Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 93 (2016) 14 – 18

Energy Procedia

Africa-EU Renewable Energy Research and Innovation Symposium, RERIS 2016, 8-10 March 2016, Tlemcen, Algeria

Effect of biochar type and rate of application on maize yield indices and water use efficiency on an Ultisol in Ghana

Edward Yeboah[a]*, Gideon Asamoah[a], Boafo Kofi[b] and Akwasi Adutwum Abunyewa[c]

[a]*Council for Scientific and Industrial Research-Soil Research Institute, Academy Post Office, Kwadaso, Kumasi, Ghana*
[b]*SNV Netherlands Development Organisation No. 10 Maseru Street, East Legon, P. O. Box 30284, Accra Ghana*
[c]*Kwame Nkrumah University of Science and Technology, College of Agriculture and Natural Resources, Kumasi, Ghana*

Abstract

In an integrated approach to cut-down on inorganic fertilizer use by smallholder farmers for agricultural production through the use of biochar, a split-split plot experimental design with three replications was carried to determine the effect of biochar from three different feedstock (corn cob, rice straw and cocoa pod husk) applied at two different rates of the feedstock (2.5 t ha^{-1} and 5 t/ha) with three application rates of Nitrogen, Phosphorus and Potassium (N-P-K) as inorganic fertilizer (90-60-60, 45-30-30 and 0-0-0) on maize growth and yield as well as soil chemical properties. The main plots of the experimental design were allocated to the biochar types while the Sub-plot was allocated to the biochar rates. The Sub-sub-plot went for the inorganic fertilizer rates. The maize seeds were sown at spacing of 80 cm between rows and 40 cm between plants. Three seeds were sown per each stand which was later thinned to two plants two weeks after planting. Urea, Triple superphosphate and Muriate of Potash were used as the sources of inorganic nitrogen, phosphorus and potassium (N-P-K) respectively. The P and K were applied once two weeks after planting while the N was split applied. One third of the application rate of nitrogen was applied two weeks after planting and the remaining two thirds applied six weeks after planting. Soil samples were collected from 0-20 cm depth before planting (one composite sample from the experimental site) and at harvest (from each treatment plot) to evaluate the effect of the different amendments on different soil chemical properties notable N, P, K, CEC, and pH. The quantity of biochar application had pronounced effects on maize grain yields where higher application rates (5 t/ha) showed superior performance to 2.5 t/ha.

Peer-review under responsibility of the organizing committee of RERIS 2016

Keywords: Biochar; maize grain yield; pyrolysis; ultisol; soil fertility.

* Corresponding author. Tel.: +233 3220 50354; fax: +233 3220 50308.
E-mail address: eyeboah5@hotmail.com

Peer-review under responsibility of the organizing committee of RERIS 2016
doi:10.1016/j.egypro.2016.07.143

1. Introduction

Biochar is charcoal obtained from biomass meant to be incorporated into the soil [1]. In the past years, biochar grew into one of the great promises to improve soil fertility and, in addition, to mitigate climate change through carbon sequestration [2,3]. Biochar has received particular interest for improving the inherently poor soils in the humid tropics, where large amounts of fallow vegetation from shifting cultivation – at present usually burned – could be used as feedstock for charring.

However, although considerable research on biochar in recent years has yielded promising results, these are inconsistent and the mechanisms leading to better soil fertility and higher yields are not yet well understood [4,5,6]. The main hypothesis of the current study is that biochar feedstock type has the potential to improve maize grain yields when applied solely or in combination with inorganic fertilizers. As biomass resources are limited, there are inevitable trade-offs between different uses of biomass for energy or as biochar applied to soil. Nevertheless, there are opportunities for pyrolysis technology to enable win-win-solutions for improved livelihoods and natural resource management

2. Methods

The experimental design was a split-split plot design with three replications. The whole plots were allocated to the biochar type (No biochar, corn cob, rice straw and cocoa husk biochar), the Sub- plot to the biochar rate (2.5 t/ha and 5 t/ha) while the sub-sub plot was for the fertility level (NPK: 0-0-0, 45-30-30 and 90-60-60). The area of a whole plot used was 9.4 m x 12.8 m with 2 m alley each between whole plots and replicates. Each sub-sub plot measured 4.2 m x 3.6 m with 1 m alley between them. The biochar was applied to the soil by broadcasting and manually incorporated to the soil with a hoe to a depth of approximately 15 cm. The chemical composition of the biochar feedstock is presented in Table 1.

2.1. Planting and fertilizer application

The hybrid maize variety 'mamaba' was used as the test crop. Three seeds were planted per stand which was later thinned to two after two weeks from planting using a planting distance of 80 cm x 40 cm. Urea, Triple superphosphate and Muriate of Potash were the sources of N, P and K. The P and K were applied once at two weeks after planting while the N was split applied; one third of the N was applied two weeks after planting and the remaining two thirds were applied six weeks after planting. Weeding of the field was done on the second, fifth and eighth week after planting.

2.2. Soil analyses

Soil pH was measured in soil to water ratio of 1:1 [7]. The Walkley Black procedure was used to determine soil organic carbon [8]. Total nitrogen (N) was determined using the Kjedahl digestion and distillation procedure.

The cation exchange capacity (CEC) at pH 7 was determined by the NH_4OAc method. Calcium (Ca) and Magnesium (Mg) were determined by atomic absorption spectrophotometry while potassium (K) and sodium (Na) were determined by flame photometry.

Table 1: Chemical composition of biochar feedstock

Feedstock type	pH H_2O (1:5)	% Org.C	% N	C/N ratio	Ca $Cmol_c Kg^{-1}$	Mg [$Cmol_c Kg^{-1}$]	K $Cmol_c$ [Kg^{-1}]	Na [$Cmol_c Kg^{-1}$]	Avail. P [ppm]	Avail K [ppm]
Cocoa husk	10.4	17.4	1.08	16.11	18.6	17.09	13.5	4.5	263.31	6431.66
Corn cob	10.3	13.6	0.82	16.59	2.67	7.34	6.75	1.35	300.57	2890.21
Rice straw	10.4	4.41	0.83	5.31	2.14	18.69	16.88	3.15	343.62	3477.58