The combined effect of compost and biochar application on carbon sequestration and some soil properties

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Abstract

Compost and biochar are widely used to improve soil quality by carbon sequestration. A laboratory experiment focused on evaluating the effectiveness of compost or biochar (from the same source) additions individually or in combinations on the soil organic mineralization (SOM), carbon stocks and some soil chemical properties after 45- and 90-days incubation was done. Six treatments were performed based on even mixture of biochar and compost as control without any addition (C), 1% compost (T1), 1% biochar (T2), 0.75 % biochar + 0.25 % compost (T3), 0.50 % biochar + 0.50 % compost (T4), 0.25 % biochar + 0.75 % compost (T5). The results clearly indicated that adding mixture of biochar and compost significantly reduced gaseous emissions and build up soil carbon content. Soil organic carbon decomposition percentage (SOC) was at a minimum amount when the soil treated by 100% biochar (T2) since it was 1.03 and 2.27% after 45 and 90 days, respectively. While it was at a maximum amount when the soil treated by 100% compost (T1) since it was 3.29 and 4.74% after 45 and 90 days, respectively. These results suggested that charring would considerably sequester soil C, especially at high application rates and in fine-textured soils. Biochar application is considered a new economic and environmental protection process as well as reducing carbon dioxide emissions.

Keywords: biochar, compost, carbon dioxide emissions, soil carbon sequestration.

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1. Introduction

Composting and pyrolysis process can recycle nutrients from organic wastes, residue and grown crops (Duan et al., 2021; Mudiyanseelage and Herat, 2021). Pyrolysis produces biochar, which is carbon (C) rich and contains many nutrients (Liao et al., 2022). Composting produces materials that contain organic matter, C and available nutrients (Greff et al., 2022). Biochar and compost offer significant potential for soil C sequestration. Biochar is a black carbon-rich solid produced by thermal decomposition of biomass under oxygen-limited conditions at temperatures between 300 and 700 °C (Jiao et al., 2021; Peng et al., 2018). Feedstock for biochar production may comprise purpose-grown biomass or diverse waste materials from industry including agriculture, on-farm vegetation such as ruches and clippings from hedgerows, hard- and soft-woods, biosolids and urban wastes (Peng et al., 2018; Rey-Salgueiro et al., 2016). Adding biochar on agricultural land is an important practice for improving degraded soils as it restores soil properties and in turn enhances plant growth (Al-Wabel et al., 2018). Compost properties vary widely depending on feedstocks and composting procedure (Stehouwer et al., 2022). Efficient use of composts relies on a better understanding of compost properties and their interaction with soils, how these changes over time and it is modulated by soil type. Compost has two main effects on soils, particularly nutrient-poor soils: replenish soil organic matter and supply plant nutrients (Elia and Boulos, 2019). Organic matter plays a crucial role in improving physical, chemical and biological properties of soils. Soil structure can be improved by the binding between soil organic matter and clay particles via cation bridges and through stimulation of microbial activity and root growth (Audette et al., 2021; Dalal and Bridge, 2020). A large proportion of carbon is lost due to the release of CO2 during organic matter decomposition (Awasthi et al., 2016). Up to 13% of N content in slurry can be lost as N2O emissions due to nitrification and denitrification during anaerobic composting processes (Yang et al., 2019). The major effect of adding biochar could be most likely related to increase the total amount of soil organic matter (SOM) due to its intrinsic recalcitrance (Bi et al., 2021; Zhang et al., 2021a) and to the reduction of mineralization rate of the native SOM (Palansooriya et al., 2019). The way on which biochar can reduce SOM mineralization might be related to its sorbent properties, which could restrict the microbial access to essential nutrients, therefore limiting its activity. Also, to an increase in the amount of SOM physically occluded and chemically adsorbed, and then protected (Zhang et al., 2021b). Moreover, it suggested that the high C/N ratio of the biochar can cause a significant N immobilization so to reduce native SOM
mineralization. On the other hand, it was mentioned a priming effect of black carbon that could enhance the mineralization forest humus (Dodor et al., 2018), thus the biochar effect on native SOM mineralization remains unclear (Li et al., 2019). Biochar addition to arable soil secures the nutrient loop and increases C sequestration, potentially forging a carbon-negative cycle. Due to the high C content (60–80%) and the C sequestration potential of biochar, it is considered a viable tool for climate change abatement. Therefore, calculation of C stocks and the stability of this store have become important (Simo et al., 2019). Preventing the decline of C stocks and indeed building C stocks through incorporation of organic amendments is supposed to be a new research area. This might be attributed to its highly recalcitrant OM. Also, biochar may contain significant quantities of labile material that could be mineralized in the short term. This paper aims to assess the effects of biochar and compost application on the SOM mineralization, carbon stocks and some soil chemical properties during different incubation periods.

2. Materials and methods

2.1 Soil, biochar and compost preparation

Surface soil samples (0-30 cm) were collected from scatter points at The Experimental Farm, Agricultural research Station, Arab Al Awamer, Assiut, Egypt (27° 12- 16.67= N latitude and 31° 09-36.86= E longitude). Before handling, the soil samples were homogenized, crushed, and passed through a 2-mm sieve for some chemical and physical analysis according to Page et al. (1982) and Klute (1986) and they are shown in Table (1).

| Property                  | Value  |
|---------------------------|--------|
| Sand (g/kg)               | 900    |
| Silt (g/kg)               | 71     |
| Clay (g/kg)               | 29     |
| Texture                   | Sandy  |
| CaCO₃ (g/kg)              | 261    |
| pH (1: 2.5)               | 8.7    |
| EC (dS/m) (1:2.5)         | 0.30   |
| Organic matter (g/kg)     | 5.0    |
| Available-N (mg/kg)       | 0.6    |
| Available-P (mg/kg)       | 4.5    |
| Available-K (mg/kg)       | 46     |

Table (1): Some physical and chemical properties of the studied soil.
Both biochar and compost were produced from the same feedstocks, which are by-product of oil production from the oregano straw (*Origanum majorana*). The tested biochar was produced by the pyrolysis of marjoram straw at the temperature of 350 °C with residence time of three hours. The chemical analyzes of the tested biochar and compost is presented in Table (2).

**Table (2): Chemical composition of the tested biochar and compost.**

| Property           | Unit      | Biochar | Compost |
|--------------------|-----------|---------|---------|
| pH (1: 2.5)        | ---       | 10.8    | 7.8     |
| EC                 | (dS/m)    | 12.0    | 7.6     |
| Organic matter     | (g/kg)    | 630     | 540.3   |
| Total carbon       | (g/kg)    | 313.4   | 365.4   |
| C/N ratio          | ----      | 17.29   | 29.43   |
| Available-N        | (mg/kg)   | 3.9     | 4.2     |
| Available-P        | (mg/kg)   | 5.1     | 1.6     |
| Available-K        | (mg/kg)   | 37.2    | 3.2     |

### 2.2 Incubation experiment and design

Two hundred grams of soil sample were inserted into plastic cups and mixed well with different amounts of biochar or compost to form the following treatments:

- 100% compost T<sub>1</sub>
- 100% biochar T<sub>2</sub>
- 75 % biochar + 25 % compost T<sub>3</sub>
- 50% biochar + 50 % compost T<sub>4</sub>
- 25% biochar + 75 % compost T<sub>5</sub>
- In addition to control treatment received neither biochar nor compost (C)

The experiment was laid out in a randomized block design with six treatments and three replications. The plastic cups were moistened to the field capacity and their moisture level was monitored and adjusted weekly. All treatments were subjected to two incubation periods of 45 and 90 days under laboratory condition (25–30 °C). Weekly measurements of C mineralized to CO<sub>2</sub> were carried out with 1N NaOH traps (Anderson, 1982) along the incubation period to allow the mineralization of both active and slow organic matter pools. Evolved carbon dioxide was estimated according to Stotzky (1965).

### 2.3 Laboratory analysis

Soil salinity expressed as electrical conductivity (EC) was determined in (1:2.5) soil-water extract using conductivity meter according to Jackson (1973). The soil reaction (pH) was determined in a soil to water ratio of 1:2.5 using a glass electrode pH meter (McLean, 1982). Total Nitrogen was determined using modified kjeldahl digestion procedure (Bremnen and Mulvaney, 1982). Organic Carbon was
determined according to the method of Nelson and Sommers (1982). Decomposition percentage was estimated by calculating the percentage of soil organic C evolved as CO$_2$ after correction for the CO$_2$ evolved from untreated soil according to Ajwa and Tabatabai (1994) using the following equation:

\[
\text{C decomposition} \% = \left[ \frac{(X - Y)}{Z} \right] \times 100
\]

Where: \(X\) = C evolved as CO$_2$ from soil-fertilizer treatments (mg), \(Y\) = C evolved as CO$_2$ from untreated soil (control) (mg), \(Z\) = C in the soil organic matter (mg). Available nitrogen, phosphorus and potassium were determined according to the method outlined by Burt (2004). Carbon storage was calculated according to the formula of Rowell (1994) as follows:

Carbon storage \% = \frac{\text{organic carbon} \%}{100} \times \frac{\text{bulk density}}{\text{soil collection area}} \times \text{soil collection depth}

### 2.4 Statistical analysis

Data were subjected to analysis of variance according to Snedecor and Chocran (1980), and treatment means were compared using Duncan’s multiple range tests at 5% level according to Duncan (1955).

### 3. Results

#### 3.1 Organic application and some soil properties

The effect of adding biochar and compost on soil salinity (EC) was significant (P<0.05%) during all incubation periods (Table 3). The EC values ranged between 0.33 at C treatment and 0.60 at T$_1$ and T$_3$ after 45 incubation days. The EC values were 0.35 at C treatment and 0.68 at T$_2$ after 90 incubation days. The EC values increased by 57.4% at T$_3$ and by 82.0 at T$_1$ and T$_3$ after 45 incubation days compared to control treatment (C). Also, the EC values increased by 34.3% at T$_3$ and by 94.3% at T$_2$ after 90 incubation days compared to control treatment (C). Regarding soil reaction, the effect of adding compost or biochar significantly increased soil pH and these increases were more evident after 90 incubation days than those after 45 incubation days. Regardless the incubation period, the highest pH values were recorded at T$_2$ and T$_3$ treatments. The pH values increased by 0.82, 8.78, 6.67, 4.10 and 3.98% at T$_1$, T$_2$, T$_3$, T$_4$ and T$_5$, respectively compared to C treatment after 45 incubation days. After 90 incubation days, the differences of pH values among all treatments were diminished.
Table (3): Effect of biochar and compost on soil pH (1:2.5) and electrical conductivity (EC, dS m$^{-1}$) during 45 and 90 days of incubation.

| Treatments | pH | EC (1:2.5) |
|------------|----|------------|
|            | 45 days | 90 days | 45 days | 90 days |
| C          | 8.54±0.08$^d$ | 9.03±0.1$^b$ | 0.33±0.01$^c$ | 0.35±0.04$^d$ |
| T1         | 8.61±0.09$^d$ | 9.24±0.33$^a$ | 0.60±0.00$^a$ | 0.48±0.01$^{bc}$ |
| T2         | 9.29±0.01$^a$ | 9.29±0.15$^a$ | 0.58±0.02$^a$ | 0.68±0.03$^a$ |
| T3         | 9.11±0.06$^b$ | 9.24±0.06$^a$ | 0.60±0.03$^a$ | 0.52±0.00$^b$ |
| T4         | 8.89±0.02$^c$ | 9.08±0.05$^b$ | 0.58±0.01$^a$ | 0.50±0.02$^{bc}$ |
| T5         | 8.88±0.03$^c$ | 8.97±0.05$^c$ | 0.52±0.03$^b$ | 0.47±0.00$^c$ |

C = without application, T1 = 100% compost, T2 = 100% biochar, T3 = 75% biochar + 25% compost, T4 = 50% biochar + 50% compost, T5 = 25% biochar + 75% compost. Means (± SD, n = 10) denoted by the same letter indicate insignificant difference according to Duncan’s test at $p < 0.05$.

Nevertheless, the incubation period, there were a significant (P<0.05) increases in soil organic matter (SOM) content as a result of adding biochar and compost (Table 4). Among all treatments, SOM content varied from 0.46 and 0.65 and from 0.51 and 0.81% after 45 and 90 day of incubation periods, respectively. The highest SOM values were recorded at T1 and T2 treatments during both incubation periods. There were significant differences of soil C/N ratio as a result of adding biochar and compost. In general, the soil C/N ratio recorded higher value after 90 incubation days compared to that after 45 incubation days. The highest soil C/N ratio was found at T3 (12.80), followed by T1 (9.74) and T3 (9.47) treatments after 90 incubation days (Table 4).

Table (4): Effect of biochar and compost on soil organic matter and C/N ratio during 45 and 90 incubation days.

| Treatments | Organic matter (%) | C: N (ratio) |
|------------|--------------------|--------------|
|            | 45 days | 90 days | 45 days | 90 days |
| C          | 0.46±0.02$^d$ | 0.51±0.02$^b$ | 4.94±0.57$^c$ | 6.65±0.23$^a$ |
| T1         | 0.64±0.02$^a$ | 0.74±0.02$^{ab}$ | 6.02±0.57$^b$ | 9.74±0.68$^a$ |
| T2         | 0.65±0.00$^a$ | 0.81±0.02$^a$ | 7.72±0.60$^a$ | 8.55±0.32$^c$ |
| T3         | 0.62±0.07$^a$ | 0.72±0.07$^b$ | 5.12±0.06$^c$ | 9.47±0.29$^b$ |
| T4         | 0.53±0.01$^b$ | 0.68±0.02$^b$ | 5.07±0.38$^c$ | 7.74±0.27$^a$ |
| T5         | 0.52±0.03$^b$ | 0.62±0.03$^b$ | 6.38±0.26$^b$ | 12.80±0.48$^a$ |

C = without application, T1 = 100% compost, T2 = 100% biochar, T3 = 75% biochar + 25% compost, T4 = 50% biochar + 50% compost, T5 = 25% biochar + 75% compost. Means (± SD, n = 10) denoted by the same letter indicate insignificant difference according to Duncan’s test at $p < 0.05$.

Meanwhile, T4 treatment showed the lowest soil C/N ratio of 5.07 and 7.74 after 45 and 90 incubation days, respectively. Adding biochar and compost significantly increased nitrogen availability compared to the control treatment (Table 5). Nitrogen availability was declined as incubation time proceeded. The combined application of compost and biochar (T3, T4 and T5)
increased available N compared to the compost (T2) or biochar (T1) only after 45 incubation days. T4 and T5 treatments gave the maximum available nitrogen. T4 and T5 increased the availability of N by 144 and 375% over the control treatment after 45 and 90 days, respectively. Application of biochar and compost significantly increased available phosphorus as the incubation time increased (Table 5). Regardless the incubation time, the highest amounts of available P were realized at T3 and T4 while the lowest ones were recorded at T2 and control treatment. In general, combined application of compost and biochar (T3, T4 and T5) achieved the maximum available phosphorus.

Table (5): Effect of biochar and compost on available N, P and K (mg kg\(^{-1}\)) during 45 and 90 incubation days.

| Treatments | N  | 45 days | 90 days | P  | 45 days | 90 days | K  | 45 days | 90 days |
|------------|----|---------|---------|----|---------|---------|----|---------|---------|
| C          |    | 28.1±0.6a | 41.1±3.6a | 9.6±0.8a | 12.9±0.3a | 97.5±8.3a | 145.2±3.8a |
| T1         |    | 77.0±4.5b | 46.3±4.0b | 14.9±1.2b | 21.8±0.2b | 207.6±12.0b | 366.4±298b |
| T2         |    | 92.0±7.8b | 77.7±9.9b | 11.1±0.9b | 15.7±1.1b | 167.6±19.3b | 571.2±35.3b |
| T3         |    | 119.1±7.6c | 70.7±8.9c | 16.3±0.5c | 24.8±1.0c | 216.5±3.1ab | 591.2±14.5bc |
| T4         |    | 133.1±3.5a | 132.0±7.2ab | 16.3±0.8a | 28.7±2.5a | 193.1±6.7ab | 461.5±54.2bc |
| T5         |    | 115.7±17.6c | 100.7±9.8c | 15.8±1.2c | 17.0±1.7d | 155.6±10.8c | 337.2±18.6c |

C = without application, T1 = 100% compost, T2 = 100% biochar, T3 = 75% biochar + 25% compost, T4 = 50% biochar + 50% compost, T5 = 25% biochar + 75% compost. Means (± SD, n = 10) denoted by the same letter indicate insignificant difference according to Duncan’s test at p<0.05.

Addition of biochar and compost significantly increased available potassium and these increases were magnified with incubation time (Table 5). After 45 incubation days, available K increased by 112.92, 71.90, 122.05, 98.05 and 59.59% at T1, T2, T3, T4, and T5, respectively compared to control treatment (C). The corresponding values were 152.34, 293.39, 307.16, 217.84 and 132.23% after 90 incubation days.

### 3.2 Carbon dioxide emitted as affected by organic application

The soil CO\(_2\) flux was high at the beginning of incubation time then reduced gradually as incubation time proceeded with almost steady flux after 8 weeks for all treatments (Figure 1). After the 1st week, soil CO\(_2\) emission amounted of 15, 23, 16, 18, 19 and 22 mg carbon/200 g soil for C, T1, T2, T3, T4 and T5 treatment, respectively. The corresponding values were 3, 12, 9, 12, 14 and 12 mg carbon/200 g soil after 6th weeks while soil CO\(_2\) emissions were about 5 mg carbon/200 g soil after 12th weeks (Figure 1). In general, cumulative soil CO\(_2\) emissions increased as with incubation time proceeded (Figure 2). The cumulative soil CO\(_2\) flux varied from 57.2 to 98.6 and from 77.4 to 136.0 mg / 200 g soil after 45 and 90 incubation days.
days, respectively. Regardless the incubation time, the amount of cumulative soil CO$_2$ flux from T$_1$ treatment realized the highest compared to other treatments.

Figure (1): Soil CO$_2$ emission in relation to organic application during incubation time.

Figure (2): Cumulative CO$_2$ emissions in relation to organic application after 45 and 90 incubation days.
3.3 Organic application and soil organic carbon decomposition

The impact of biochar and compost on soil organic carbon decomposition after 45 and 95 incubation days is shown in Figure (3). Biochar and compost realized a significant effect (p<0.05) on SOCD (Figure 3). It was observed that SOCD was at a minimum amount when the soil treated by 100% biochar (T2) and it was at a maximum amount when the soil treated by 100% compost (T1 treatment). The SOCD % recorded at T2 ranged from 1.03 and 2.27%, while it varied from 3.29 and 4.74% at T1 treatment after 45 and 90 incubation days, respectively. In general, data indicated that SOCD increased when soil treated by both biochar and compost compared to the biochar only.

![Figure (3): Soil organic carbon decomposition (SOCD %) in relation to incubation time when soil treated by biochar and compost.]

3.4 Organic application and carbon storage

Changes in carbon storage due to adding biochar and compost after 45 and 95 incubation days are shown in Figure (4). The carbon storage was significantly (P<0.05) increased as a result of adding biochar and compost compared to control treatment. In general, carbon storage increased with incubation time proceeded. The carbon storage ranged between 1.35 and 2.34 kg/m² land after 45 and 90 incubation days, respectively whatever the treatments are. Regardless of the incubation time, the highest values of carbon storage were observed for T2 (100% biochar) while the lower ones were noticed for T5 treatment.
4. Discussion

4.1 Soil properties

During all incubation time, adding biochar and compost significantly increased soil salinity and soil reaction. The increase in soil salinity with adding biochar and compost could be due to their high salt content. Shah et al. (2017) revealed that adding biochar increased soil salinity (EC) and alkalinity (pH). Kloss et al. (2014) found slight increment of soil pH (0.3 units) in an acid soil after application of woodchip-derived biochar. Soil pH was increased from 4.0 to 4.5 due to addition of biochar, (Rodriguez et al., 2009). Bista et al. (2019) found that biochar produced from Douglas fir (Pseudotsuga menziesii) at 900 °C and applied to a silt loam at 22.4 Mg ha\(^{-1}\) increased soil pH and organic carbon. The application of biochar and compost with all treatments showed a significantly higher organic matter (OM) compared to control treatment after incubation time (Table 4).

In general, OM was increased with individual addition of compost (T\(_1\)) or biochar (T\(_2\)) compared to their combination (T\(_3\), T\(_4\) and T\(_5\)). Nyambo et al. (2018) found that biochar increased soil organic carbon by almost 2.25% compared to control after 140 days. Scislowska et al. (2015) explained that biochar, regardless of its origin, improved soil carbon content and soil’s water holding capacity by a certain degree based on the type of soil. Widowati et al. (2020) found that some soil properties, such as OM% and phosphorus content were significantly increased by adding biochar nevertheless of the recommended NPK dosage compared to control. Combined biochar and compost (T\(_3\), T\(_4\) and T\(_5\)) significantly increased NPK availability compared to
control (C) and 100% compost (T_1) treatments. Thus, biochar appears to be a helpful material for recycling NPK in agricultural systems. This is due to the ability of biochar to retain soil nutrients and reduce leaching into drainage water or beyond the root zone (Cao et al., 2017; Gul et al., 2015). The higher the quantity of biochar applied, the higher the magnitude of total N, available P and K is observed. This might be attributed to the large carbon component of biochar and the elemental composition of biochar which consists of different minerals such as Nitrogen, Phosphorus, exchangeable bases etc. (Lehmann et al., 2009). The thermo chemical conversion of manure into biochar seems to be a helpful practice to minimize the production of mineral P fertilizer (Steinfeld et al., 2006). Recycling P from organic residues has environmental benefits compared to direct land application (e.g., protection of water bodies) and can provide a continuous P source for soils (Manolikaki et al., 2016).

4.2 Soil CO₂ emissions

In addition to increasing soil fertility and quality, adding biochar is basically aimed at increasing C sequestration for climate change mitigation (Du et al., 2017; Windeatt et al., 2014). High CO₂ emissions rate was found at the beginning of incubation time then it declined as the incubation time proceeded (Figure 1). The rate of soil CO₂ flux reached a peak in the 1st and 3rd week from biochar and compost addition, mainly might be due to the microbial activity or the dissociation of carbonates. The cumulative CO₂ emissions from 100% biochar treatment (T_2) were significantly lower than those of 100% compost (T_1), 75% biochar + 25% compost (T_3), 50% biochar + 50% compost (T_4) and 25% biochar + 75% compost (T_5) treatments during incubation time. The CO₂ emissions were proportional to the amount of adding biochar. These results suggest that charring would considerably improve soil C sequestration, especially at high application rates and in fine-textured soils. These results are in line with the findings of several studies that observed decreased CO₂ evolution from soil treated with biochar (Egamberdieva and Wirth, 2015; Yao et al., 2015). The high C sequestration potential found for biochar-amended soils are in agreement with previous findings (Du et al., 2017; Ouyang et al., 2014). Similarly, increasing biochar addition caused a progressive reduction of CO₂ emissions (Prayogo et al., 2013), which may be ascribed to the sorption of labile C onto the surface or into the pores of biochar (Lehmann et al., 2011).

4.3 Soil organic carbon decomposition (SOCD %)

The decrease in SOCD rate with increasing the level of biochar addition followed the order of T_2 > T_3 > T_4 > T_5. This might be because the biochar is characterized by its high content of more stable organic carbon compounds.
compared to compost, therefore it slowly decomposes in the soil (Eissa, 2019; Mahmoud et al., 2018). Also, Benito et al., (2005) reported that, when immature compost is applied, its high content of water soluble carbon can lead to stimulation of microbial activity followed by an increased carbon dioxide (CO$_2$) fluxes and higher soil organic matter (SOM) decomposition through priming effect.

4.4 Soil C storage

The calculation of C stocks and the stability of this store have become important (Simo et al., 2019). Adding biochar and compost individually or in combination realized positive effects on the amount of carbon storage in the soil during the incubation periods. It was noticed that the stored carbon increased with the increase the level of adding biochar as follows $T_2 > T_3 > T_4 > T_5$. Carbon in biochar is highly stable (Raya-Moreno et al., 2017). Its stability and low H/C ratio (less than 0.7) make it difficult to decompose (International Biochar Initiative, 2015) resulting in significantly high levels of carbon storage in soils with added rice husk biochar (RHB). Even though rice husk biochar and vermicompost contain carbon, the amount of carbon in the vermicompost is less than in the RHB and is also in a form that is more easily decomposed compared to the carbon in rice husk biochar (Kim et al., 2012).

5. Conclusion

It might be concluded that additions of compost and biochar separately or in combination enhanced soil quality in terms of increased organic matter, nutrients NPK and carbon storage. Furthermore, the low of soil organic carbon decomposition in all biochar treatments regardless if it was added solely or in combination with compost, increasing the level of addition from biochar led to an increase in soil C stabilization exemplified by lower CO$_2$ emissions in biochar amended soils compared to compost amended treatment attributable to a relatively high labile C availability in the sole compost treatment.

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