/j.apsoil.2006.12.001.

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