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Influence of Integrated Application of Biochar and Inorganic Fertilizer for Better Maize Production in Halaba District

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Abstract
Soil degradation is considered as the most serious challenge affecting crop production in Ethiopia. Due to decreased agricultural soil fertility, the nation's agricultural growth and food security negatively impacted. Nationwide, integrated soil fertility management approach is now held as the most promising strategy for enhanced soil fertility and better crop production. Afield trial was executed since 2023 G.C main cropping (summer) season to evaluate the integrated application of organic (biochar) and inorganic (NPSB) fertilizer on growth and yield of maize at Halaba district on two farmers field (farmers as replication). About four treatments were arranged in random complete block design (RCBD) design. 3.75m*4.2m plot size where 0.75 cm, 1 meter and 1.5 meter were used for separation between plants, plots and blocks respectively. The treatments were, (1) No inputs, (2) 100% inorganic fertilizer (100Kg/ha NPSB +260 Kg/ha urea), (3) 100% biochar (10 t/ha) and (4) 50% Inorganic fertilizer + 50% biochar. The result of the study revealed that integrated application of biochar and inorganic fertilizer were significantly affect the growth and yield parameters of maize. Application of 50% inorganic fertilizer and 50% biochar gave superior result in all growth and yield parameters i.e. plant height (255.2 cm), cob length (28.3 cm), biomass (28.2 t/ha) and grain yield (7153.4 kg/ha). The result also indicated that sole application of biochar was not statistically different in all growth and yield parameters compared with the control treatments. The higher growth and yield result recorded from the integrated application of 50% biochar and 50% inorganic fertilizer indicated that the applied biochar could made the soil to hold water and nutrient efficiently. Therefor it can be concluded that integrated application of 50% biochar and 50% inorganic fertilizer is effective to produce higher maize yield in the area.

Keywords: Biochar, Integrated Application, Growth, Yield, Maize

Background and justification

Declining soil fertility has continued to be a major constraint to food production in many parts of Ethiopia. Soil degradation in cropping systems is mainly caused by lack of integrated use and management of nutrients, which leads to nutrient losses and decline in soil biological, chemical, and physical quality, thereby reducing the capacity to support production and environmental functions. Soils in Ethiopia are becoming resistant to fertilizer since they are degraded to the extent of not absorbing water with fertilizers thus resulting in low crop yield (Negasa KA, 2022) [6].

Soil acidification is the one form of soil degradation that can be caused by several factors, from the nature of the soil and climatic conditions (mainly rainfall) to anthropogenic factors such as poor soil and crop management practices. In Ethiopia, around 7 million hectares of agricultural land is affected by different levels of acidity (Temesgen 2023) [7]. Out of which over 3 million hectare of agricultural land is estimated to be affected by strong acidity (pH < 5.5) with a significant impact on crop productivity. Most importantly, the bulk of these strongly affected areas are found in the highlands of the country which receive the highest annual rainfall where wheat, barley, maize, and tef are widely grown (Temesgen 2023) [7].

On the other hand depletion of soil carbon across Ethiopia has been severe due to increased population, deforestation, agricultural intensification and high livestock pressure (Assefa *et al*, 2017), thus influencing against sustainable agricultural productivity. Thus, it is strongly and negatively impacting food security of communities and the national economy. Therefore, Sustainable soil management practices should be implemented instantly for enhanced soil carbon sequestration.

Remediation of soils by adding organic amendments, including manures, composts, and digestates, is now among accepted standard practices for improving degraded soils through the modification of soil hydraulic properties and influencing the geochemistry of nutrients and trace elements. The pyrolytic conversion of organic matter in limited oxygen into biochar is one-step further toward achieving an organic material of increased stability and suitability to achieve those same advantageous soil improvements (Blanco-Canqui, 2017; Burrell *et al*., 2016) [2, 3]. The potential of biochar as a soil amendment in agricultural fields is a recently recognized and yet it is underutilized technology. It stores carbon for long time, ameliorates degraded soils and reduces soil acidity for better crop production (Anteneh *et al*., 2014) [1]. Indeed, several studies have shown that biochar application to soil can improve soil physical and chemical properties, enhance plant nutrient availability and correlated growth and yield, increase microbial population and activities, reduce greenhouse gas emissions through C sequestration, reducing waste and enhance climate change mitigation.

In Ethiopia, there are huge amounts of organic waste materials which can be converting to biochar, compost and/or vermicompost which give us multipurpose benefits. In the country, about 192000 metric tons of coffee husks are generated per year as by-product. (Hibret D. *et al*, 2023) [5]. Therefore this study was aimed to determine the effects of integrated application of biochar and inorganic fertilizer on growth and yield of maize in Halaba district.

Materials and Methodologies

Description of the Study Area

The Halaba is located between 7˚10'N and 7˚42'N latitude and 38˚00'E and 38˚25'E longitude in the south-eastern part of Ethiopia. The total area of the district is 994.66 square kilometers, with 70% flat, 27% slope, and 3% mountainous. Altitude ranges in the area from 1554 to 2149 m.a.s.l (Ethiopia Central Statistical Agency, 2013). The area is located about 315 km south of Addis Ababa. The administrative center is Halaba-Kulito. The mean annual rainfall ranges between 544 and 1271 mm, which show large spatial variability with maximum rainfall being as large as 2.34 times the minimum rainfall. The rainfall pattern is erratic and irregular in the area. Due to the severe and heavy rains, soil erosion and flooding are very common in the low-lying areas of the study area. The mean monthly minimum and maximum temperatures are 12.8˚C and 26.8˚C. The district is considered a "*woina degas*", or temperate zone, having two major seasons, namely *Belg* (February, March, April, and May) and *Kiremt* (June, July, August, and September), and irrigation is practiced in some parts around the *Bilate* river. The livelihood strategy of the rural people of the area is predominantly mixed agriculture (crop production and animal husbandry).

Biochar Preparation and Application

Chat husk was used as feed stock material of the biochar. The husk was collected from Halaba town and farmers field. Biochar was prepared in traditional cone type 1 meter depth pit. Then the biochar was crushed to accelerate its incorporation in to the soil. The biochar was applied at planting with inorganic fertilizer.

Experimental Design and Treatments

The study was conducted in 2023 GC main cropping season (summer) on two farmers field. Random complete block design (RCBD) design was used with three replication in each farmer. Maize was planted on 3.75m*4.2m plot size where 0.75 cm, 1 meter and 1.5 meter were used for separation between plants, plots and blocks respectively.

Treatments

1. No inputs
2. 100% inorganic fertilizer (100Kg/ha NPSB +260 Kg/ha urea)
3. 100% biochar (10 t/ha)
4. 50% Inorganic fertilizer + 50% biochar

Result and Discussion

The statistical analysis result of the study showed that application of biochar and inorganic fertilizer influence the growth and yield parameters significantly (Table 1). Application of 50% inorganic fertilizer and 50% biochar showed higher result in all growth and yield parameters i.e. plant height (255.2 cm), cob length (28.3 cm), biomass (28.2 t/ha) and grain yield (7153.4 kg/ha). Application of l00% inorganic fertilizer gave higher above ground biomass and yield compared to sole application of biochar and control (no input) treatments. The result also indicated that sole application of biochar was not statistically different in all growth and yield parameters compared with the control treatments. Higher growth and yield parameters recorded from 50% inorganic fertilizer and 50% biochar might due to the soil conditioner property of biochar, which can improve the nutrient and water holding capacity of the soil. The biochar also decrease nutrient leaching and made the applied nutrient available to the crop. The result of the study was in line with the finding of Abdela Tufa and his friends who reported that integrated application of biochar at 8 $t \cdot ha^{-1}$ with NPS fertilizer at 50 $kg \cdot ha^{-1}$ improved the yield of maize by about 16.85% with net benefit of 61700.50 ETB ha^{-1} and marginal rate of return 733.68% (Abdela T. *et al*, 2022).

Table 1: Effects of application of biochar and inorganic fertilizer on growth and yield paremeters of maize

Treatments	Plant height (cm)	Cob length (cm)	Biomass (t/ha)	Yield (kg/ha)
1. No input	212.9b	19.67b	11.1c	3667.5c
2. Full inorganic	254.5a	26.9a	21.3b	6107.2b
3.10 t/ha biochar	223.1b	21.7b	14.6c	4674.8c
4. 50% inorganic + 50% biochar	255.2a	28.3a	28.2a	7153.4a
CV	4.49	6.3	17.03	9.66
LSD (0.05)	21.232	3.04	6.39	1042

Fig 1: Biochar preparation at Hawassa Agricultural Research Center

Conclusion and Recommendation

The result of the study indicated that integrated application of organic and inorganic fertilizer can produce better maize yield. Application of 50% biochar and 50% inorganic fertilizer showed better in all growth and yield parameters of maize in the study area. About 7153.4a Kg/ha grain yield was obtained from the application of 50% biochar and 50% inorganic fertilizer followed by 6107.2b Kg/ha from 100% inorganic fertilizer. While lower grain yield was obtained from the control plot (3667.5c) which is statistically similar with sole application of 100% biochar (4674.8c). From the result of the study it can be concluded that integrated application of 50% biochar and 50% inorganic fertilizer is enough to produce higher maize yield in the Halaba area.

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