FARMING PRACTICE
SOIL AMENDMENT WITH BIOCHAR

IMPACT: CARBON SEQUESTRATION

Reference 16

Bai, XX; Huang, YW; Ren, W; Coyne, M; Jacinthe, PA; Tao, B; Hui, DF; Yang, J; Matocha, C 2019 Responses of soil carbon sequestration to climate-smart agriculture practices: A meta-analysis Agric For Meteorol. 278:107625. 10.1111/gcb.14658

Background and objective

Climate-smart agriculture (CSA) management practices (e.g., conservation tillage, cover crops, and biochar applications) have been widely adopted to enhance soil organic carbon (SOC) sequestration and to reduce greenhouse gas emissions while ensuring crop productivity. However, current measurements regarding the influences of CSA management practices on SOC sequestration diverge widely, making it difficult to derive conclusions about individual and combined CSA management effects and bringing large uncertainties in quantifying the potential of the agricultural sector to mitigate climate change. Simultaneously examine the effects of three widely used CSA management practices (i.e., conservation tillage [no-till, NT; and reduced tillage, RT], cover crops, and biochar) on SOC sequestration. Scientific objectives were to: (a) evaluate and compare the effects of conservation tillage, cover crops, and biochar use on SOC; (b) examine how environmental factors (e.g., soil properties and climate) and other agronomic practices (e.g., nitrogen fertilization, residue management, irrigation, and crop rotation) influence SOC in these CSA management environments. Here, we report only results regarding biochar amendment.

Search strategy and selection criteria

The search keywords were "soil organic carbon" and "tillage" for conservation tillage treatments; "soil organic carbon" and "cover crop" for cover crop treatments; and "soil organic carbon" and "biochar" for biochar treatments. 1) SOC was measured in field experiments (to estimate the potential of biochar to increase soil carbon, we also included soil incubation and pot experiments with regard to biochar use); 2) observations were conducted on croplands excluding orchards and pastures; 3) ancillary information was provided, such as experiment duration, replication, and sampling depth; and 4) other agronomic management practices were included besides the three target management practices in this study.

Data and analysis

A random-effect model of meta-analysis was used to explore environmental and management variables that might explain the response of SOC to CSA management practices. The data analysis was performed in R (R Development Core Team, 2009).

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
56	Pot and field experiments	Soil amendment with biochar	No amendment	Metric: Soil organic carbon stocks (10-30 cm); Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	0.6875

Results

- Biochar applications enhanced SOC storage by 39% (28% in the field and 57% in field and pot experiments).

Factors influencing effect sizes

- Pedo-climatic conditions : Biochar increased 12% (38% vs. 26%) more SOC in arid areas, respectively, compared to humid areas. In warm areas, biochar applications only increased SOC by half of the enhancement observed in cool areas.
- Soil type : Biochar applications increased SOC by 63%, 62%, and 52% in silty clay and silty clay loam soils, loam soils, and loamy sand soils, respectively. While relatively lower soil carbon uptakes under biochar applications were found in clay loam and clay soils (32%), silt loam soils (35%), and sandy loam soils (34%).
- Soil depth : Biochar significantly increased SOC by 41% and 14% in the 0–10 cm and 0–30 cm soil layers, respectively.
- Soil pH : Biochar use increased SOC by 65%, 35%, and 28% in alkaline, neutral, and acid soils, respectively.
- Time scale : Biochar amendments significantly increased SOC by 45% and 36% in short-term and medium-term experiments, respectively.

Conclusion

On average, biochar applications represented an effective approach for significantly increasing SOC content (39%).