Nigerian Journal of Soil Science

journal homepage:www.soilsjournalnigeria.com

THE RELEVANCE OF BIOCHAR TECHNOLOGY TO SUSTAINABLE SOIL PRODUCTIVITY AND CROP PRODUCTION IN ORGANIC FARMING SYSTEMS

[1]Fagbenro, J. A. and [2]O. A. Onawumi

[1]Department of Crop Production, Soils and Environmental Management, Bowen University, P.M.B. 284, Iwo, Osun State, Nigeria.
[2] Federal College of Forestry, P.M.B. 5054, Ibadan, Oyo State, Nigeria.
[1]Corresponding author: pastfagbenro@yahoo.com

ABSTRACT

The desire for a sustainable and productive agriculture is universal but the means to progress towards it remains elusive. This is why organic farming, as a more sustainable form of agriculture than the conventional type, is being advocated by various organizations the world over. However, organic farming system, as it is currently practiced, is not necessarily, truly sustainable in terms of soil productivity and crop yield. This paper discussed the likely positive effect of the intervention of biochar technology on organic farming. The relevance of biochar technology to organic farming is considered in relation to the reported beneficial effects of biochar on soil and crop production.

Keywords: organic farming, biochar, sustainable, crop yield

INTRODUCTION

One emerging and very promising way by which some of the observed limitations to sustainable soil productivity and high crop yield in organic farming can be addressed is the intervention of biochar technology. Biochar is a term used to designate a carbon-rich product obtained when a biomass (such as wood, crop residues, etc.) is heated in a closed container with little or no available oxygen (Lehmann and Joseph, 2009a). It is a charcoal destined for addition to soil. When added to soil, biochar has been reported to increase available nutrients and prevent their leaching, stimulate activity of agriculturally important soil micro-organisms, act as effective carbon sink for several hundred years, convert applied inorganic fertilizer into organic form, sequester atmospheric CO_2 in soil, suppress emissions of other green house gases (GHGs), and mitigate off-sets from agrochemicals. (Thies and Rillig, 2009).

This paper discusses opportunities in involving biochar technology to make farm organic more productive. The relevance of biochar technology is considered in relation to the reported beneficial effects of biochar on soil productivity and crop production.

Biochar Technology Intervention in Enhancing Sustainable Productivity in Organic Farming

Biochar technology has been described as the most potent "engine" of atmospheric cleaning, the most single important initiative for

humanity's environmental future and an opportunity for sustainable development of agriculture (Lehmann and Joseph, 2009a). According to Rosillo-Calle *et al*. (2009), it is a technique that could prove particularly relevant in parts of sub-Saharan Africa where increased soil productivity could provide an important dimension of sustainable rural development.

Biochar technology has been, and is still being, proved to be very relevant in conventional agriculture (Lehman and Joseph, 2009a). It is even likely to be more relevant in organic farming since biochar farming is essentially an organic farming. Specifically, what follows are possible areas where biochar is relevant to organic farming.

Increasing scope of organic material supply

In biochar technology, any type of biomass is a potential feedstock for the production of biochar that can be used to increase soil fertility. This implies that "foreign" organic materials, either from the neighbouring bush, farm or elsewhere, can be brought to increase the volume of organic materials already present on the organic farm and then charred under slash-and-char system. This latitude may solve the limitation of insufficiency of organic inputs on the organic farm without any fear of pathogen transfer or contamination since every organic material being brought in has to be screened and charred before ·use.

Soil fertility increase

Biochar addition can positively affect soil fertility directly' or indirectly. Direct influence may be in any of these four ways:

i. Abiotic and biotic oxidation of added biochar can lead to increased availability of major cations, P and total N concentrations in soil (Glaser *et al.*, 2002; 2000b). The extent biochar does this will depend on its nutrient composition.

ii. Co-composting of biochar with organic waste can accelerate composting and produce a compost that is of higher quality in terms of stability and nutrient retention (Steiner *et al.,* 2004).

iii. Biochar addition to soil can decrease the Al saturation of acid soils which often is a major constraint for productive cropping in highly weathered soils of the humid tropics (Cochrane and Sanchez, 1980).

iv. Addition of biochar to soil is effective in reducing the leaching of all essential nutrients from the soil, at least in the short term (Lehmann *et al.,* 2003b). It particularly adsorbs applied mineral fertilizers on its surface as it ages thereby, converting it into organic form which should be acceptable in organic farming since the problem with mineral fertilizers is their soluble form and rapid release of nutrients into the soil (Fairweather and Campbell, 1996). Lehmann *et al*. (2003b), demonstrated the ability of biochar to retain applied mineral fertilizer against leaching with resulting increase in fertilizer-use efficiency.

Indirect influence of biochar is more important in enhancing soil productivity as an organic conditioner and driver of nutrient transformations and less so as a primary source of nutrients, considering its high stability in the soil. When biochar is applied to soil, it has the potential to transform N, P and S by enhancing their increase and availability. It reduces ammonification (Gundale and DeLuca, 2006), increases nitrification (Berglund *et al.,* 2004), increases N_2 fixation (Rondon *et al.,* 2007), increases extractable PO_4^{3-}(Gundale and DeLuca, 2006) and reduces SO_4^{2-} sorption in acid soils (Johnson, 1984).

Stability of soil organic matter

All forms of biomass, including composts, decompose rapidly in the soil (Jenkinson and Ayanaba, 1977) but biochar is very stable

because of its aromatic structure (McLaughlin *et al.*, 2009). Its management may therefore, overcome the limitation of rapid decomposition of uncharred organic materials commonly used in organic farming and provide an additional soil management option in the system.

Adsorption of heavy metals

The presence of biochar in soil has been reported to enhance the adsorption of potentially toxic compounds such as pesticides, heavy metals and toxic secondary metabolites (Thies and Rillig, 2009).

Improvement of crop yield

As presented in Tables 1a and 1b, positive response by plant to biochar addition to mineral soil can be very significant (Glaser *et al*., 2002b; Fagbenro *et al.,* 2011). However, the effect of biochar on plant productivity depends on a number of factors which include the properties and quantity of biochar added, soil properties, and plant species. Intervention of biochar technology may therefore, solve the limitation of low crop yield commonly associated with organic farming.

Table 1a: Main effect of saw dust biochar on 13-week *Moringa oleifera* seedlings grown in an Oxisol.

Biochar Level (t C ha^{-1})	Height (cm)	Stem Diameter (mm)	Dry Matter (DM) (g)	% increase in DM over control
0	27.8	8.8	100.3	-
3.75	31.3	10.5	192.7	92
10.0	35.2	11.3	202.7	102
20.0	36.5	12.5	320.0	220

Source: Fagbenro (2011).

Table 1b: Combined effects of saw dust biochar and N.P.K. 15:15:15 mineral fertilizer on 13-week *Moringa oleifera* seedlings grown in an Oxisol.

Biochar Level (t C ha^{-1})	Fertilizer level (kgNha^{-1})	Height (cm)	Stem Diameter (mm)	Dry Matter (DM)(g)	% increase in DM over control
0	0	27.8	8.8	100.3	-
3.75	22.5	29.3	10.2	221.8	121
3.75	45.0	36.0	10.7	236.4	136
3.75	90.0	41.3	12.8	249.1	149
10.0	22.5	39.7	11.7	251.8	151
10.0	45.0	45.0	12.3	262.7	162
10.0	90.0	44.7	13.7	263.6	163
20.0	22.5	44.7	14.0	275.5	175
20.0	45.0	44.5	14.0	292.7	192
20.0	90.0	46.7	14.8	378.2	278

Source: Fagbenro, (2011).

RECOMMENDATION AND CONCLUSION

The potential use of biochar for sustainable organic farming presents the following advantages:

a) Increased frontier of supply of organic materials for soil fertility improvement.

b) Increase in soil fertility directly as a source of plant nutrients and indirectly as an organic conditioner and driver of nutrient transformation.

c) Adsorption of applied mineral fertilizers, converting them into organic form and reduction of nutrient losses by leaching.

a. Stabilization of soil organic matter as biochar is very stable in the soil.

d) Improvement of crop yield as low crop yield is commonly associated with organic farming.

Biochar technology has proved and is proving its relevance in conventional agriculture. It is our belief that it can even do more in organic farming, being an organic farming itself!

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