



Agronomic Assessment of Biochar-Enriched Compost in the Southern Sudanian Zone of Burkina Faso for Yam Production

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Authors' contributions

This work was carried out in collaboration among all authors. Authors ACC, DIK, OYAT and HBN conceptualized the study. Authors SEO and ACC collected the data. Author ACC performed the statistical analyses and prepared the manuscript. Authors OYAT and DIK reviewed and corrected the manuscript. Authors OYAT, DIK and HBN supervised the study. All authors read and approved the final manuscript.

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ABSTRACT

Biochar production requires large quantities of pyrolysable materials, posing challenges for producers to mobilize. The addition of reduced quantities of biochar during composting of organic residues could be an alternative for better promoting the use of biochar in agriculture. This study was carried out in the southern Sudanian zone of Burkina Faso with the aim of improving the agronomic value of composts via addition of biochar during composting for sustainable soil management. The first phase of the experiment involved a composting trial with three replicates and two treatments (sole compost and biochar-enriched compost). The composts which were produced were then evaluated for yam production in a completely randomized block design with four replicates. The parameters studied involved the changes in temperature and dry matter content during composting, as well as the chemical characteristics of the composts, yam tuber yield and soil organic C content. The composts were statistically similar in terms of temperature evolution, dry matter content, total N, P, K content and C:N ratio. The sole compost had a pH-H₂O of 8.6 which was statistically higher than that of biochar-enriched compost (8.3). The available organic C, labile C, N and P contents of the biochar-enriched compost were 27%, 27%, 28% and 21% higher respectively than those of sole compost. The two composts were similar in terms of their effect on yam tuber yield but statistically higher than the control treatment. They did not significantly improve soil organic C compared to the control treatment. Co-composting with biochar could improve the agronomic performance of composts.

Keywords: Compost; temperature; chemical characteristics, yam; organic carbon.

1. INTRODUCTION

Sub-Saharan African soils, known for their original low organic matter content (Kabore, et al., 2020; Ouattara, et al., 2008), are also subject to low organic restitutions due to difficulties in mobilizing organic resources (Valbuena, et al., 2012). Furthermore, natural and anthropized environments in this part of the world are increasingly faced with the proliferation of exotic invasive species such as *Chromolaena odorata* (L.) King and Robinson (Asteraceae) and *Hyptis suaveolens* (L.) Poit. (Lamiaceae) (Bambara, et al., 2024; Uyi, et al., 2021). In Burkina Faso, an average of eight new *H. suaveolens* infestation points were observed per year, with a density of 527 feet m². The species' expansion is most marked in fallow and deforested savannahs, and the ratio of forage grass production loss to it is 14.7 times (3675g/257g) (Thiombiano, et al., 2009). The 6,950 tonnes of dry matter produced per hectare by *H. suaveolens* (Thiombiano, et al., 2009) can be used for compost production to improve soil organic matter levels. However, the relative richness of its stems in lignin and cellulose (Singh, et al., 2014) may lengthen composting time.

Integrating biochar into the *H. suaveolens* composting process, to produce biochar-enriched compost, could be an interesting alternative for optimizing the composting process and improving the quality of the compost

produced. Biochar is a stable carbon-rich amendment obtained by pyrolysis of various biomasses (Kimetu & Lehmann, 2010), which remains longer into soil (Wang, et al., 2016). However, this technology has several drawbacks, notably its low production yield (17% to 33%) (Lompo, et al., 2021; Mullen, et al., 2010) and nutrient poverty (Kanouo, 2019; Lompo, et al., 2020). Teodoro, et al. (2020) initiated biochar composting, which they claimed would speed up the decomposition process and result in a composite material with reduced odor, greater maturity, pH closer to neutrality and higher water retention capacity than conventional compost. In addition, composting with biochar would enable the biochar to be loaded with readily bioavailable nitrogen (N) sources, thereby increasing its potential fertilizer value, improving crop growth and yields compared with conventional compost (Antonangelo, et al., 2021; Chen, et al., 2019; Qayyum, et al., 2017). Composting *H. suaveolens* biomass with biochar addition is therefore an avenue worth exploring to make the most of the large biomass of this invasive species, while rationalizing biochar use rates and improving the agronomic value of composts. By improving the carbon (C) stability of composts (Fischer, et al., 2018), this technology could also produce a good organic amendment that may allow reducing the loss of soil organic matter under cropping systems yams (*Dioscorea* Spp.) cropping, known to lead to high mineralization of soil organic C (Hgaza, 2012).

The present study was initiated with the aim of contributing to an improvement in agronomic value of composts for sustainable soil management in Burkina Faso. We hypothesized that (i) the addition of biochar during composting leads to a reduced composting time (ii) improved chemical characteristics of composts and (iii) increased yam tuber yield and improved soil organic carbon content.

2. MATERIALS AND METHODS

2.1 Study Sites

The compost production experiment was set up at the animal production unit of the “Ecole Nationale de Formation Agricole de Matourkou (ENAFa de Matourkou)” (11°05' N, 4°20'W and 424 m altitude). The assessment of the produced composts for yam production was carried out in the Farako-Bâ station of “Institut de l'environnement et de recherches agricoles (INERA)” (11°06' N, 4°20'W and 405 m altitude). The villages of Matourkou and Farako-Bâ are located in the southern Sudanian part of Burkina Faso. The climate is characterized by dry and rainy seasons, from November to May and June to October respectively. Average rainfall is 1025 mm in the region, with average monthly temperatures ranging from 25°C to 31°C, (Tirogo, et al., 2016).

The soil of the field experiment is ferric Lixisol (Schad, 2016) with a sandy-clayey textural class, an acidic pH (4.97) and respective organic C and total N of 4.07 g kg⁻¹ and 0.55 g kg⁻¹. Before the experiment, the soil was under fallow land for more than seven years (Table 1).

2.2 Composting

2.2.1 Composted substrates

The biochar used for the composting was a corn cob biochar, produced from December 2022 to January 2023 at ENAFa Matourkou, using a Top-lit updraft pyrolyzer (TLUD) (Tarpilga, 2022). Pyrolysis temperature and production yield were 545.8°C and 34% respectively. This biochar was then coarsely fragmented (0.5-5 cm) before being fed into the composting process.

H. suaveolens was the main plant material to be composted, as it is widespread at the Matourkou site. It was coarsely ground (about 5 cm long) before composting. When the compost piles were placed, the water content of the crushed

material was 6.4%. Cattle manure was also collected at the ENAFa Matourkou cattle yard and used as fermenting agent. Its moisture content was 5%.

The chemical characteristics of the substrates are presented in Table 2.

Table 1. Initial physical and chemical characteristics of the soil

Characteristics	Values
pH (H ₂ O)	4.97
Organic C (g kg ⁻¹)	4.07
Total nitrogen (g kg ⁻¹)	0.55
Total phosphorus (g kg ⁻¹)	0.11
Total potassium (g kg ⁻¹)	1.42
Sand (%)	68.63
Clay (%)	12.01
Loam (%)	19.36

2.2.2 Composting trial

The composting trial was set up on January 19th, 2023, at ENAFa Matourkou. It was made up of two treatments namely sole compost and biochar-enriched compost. Each treatment had three replicates. The piles composting technique was used. The size of the piles was 1.5 m x 1.5 m x 1 m, giving a volume of 2.25 m³ per heap. Each pile was spaced 0.5 m from its turning area. The blocks were separated by 1.5 m, and within the block, the treatments were also separated by 1.5 m of distance.

The different piles were built in three layers. Each layer was made by a succession of *H. suaveolens* crushed material and cattle manure for the sole compost, and a succession of *H. suaveolens* crushed material, cattle manure and biochar for the biochar-enriched compost.

The mass ratio of *H. suaveolens* manure to crushed material was 1:3 for both compost and biochar-enriched compost, but the latter included an additional 20% biochar according to Fischer, et al. (2018).

Once the compost piles had been set up, they were turned at regular two-week intervals to regulate moisture levels and aerate the piles, thereby promoting microbial activity. Nine turnings of the composts were made between January 29 and May 21, 2023. Water was required for the first four turnings. For the remaining five turnings, no water was added. In

Table 2. Chemical characteristics of substrates before composting

Substrates	Moisture %	pH H ₂ O	C org g kg ⁻¹	total N g kg ⁻¹	total P g kg ⁻¹	total K g kg ⁻¹
<i>Hyptis suaveolens</i>	6.4	7.31	468.3	9.6	1.73	13.25
Corn cob biochar	-	9.52	473.9	9.0	1.31	14.43
Corn cob	-	6.05	481.7	9.1	1.14	6.42

C org = organique carbon

total 1530 liters and 1540 liters of water were used for the sole compost and the biochar-enriched compost respectively.

2.2.2.1 Sampling of composts, temperature and dry matter measurement and chemical analysis

Compost samples were taken at each turning period. Approximately 100 g of compost were taken at random from the 3 layers of each pile, to obtain a composite sample per pile. These samples were packaged, labelled and transferred to the laboratory for analysis.

The temperature of the compost heaps was measured every three days using a needle thermometer. The principle of measurement was to hold the thermometer needle down in the center of the pile for 5 minutes, then read the value indicated on the thermometer dial.

The dry matter content of the composts was determined on 100 g samples after oven-drying at 105°C for 24 hours.

The pH-H₂O of the composts was determined using the potentiometric method (AFNOR, 1999). The organic matter (OM) content was determined using the Loss on Ignition method. This is a weight determination based on calcination at 550°C of total organic matter in dry condition. After calcination, the organic matter content was calculated.

For the determination of total N, total P and total K, one gram of each sample was mineralized with the mixed solution of sulfuric acid and selenium in the presence of peroxide as catalyst. The Kjeldahl method (Hillebrand, et al., 1953) was used for the determination of total N. Total P was determined using the method of Anderson & Ingram (1993). Total K was determined using a flame photometer after wet digestion.

The C and N extracted from the composts with a K₂SO₄ solution were considered as the fractions of labile C and available N. One gram of compost

was used to extract N and C in 40 ml of 0.5M potassium sulfate (K₂SO₄). Four ml of the extract was taken, then 1 ml of potassium dichromate (K₂Cr₂O₇) and 5 ml of concentrated sulfuric acid were added as extractant. The whole solution was heated to 150°C for 1 hour in a digestion block. Finally, the digestate was titrated with a MOHR salt solution (FeSO₄(NH₄)₆) (Nelson & Sommers, 1982). The Kjeldahl method (Brookes, 1995) was used to extract N dissolved in the K₂SO₄+ compost solution.

Resin P, considered as an indicator of the P available to the plant, was determined by introducing 1 g of compost into 50 ml tubes. Then 30 ml of H₂O was added, following by an addition of a strip of anion exchange resin (6x2 cm) previously saturated with CO₃²⁻. The tubes were then shaken using an horizontal shaker at 150 rpm for 16h. At the end of shaking, the resin strips were removed from the tubes, rinsed with distilled water and transferred to new 50 ml tubes containing 30 ml 0.1 M NaCl+HCl. These tubes were then shaken for 30 min to elute inorganic P from the resin membranes. The amount of P available was obtained by measuring the concentration of P in the NaCl+HCl eluate using spectrophotometer colorimetry at 880 nm (Kouno, et al., 1995).

2.3 Field Trial

2.3.1 Experimental design and field management

The field trial was a completely randomized block design with 4 replicates installed on a land of about 7 years of fallow. The land was cleared in advance, then ploughed and sprayed with a tractor between April and May 2023. Three treatments were considered in this study namely the unfertilized control, sole compost (8 t ha⁻¹) and biochar-enriched compost (8 t ha⁻¹). The dose of organic amendment was chosen in accordance with the recommendations of (Hgaza, et al., 2021). The yam was planted on mounds at a density of 10,000 plants ha⁻¹, i.e. one mound per m². Each plot was planted with

20 plants, six of which were selected centrally for yield evaluation. The yam mounds were made using traditional hoe, after application of organic amendments in accordance with the treatments.

The yam specie used was *Dioscorea rotundata* Poir. (variety R3). Its cropping cycle extends over 7 to 8 months, with a potential yield of 35 t. ha⁻¹ (Diby, et al., 2011). The choice of yam is based on its requirement in terms of soil fertility (Diby, et al., 2009) and particularly in terms of organic C, with levels of up to 12 g C kg⁻¹ (Carsky, et al., 2010). Planting took place on May 27, 2023. The plants were staked, and weeding was made regulary. Harvesting was carried out at 24 weeks after planting (WAP).

2.3.2 Soil sampling and carbon analysis

The soil was sampling at five points in each plot after the yam harvest along the diagonals using an auger. The method of Walkley & Black (1934) was used to analyse the organic carbon content of samples.

2.3.3 Calculation of fresh yam tuber yield

Fresh yam tuber yield was calculated as follows (Pouya, et al., 2022):

$$\text{Yield (t ha}^{-1}\text{)} = \frac{\text{TTW (kg)} \times \text{PD (mounds ha}^{-1}\text{)}}{N} \times \text{sprout emergence} \times 1/1000$$

With Yield= yam fresh tuber yield; TTW= total weight of harvested tubers at plot level; PD= density of planting (10 000 mounds ha⁻¹); N= number of mounds in a plot (six); t sprout

emergence= the final sprout emergence rate of yam tuber setts.

2.4 Statistical Analyses

R software (v. 4.4.0) and its R Studio environment (v. 1.4.1717) were used for statistical analysis. Depending on the normal or non-normal distribution of the data (Shapiro Wilk test), the Student or Wilcoxon tests were respectively used to compare the treatments during the composting experiment. Anova was used to compare treatments in the yam trial. Figures were generated using the ggplot2 package (v. 3.5.1).

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Temperature changes during composting

The temperature trend observed was similar for both treatments, with however, relatively lower temperature for the biochar-enriched compost treatment. As early as at day 3 of composting, temperatures were 62°C and 51°C for sole compost and biochar-enriched compost respectively. They peaked at 73°C and 69°C on the 27th day of composting before dropping to 46°C and 47°C for these two treatments respectively at 132 days of composting. The treatments were similar at all measurement dates except at 3 day of composting ($P < .000$), when the temperature was significantly higher in the sole compost than the biochar-enriched compost (Fig. 1).

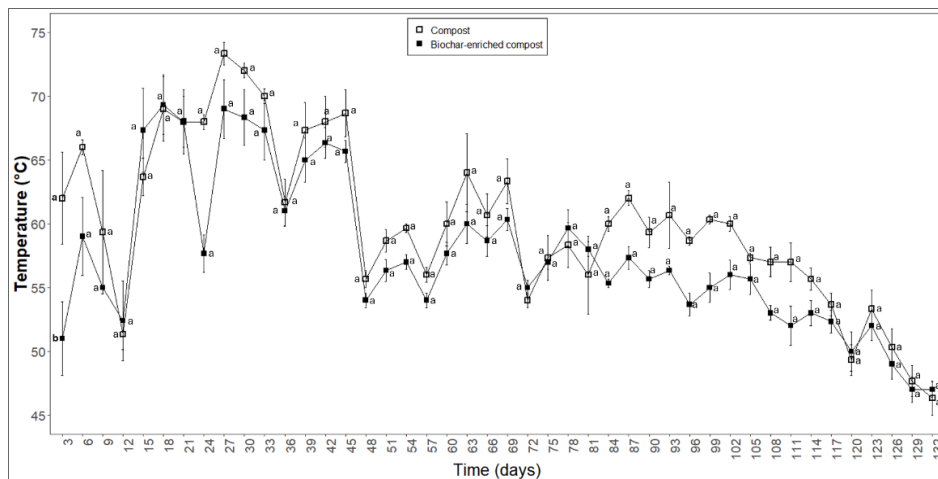


Fig. 1. Temperature changes during composting as a function of treatments Treatments marked with different letters are statistically different at 5% level. Error bars represent standard errors ($n=3$)

3.1.2 Changes in dry matter content during composting

The trend of the dry matter content was similar for all composting treatments. However, there was a relatively lower dry matter rates in the sole compost treatment compared to the biochar-enriched compost. These rates were 43% and 46% for sole compost and biochar-enriched compost respectively and fall to a minimum of 25% and 29% at 52 and 66 days of composting respectively for sole compost and biochar-enriched compost, before rising again to 37% and 41% respectively at 122 days of composting. In addition, the dry matter content of the biochar-enriched compost was significantly higher than that of the sole compost at 52 day of composting ($P < .000$) (Fig. 2).

3.1.3 pH-H₂O, C:N ratio and total element contents after 132 days of composting

Treatments were statistically similar ($P > .5$) in terms of total N, C:N ratio, total P, and total K. Mean values for these variables were 9.66 g kg⁻¹,

24.0, 3.4 g kg⁻¹ and 12.6 mg kg⁻¹ for sole compost and 9.9 g kg⁻¹, 29.8, 3.4 g kg⁻¹ and 12.8 mg kg⁻¹ for biochar-enriched compost respectively. On the other hand, significant differences were observed between treatments, regarding pH-H₂O and organic C. The pH-H₂O of the sole compost (8.6) was significantly higher ($p = 0.031$) than that of the biochar-enriched compost (8.3). Conversely, the organic C of the biochar compost (293 g kg⁻¹) was significantly higher ($P = .003$) than that of the compost (230 g kg⁻¹) (Table 3).

3.1.4 Labile carbon, available nitrogen and phosphorus contents after 132 days of composting

Labile C and available N and P contents are shown in Fig. 3. Mean values of 2767 mg kg⁻¹, 281 mg kg⁻¹ and 437 mg kg⁻¹ of labile C and available N and P were reported on biochar-enriched compost, and 2183 mg kg⁻¹, 219 mg kg⁻¹ and 362 mg kg⁻¹ respectively for sole compost. The biochar-enriched compost showed significantly higher C and nutrient contents than the sole compost.

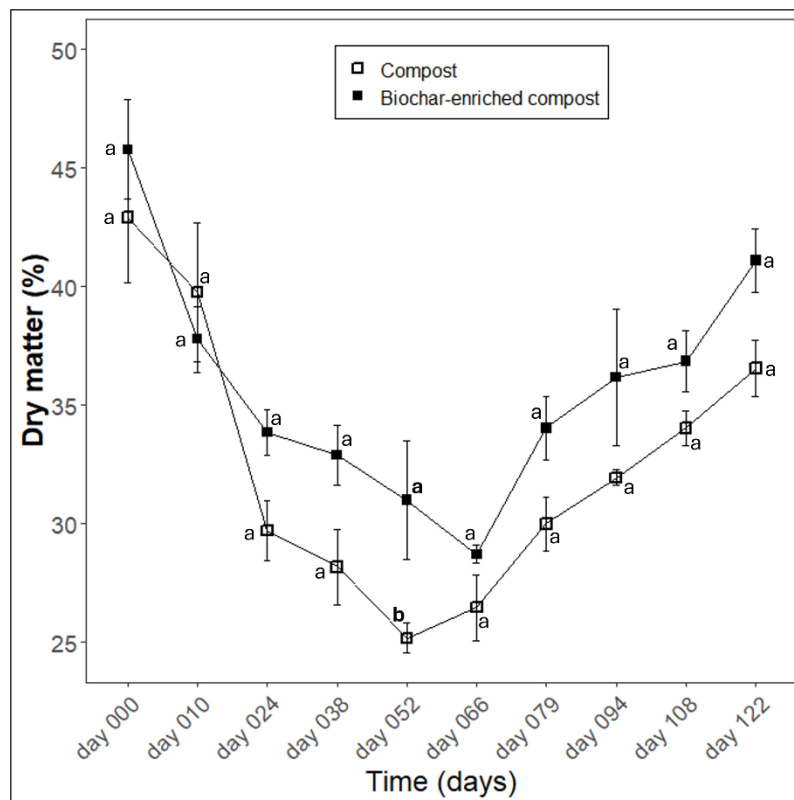


Fig. 2. Changes in dry matter content during composting as a function of treatments
Treatments marked with different letters are statistically different at 5% level. Error bars represent standard errors (n=3)

Table 3. pH-H₂O and total element contents after 132 days of composting

Treatments	pH-H ₂ O	C org g kg ⁻¹	total N g kg ⁻¹	C:N	total P g kg ⁻¹	total K g kg ⁻¹
Compost	8.6±0.0 ^a	230.8±5 ^b	9.66±0.4 ^a	24.0±0.9 ^a	3.4±0.0 ^a	12.6±0.1 ^a
Biochar-enriched compost	8.3±0.0 ^b	292.9±1 ^a	9.90±0.6 ^a	29.8±1.9 ^a	3.4±0.0 ^a	12.8±0.5 ^a
Test	Student	Student	Student	Student	Student	Student
P-value	.03 [*]	.003 [*]	0.8	0.07	0.1	0.7

Treatments marked with different letters are statistically different at 5% level. Mean±standard errors (n=3); C org = Organic carbon

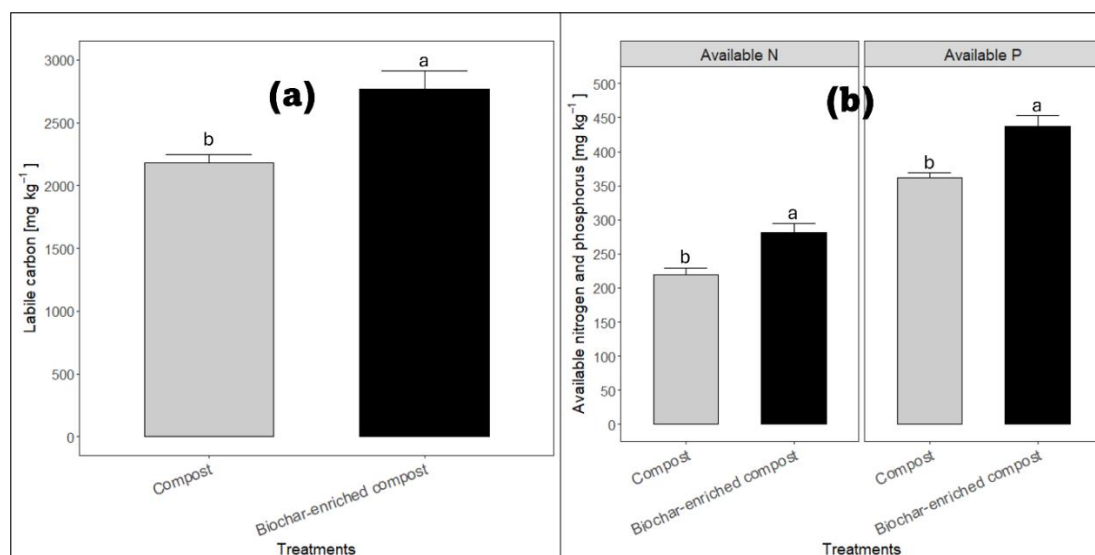


Fig. 3. Labile carbon content (a) and Available nitrogen and phosphorus (b) contents after 132 days of composting

Treatments marked with different letters are statistically different at 5% level. Error bars represent standard errors (n=3)

3.1.5 Effect on yam tuber yields

The biochar-enriched compost led to the highest yam fresh tuber yield (14.30 t ha⁻¹), while the lowest yield (9.32 t ha⁻¹) was obtained with the control. Biochar-enriched compost and sole compost treatments (13.21 t ha⁻¹) were statistically similar and higher than the control ($P = .004$) (Fig. 4).

3.1.6 Effect on soil organic carbon content

Soil organic C contents were 3.74 g kg⁻¹, 4.52 g kg⁻¹ and 4.53 g kg⁻¹ for control, biochar compost and compost treatments respectively. No significant differences ($P = .18$) were observed between the treatments (Fig. 5).

3.2 Discussion

The temperature remained above 50°C from the 2nd to the 122nd day of composting, i.e. for four

months, reflecting intense microbiological activity and therefore the presence of substrates to be decomposed. The composting time was relatively long, probably due to the more lignified nature of the composted substrate and the overall very high C:N ratio in the starting materials. Indeed, according to Hoorman & Islam, (2010), a C:N ratio of less than 20 enables organic substrates to decompose in 4 to 8 weeks, whereas a higher C:N ratio requires additional N and slows down decomposition. Similarly, Manka'abusi, et al. (2025) had observed lower temperature peaks during co-composting of rice husk biochars and corn cobs compared to co-composting of the same non-pyrolyzed substrates. Contrary to the results obtained by Wei, et al. (2014), in our study, biochar incorporated at the start of composting did not increase the temperature throughout the process, compared with sole compost treatment. This result could be explained by the lower amount of manure (21%) added to the biochar-enriched compost

treatment, compared with 26% for the sole compost. Indeed, one of the roles of manure in the composting process is to provide a supply of

microorganisms; these microorganisms being the actors whose activity induces an increase in temperature during composting.

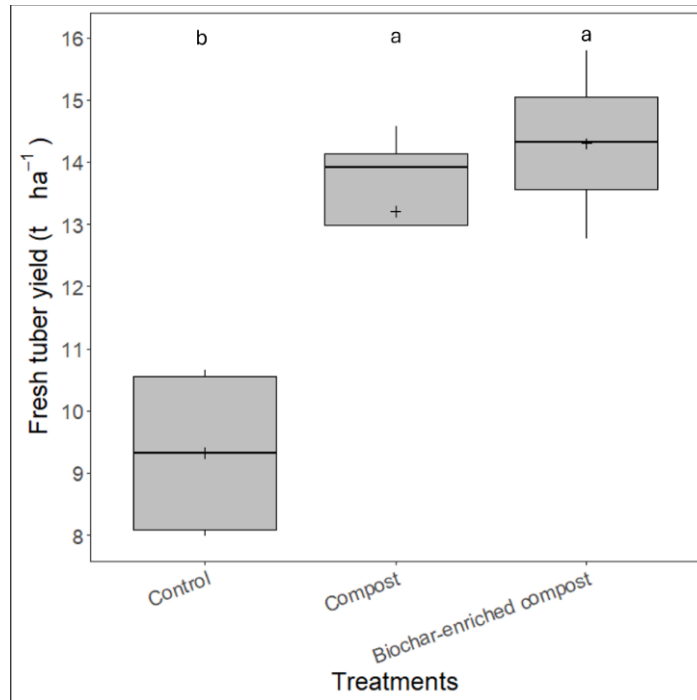


Fig. 4. Effect of organic amendments on fresh yam tuber yields
Treatments marked with different letters are statistically different at 5% level ($n=4$)

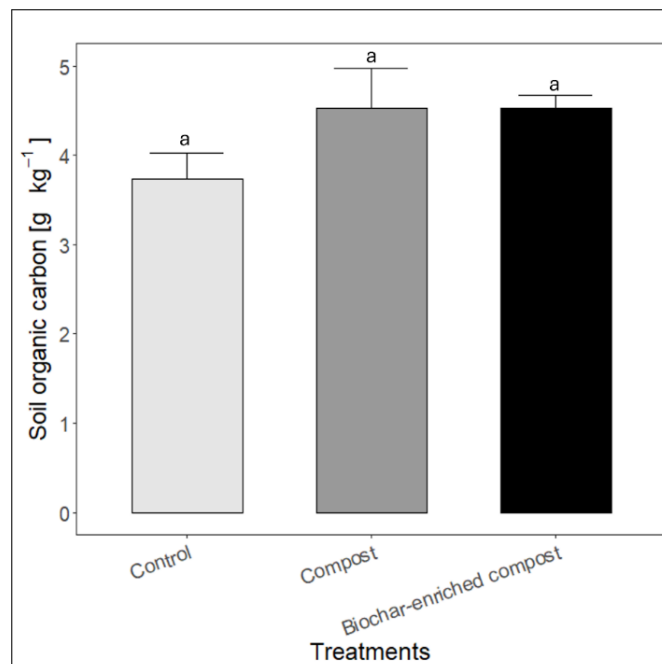


Fig. 5. Effect of organic amendments on soil organic carbon content
Treatments marked with different letters are statistically different at 5% level. Error bars represent standard errors ($n=4$)

Dry matter content is a parameter that undergoes strong variations during composting (Wojcieszak, et al., 2021). The drop in dry matter content observed from set-up to the 52nd day of composting could be the result of the addition of water during this period. Similarly, the increase in dry matter content from day 52 to the end of composting may be explained by the interruption of watering during turning. Furthermore, the optimum moisture content of compost is between 50 and 70% (Kuo, et al., 2004). Therefore, the optimum dry matter content should be between 30 and 50%. Dry matter contents between 43% and 29%, 46% and 25% respectively for sole compost and biochar-enriched compost in our study were optimal except at 52 days of composting, when they were below 30% (Fig. 2). This was the reason for stopping watering from this stage. The no effect of composting treatments on the dry matter rate could be explained by the similar quantities of water added during the turnings.

The significant increase in pH-H₂O in compost treatment compared to biochar compost remains unexpected, even though the pH- H₂O values recorded with both treatments are above 7, in line with FAO standards (FAO, 2005). Indeed, several studies highlighted that the ability of biochar to increase soil pH due to the ash it contains, which would enrich the biochar with alkaline compounds such as KHCO₃ and CaCO₃ (Domingues, et al., 2017). The high pH-H₂O of sole compost could be explained by the greater amount of manure that was added during production (26%) compared with 21% for compost with biochar-enriched compost and the relatively low proportion of biochar added in the production of compost with biochar-enriched compost (20%). Cattle manure and biochar had respective pH-H₂O values of 10.3 and 9.5 (Table 2). Thus, overall, the pH-H₂O of the substrates used for sole compost production was more basic than that of the substrates used for biochar-enriched compost production. Teodoro, et al. (2020) nevertheless obtained a material with a pH closer to neutrality after co-composting, as attested the results obtained in our study.

The organic C contents of the composts produced during our study were four times higher than the composts produced at Farako-Bâ from solid urban waste, straw, farmyard manure and Kodjari phosphates (Compaoré & Nanéma, 2010). Furthermore, the significant improvement in organic C in biochar-enriched compost in our

study could be a direct result of the pronounced stability of biochar-C (Fischer, et al., 2018; Lehmann, et al., 2006) compared to *H. suaveolens* shred. In addition, the amount of organic C brought to the biochar-enriched compost treatment was over than that which was brought to the compost treatment (Table 2). During composting, decomposition is generally dominant in the thermophilic phase, while C stabilization becomes dominant in the maturation phase (De Bertoldi, et al., 1983). The improvement in labile C content induced by the biochar-enriched compost treatment is thought to be the result of the increase in N and P content available in this treatment, which would have led to mineralization of the less recalcitrant fraction of C in this treatment during the thermophilic phase (Gross, et al., 2022) and its retention in the pores of the biochar. Manka'abusi, et al. (2020) also observed a reduction in C losses during composting in biochar-based treatments compared with homologous treatments without biochar.

Total N content in both treatments was over 5 g kg⁻¹, indicating good quality amendments (FAO, 2005). These treatments were 1.3 times less N-rich than the compost used in the study by Koulibaly, et al. (2009) and twice as N-rich as the composts produced at Farako-Bâ from municipal solid waste, straw, farmyard manure and Kodjari phosphates (Compaoré & Nanéma, 2010). Furthermore, the lack of difference between treatments suggests that the addition of biochar to the composting process did not improve the total N level of this treatment. The proportions of 26% and 21% of cattle manure added to compost and biochar-enriched compost treatments, represent 72 kg and 57 kg respectively, a difference of 15 kg. However, cattle manure was four times richer in N than biochar and *H. suaveolens* biomass (Table 2). Despite this lower N input in the biochar treatment, it was able to store as much total N during composting as the compost treatment. Increasing the manure content in the biochar co-composting process could therefore improve the total N content of the final product, in line with the significant 48% increase in N obtained by (Cissé, et al., 2021).

Analysis of available N content revealed that biochar-enriched compost was significantly richer than sole compost. This improvement in available N could be explained by the fact that biochar has negatively charged functional groups on its surface, leading to adsorption of positively

charged NH_4^+ (Gao, et al., 2023; Singh, et al., 2010) on the biochar surface. Biochar-enriched compost could thus reduce NH_4^+ leaching and create a favourable microenvironment for nitrifying bacteria as demonstrated by Zhang & Sun (2014).

The C:N ratios of both treatments were above 20, which may reflect insufficient maturation of the composts (FAO, 2005). The absence of significant difference between the treatments in terms of C:N ratio could stem from the absence of a significant difference between these treatments in terms of total N. However, this result could confirm the low enrichment of biochar-enriched compost which, despite its significantly higher organic C content and lower N supply through the starting manure, may have led to C:N values similar to those of compost. An increase in the proportion of manure added during composting to 75% straw and 25% manure, as suggested by Segda, et al. (2001), could improve the C:N ratio of compost to biochar.

The composts produced in our study were half as rich in P as the maize straw and cattle manure compost produced in Burkina Faso as part of the study by Lompo, et al. (2009). Furthermore, the lack of effect of biochar-enriched compost treatment on total P observed in our study could be explained by the intrinsic low P content of the biochar used. Indeed, the biochar used contained only 1.31 g kg^{-1} of total P, even lower than total P content in the *H. suaveolens* shred (1.73 g kg^{-1}) used as composting material. In the same way, the significant improvement in available P induced by biochar-enriched compost would imply a relatively high content of available P in the biochar supplied (Antonangelo, et al., 2021).

The composts produced in our study showed higher total K values (12.6 to 12.8 g kg^{-1}) compared with the compost used in the study by Saba, et al. (2022) in northern Burkina Faso, whose values were 9.8 g kg^{-1} . The non improvement in total K by biochar-enriched compost in our study could imply that the 20% biochar added during co-composting was not sufficient to significantly increase the K content of the final product. However, with a total K content of 14.4 g kg^{-1} , the corn stover biochar from our study was three times richer in total K than the cotton stalk biochar (5.1 g kg^{-1}) produced by Saba, et al. (2022). Qayyum, et al. (2017) found positive correlations between the

proportion of biochar in compost and K uptake by crops.

No difference observed between the composts in fresh yam tuber yield indicates that the improvement in labile C, available N and P was not significant enough to improve yam plant nutrition and, in turn, yield. Qayyum, et al. (2017) obtained increased nutrient bioavailability and improved wheat yield in response to the addition of biochar-enriched compost in a pot experiment. In a field experiment conducted in a temperate climate, Glaser, et al. (2015) also achieved a 26% increase in maize grain yield when applying 10 t ha^{-1} of biochar-enriched compost compared with sole compost. No improvement in yam tuber yield by biochar-enriched compost in our study could imply that the 8 t ha^{-1} dose applied is not sufficient, or that the single year of application is not enough to impact yam yield. It should also be noted that the yam crop takes one to two months on average to emerge (Cornet, et al., 2014). More than two months thus elapsed between the application of organic amendments and the initiation of the autotrophy phase of the yam plants. By using this crop as a test plant, we may have missed something in terms of the release of the active nutrient pool from these amendments during the first two months of cultivation, bringing us to only partially appreciate the effect of biochar compost on the studied crop.

Organic C levels reported on treatments after one cycle of yam production show that the organic amendments applied did not significantly improve soil organic C levels. This result could be explained by a mineralization of native soil organic matter by microorganisms to maintain their metabolism, in response to the more stable C supplied by the organic amendments (Bowman, et al., 1990; Kuzyakov, 2010). The greater stability of C of biochar-enriched compost, as reported by Fischer, et al. (2018), could have led to greater mineralization of native soil C, explaining the greater drop in organic C on the aforementioned treatment. The organic C lost through mineralization would thus have masked the gain in organic C caused by the amendments applied. Furthermore, compared to the 4.07 g C kg^{-1} measured on the plot before cultivation, control resulted in organic C decline of 9%, while sole compost and biochar-enriched compost treatments increased soil organic C by 10%. The drop in organic C in the control confirms the depressive effect of cultivation on soil organic C. However, this decline observed on the control was less pronounced than the

49% drop in organic C reported after just one production cycle of *D. rotundata* on an ultisol in Benin (Law-Ogbomo & Remison, 2009). This lower organic C decline observed in our study may be explained by the low initial organic C content of the trial soil (4.07 g C kg⁻¹) compared with the 21.1 g C kg⁻¹ reported by Law-Ogbomo & Remison (2009) prior to conducting their experiment. In fact, according to Pouya (2024), the lower the soil's initial organic C content, the less organic C is lost as a result of cultivation practices. As a reminder, a significantly higher organic C content (27%) was reported on biochar-enriched compost compared with sole compost (Table 3). In a yam-based cropping system, known to lead to a drop in soil organic C (Agbede, et al., 2013; Hgaza, 2012), regular inputs of stable C-rich biochar-enriched compost could sustainably increase soil organic C content compared with sole compost. This improvement in soil organic C in the medium term is likely to lead to a significant improvement in yam tuber yields.

4. CONCLUSION

The results show that sole compost and biochar-enriched compost were statistically identical in terms of temperature and dry matter evolution during composting, but also in terms of total N, P, K and C:N ratio. Biochar-enriched compost did not significantly improve pH-H₂O compared to sole compost. On the other hand, the study highlighted the ability of biochar-enriched compost to significantly improve organic C, labile C, available N and P contents compared with sole compost. The two composts were statistically identical and higher than the control regarding yam tuber yield, but they did not significantly improve soil organic C compared with the control. The result of our study suggests that increasing the amount of manure in co-composting with biochar could optimize the composting process and improve the agronomic performance of biochar-enriched compost.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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