BIOCHAR, COMPOST AND BIOCHAR CO-COMPOST IMPROVE GROWTH AND YIELD OF AMARANTH AND COWPEA IN HIGHLY WEATHERED TROPICAL SOILS

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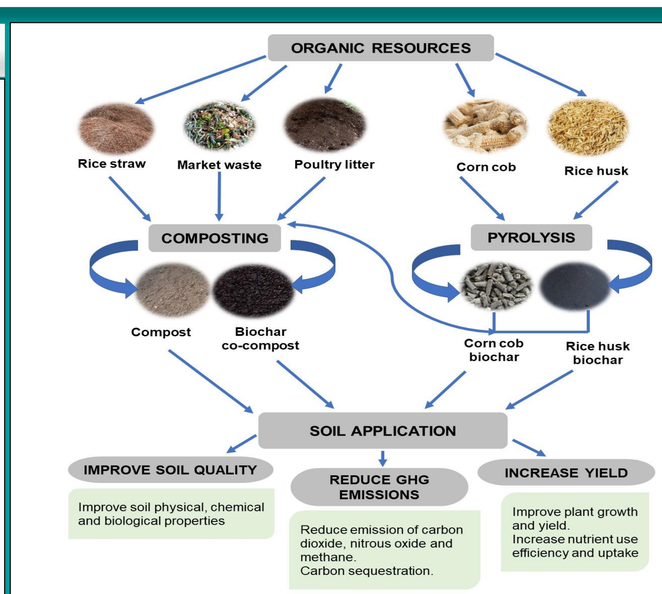
Introduction

Most soils in Sub-Sahara Africa (SSA) have low nutrient levels and a high propensity for nutrient loss due to their fragile nature (Stewart et al., 2020). The highly weathered soils commonly suffer from the leaching of easily soluble salts, resulting in multiple nutrient deficiencies and negative nutrient balances (Panpatte & Jhala, 2019). In Ghana, the highly weathered soils are continuously cropped, mostly without external nutrient inputs. Biochar co-compost is reported to be a cost-effective and environmentally friendly amendment for improving yield in low-nutrient soils. This study assessed the effects of biochar, compost, biochar-co-compost and inorganic NPK fertilizer applications on soil properties, nutrient uptake and yield of amaranth and cowpea in an amaranth-cowpea rotation.

Objectives

The study assessed;

- the effects of biochar, compost, biochar co-compost, and inorganic NPK fertilizer applications on soil chemical properties.
- the effects of biochar, compost, biochar co-compost, and inorganic NPK fertilizer applications on the growth, yield and nutrient uptake of amaranth and cowpea.



(a) mixing of soil and amendment, (b) experimental setup, (c) measurement of plant height, (d) measurement of chlorophyll index, (e) imaging of leaves for leaf area determination.

Materials and Methods

- Biochar co-compost was produced from corn cob and rice husk biochar together with easily accessible feedstocks like domestic bio-waste, poultry litter, and rice straw.
- **Treatments:** Inorganic NPK fertilizer (IF), rice husk biochar (RHB), corn cob biochar (CCB), compost without biochar (com) and biochar co-compost containing 5% or 10% of either rice husk biochar or corn cob biochar (CoRHB or CoCCB). Each treatment was applied to supply 100kg nitrogen ha^{-1}.
- **Soils:** Haplic Acrisol, Ferric Acrisol and Plinthic Acrisol collected from the coastal savanna zone (CSZ), Semi-Deciduous Forest zone (SDFZ) and the Guinea savanna zone (GSZ) of Ghana.
- **Growth and yield:** Growth parameters were determine according to methods described in Masarirambi et al. (2012). Fresh biomass were estimated at harvest. Dry biomass were determined after oven-drying at 60ºC for 48 hours.
- **Chemical analysis:** Plant and soil samples were microwave digested in nitric acid and total nutrient measured with ICP-OES.

Results

Fig 1:

- Biomass yields increased with increased biochar addition.
- Inorganic fertilizer, compost and biochar co-compost increased biomass yield of amaranth above 100%.

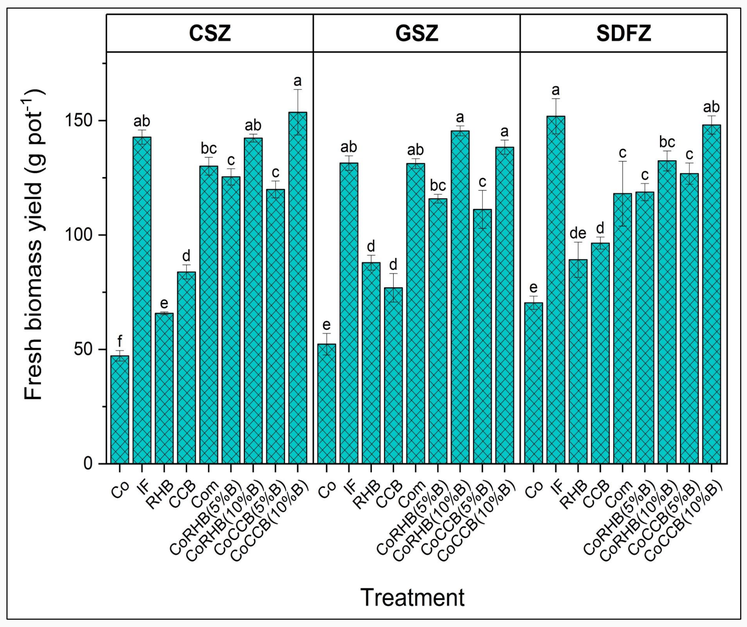


Fig 1: Fresh biomass yield of amaranth.

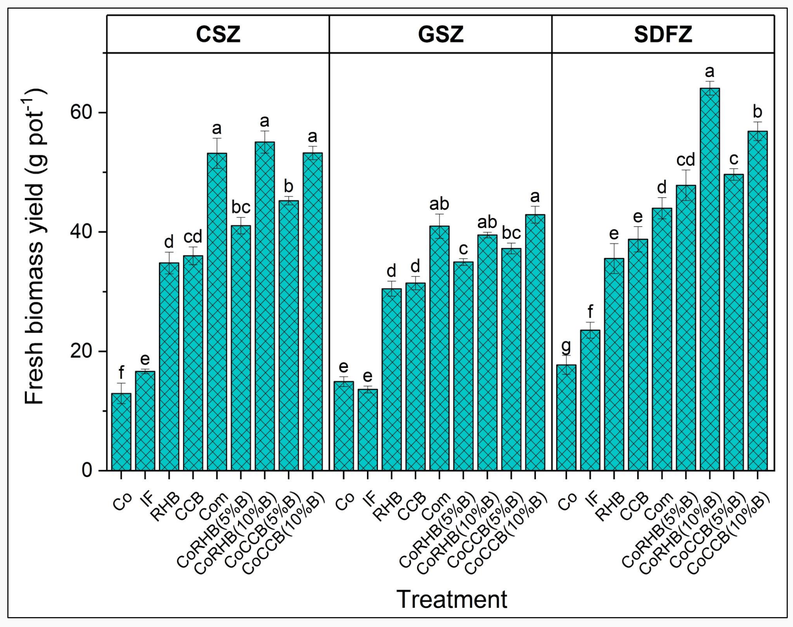


Fig 2: Fresh biomass yield of cowpea.

Fig 2:

- Cowpea biomass yields in the IF treatment were lower across all soil types, probably due to high nutrient uptake by the amaranth.
- Biochar co-compost can provide nutrients to support plant growth for at least 2 or more cropping cycles, mainly through slow mineralization and nutrient release.

Fig 3:

- CEC varied significantly between treatment and across soil types.
- Ca^{2+} forms about 56 – 65% of CEC in CSZ, 70 – 75% in GSZ, and 79 – 88% in SDFZ soils.
- Increased CEC could be attributed to the negative charges released from the carboxyl group on the compost and biochar's exchange sites.

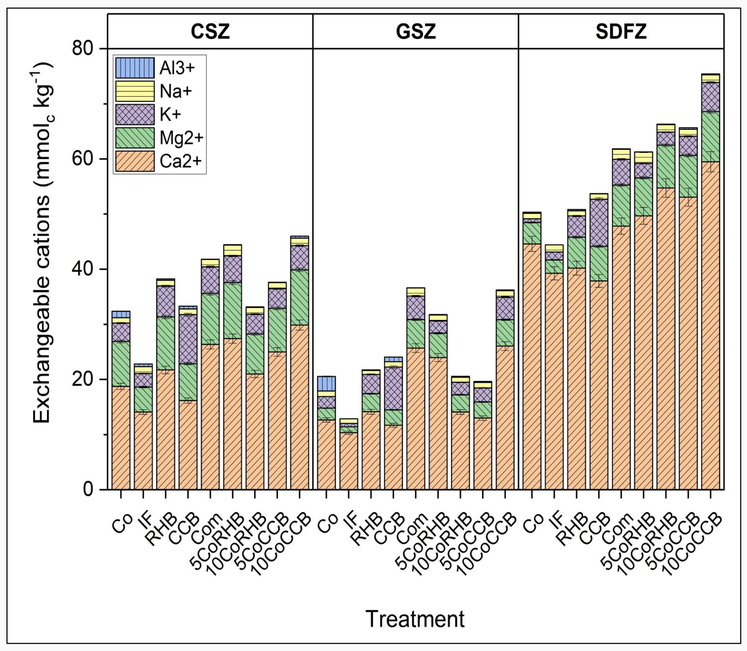


Fig 3: Soil exchangeable cations and CEC

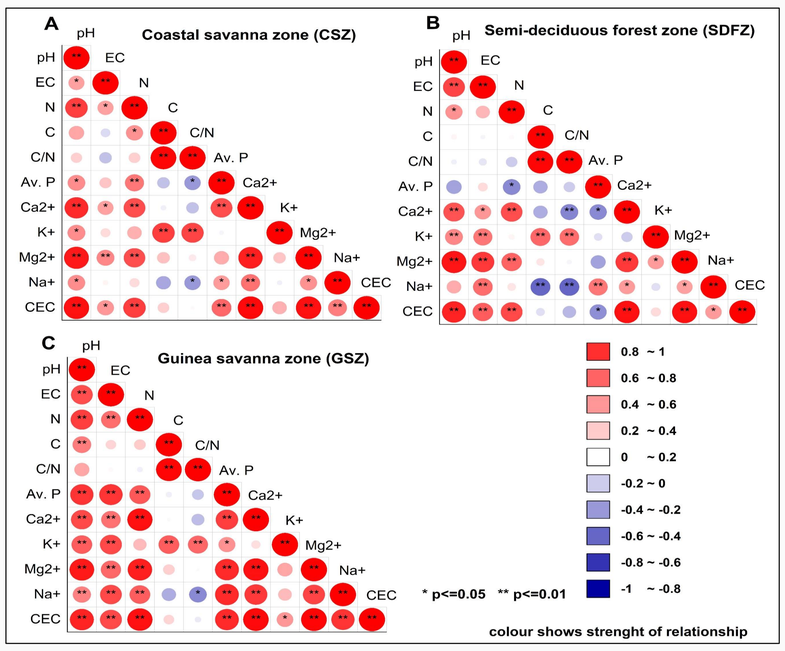


Fig 4: Pearson correlation between soil chemical properties

Fig 4:

- pH correlated positively with N, exchangeable cations, and CEC in all soil types.
- This observation suggests that the underlining problem in these soils is acidity.
- Improvement in acidity will result in increased availability of plant nutrients and improvement in soil fertility.

Conclusion

- Addition of biochar co-compost improves soil properties (pH, EC, N, C, available P, and CEC) and ensures nutrient availability for plant uptake by minimizing nutrient losses.
- Addition of biochar co-compost to soils can support the growth and yield of crops for two or more cropping cycles through slow mineralization and release of nutrient for plant uptake.
- Inorganic fertilizer application decreased or had no significant effect on soil properties compared to soils without amendment.
- Chemical fertilizer applications improves crop yields but also further deteriorates poor soils.

REFERENCE:

1. Masarirambi, M. T., Mbokazi, B. M., Wahome, P. K., & Oseni, T. O. (2012). Effects of Kraal Manure , Chicken Manure and Inorganic Fertilizer on Growth and Yield of Lettuce in a Semi-arid Environment, *4*(1), 58–64.
2. Panpatte, D. G., & Jhala, Y. K. (2019). *Soil Fertility Management for Sustainable Development*.
3. Stewart, Z. P., Pierzynski, G. M., Middendorf, B. J., & Vara Prasad, P. V. (2020). Approaches to improve soil fertility in sub-Saharan Africa. *Journal of Experimental Botany*, *71*(2), 632–641.

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