SINGLE-IMPACT FICHE
SOIL AMENDMENT WITH BIOCHAR

IMPACT: SOIL BIOLOGICAL QUALITY

Data extracted in February 2021
Fiche created in May 2024

Note to the reader: This fiche summarises the effects of Soil amendment with biochar on SOIL BIOLOGICAL QUALITY. It is based on 5 synthesis papers[1], including from 49 to 194 primary studies.

1. WEIGHT OF THE EVIDENCE

CONSISTENCY OF THE IMPACT

The effects of soil amendment with biochar, as compared to no-amendment, on soil biological quality are reported in **Table 1**.

The table below shows the number of synthesis papers with statistical tests reporting i) a significant difference between the Intervention and the Comparator, that is to say, a significant statistical effect, which can be positive or negative; or ii) a non-statistically significant difference between the Intervention and the Comparator. In addition, we include, if any, the number of synthesis papers reporting relevant results but without statistical test of the effects. Details on the quality assessment of the synthesis papers can be found in the methodology section of this WIKI.

- Soil amendment with biochar, compared to no-amendment, shows significant positive effect (improve soil biological quality), in particular on soil microbial biomass, according to four out of the five reviewed synthesis papers. Only one synthesis paper reported non-statistically tested results.

Out of the 5 selected synthesis papers, one included studies conducted in Europe (see **Table 2**).

Table 1: Summary of effects. Number of synthesis papers reporting positive, negative or non-statistically significant effects on environmental and climate impacts. The number of synthesis papers reporting relevant results but without statistical test of the effects are also provided. When not all the synthesis papers reporting an effect are of high quality, the number of synthesis papers with a quality score of at least 50% is indicated in parentheses. The reference numbers of the synthesis papers reporting each of the effects are provided in **Table 3**.

				Statistically tested			Non-statistically tested
Impact	Metric	Intervention	Comparator	Significantly positive	Significantly negative	Non-significant	
Increase soil biological quality	Soil microbial biomass	Soil amendment with biochar	No amendment	4	0	0	1

QUALITY OF THE SYNTHESIS PAPERS

The quality of each synthesis paper was assessed based on 16 criteria regarding three main aspects: 1) the literature search strategy and primary studies selection; 2) the statistical analysis conducted; and 3) the evaluation of potential bias. We assessed whether authors addressed and reported these criteria. Then, a quality score was calculated as the percentage of these 16 criteria properly addressed and reported in each synthesis paper. Details on quality criteria can be found in the methodology section of this WIKI.

2. IMPACTS

The main characteristics and results of the 5 synthesis papers are reported in **Table 2** with the terminology used in those papers, while **Table 3** shows the reference numbers of the synthesis papers reporting for each of the results shown in **Table 1**. Comprehensive information about the results reported in each synthesis paper, in particular about the modulation of effects by factors related to soil, climate and management practices, are provided in the **summaries of the synthesis papers** available in this WIKI.

Table 2: Main characteristics of the synthesis papers reporting effects on soil biological quality. The references are ordered chronologically with the most recent publication date first.

Reference number	Population	Scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Ref5	not specified	Global	107	Soil amendment with biochar	No amendment	Soil microbial carbon content	Soil microbial biomass carbon significantly increased with biochar application.	69%
Ref12	Laboratory and field studies	Global	194	Soil amendment with biochar	No amendment	Soil total microbial biomass and microbial diversity	The application of biochar, particularly that produced under low temperature and from nutrient-rich feedstocks, could better increase soil microbial biomass (based on phospholipid fatty acid analysis (MBCPLFA)) and diversity.	88%
Ref29	Lab incubations, Pot trials, field	Global	49	Soil amendment with biochar	No amendment	Soil total microbial biomass (Bacterial and fungal	Results showed that biochar addition significantly increased the ratios of soil fungi to bacteria (F/B) and the ratios of Gram-positive bacteria to Gram-	94%

[1] Synthesis research papers include either meta-analysis or systematic reviews with quantitative results. Details can be found in the methodology section of the WIKI.

Reference number	Population	Scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
	trials					phospholipid fatty acids, PLFAs)	negative bacteria (G+/G–), and microbial biomass and activities.	
Ref32	Lab incubations, Pot trials, field trials	Global	97	Soil amendment with biochar	No amendment	Soil microbial biomass carbon	This study demonstrated an overall short term increase in microbial biomass, in agricultural soils following a biochar addition.	75%
Ref33	Lab incubations, Pot trials, field trials	Global	50	Soil amendment with biochar	No amendment	Soil microbial carbon content	When averaged across all studies, biochar amendment significantly enhanced soil microbial biomass carbon by 18%.	75%

Table 3: Reference numbers of the synthesis papers reporting for each of the results shown in **Table 1**.

				Statistically tested			Non-statistically tested
Impact	Metric	Intervention	Comparator	Significantly positive	Significantly negative	Non-significant	
Increase soil biological quality	Soil microbial biomass	Soil amendment with biochar	No amendment	Ref5, Ref29, Ref32 and Ref33			Ref12

3. FACTORS INFLUENCING THE EFFECTS ON SOIL BIOLOGICAL QUALITY

Table 4: List of factors reported to significantly affect the size and/or direction of the effects on soil biological quality, according to the synthesis papers reviewed.

Factor	Reference number
Biochar application rate	Ref5, Ref29 and Ref33
Biochar feedstock	Ref33
Biochar particle size	Ref12
Biochar pyrolysis temperature	Ref29
Biochar specific surface area	Ref29
Experimental conditions	Ref33
Fertilisation	Ref29
Fertilisation practice	Ref33
Land use type	Ref33
NA	Ref5, Ref5, Ref5, Ref5, Ref5, Ref5, Ref5, Ref12, Ref12, Ref12, Ref12, Ref12, Ref29, Ref29, Ref32, Ref32, Ref32, Ref32, Ref32, Ref32 and Ref32
Soil organic carbon	Ref12
Soil pH	Ref12 and Ref33
Soil texture	Ref33
Soil type	Ref29
Time scale	Ref29 and Ref32
Vegetation presence	Ref33

4. KNOWLEDGE GAPS

Table 5: Knowledge gap(s) reported by the authors of the synthesis papers included in this review.

Ref Num	Gap
Ref32	Short term lab or pot experiments may provide biased information for interpreting biochar's effect on soil and agricultural production. The meta-analysis here demonstrated the large uncertainty about the microbial response to biochar across the experiments with different lengths of duration. Yet, information from the existing studies mainly with short term lab incubations had limited our understanding of soil microbial response to biochar and the potential impact on carbon dynamics in agricultural soils.
Ref33	The authors did not take into consideration the data on environmental and management conditions or the auxiliary data on other soil properties (e.g., soil inorganic C and N) due to lack of relevant information in studies included. The limited range of study durations did not allow us to examine the effect of biochar aging on soil CO_2 fluxes, SOC, and MBC in this meta-analysis. No studies ran more than 4 years, and only 21% of the observations included in this analysis showed results over a whole growing season with the presence of vegetation cover.

5. SYNTHESIS PAPERS INCLUDED IN THE REVIEW

Table 6: List of synthesis papers included in this review. More details can be found in the summaries of the meta-analyses.

Ref Num	Author(s)	Year	Title	Journal	DOI
Ref5	Xu, WH; Whitman, WB; Gundale, MJ; Chien, CC; Chiu, CY	2021	Functional response of the soil microbial community to biochar applications	GCB Bioenergy 13:269–81	10.1111/gcbb.12773
Ref12	Li, XN; Wang, T; Chang, SX; Jiang, X; Song, Y	2020	Biochar increases soil microbial biomass but has variable effects on microbial diversity: A meta-analysis	Sci Total Environ. 643:926–35.	10.1016/j.scitotenv.2020.141593
Ref29	Zhang, LY; Jing, YM; Xiang, YZ; Zhang, RD; Lu, HB	2018	Responses of soil microbial community structure changes and activities to biochar addition: A meta-analysis	Sci Total Environ. 643:926–35.	10.1016/j.scitotenv.2018.06.231
Ref32	Zhou, HM; Zhang, DX; Wang, P; Liu, XY; Cheng, K; Li, LQ; Zheng, JW; Zhang, XH; Zheng, JF; Crowley, D; van Zwieten, L; Pan, GX	2017	Changes in microbial biomass and the metabolic quotient with biochar addition to agricultural soils: A Meta-analysis	Sci Total Environ. 643:926–35.	10.1016/j.agee.2017.01.006
Ref33	Liu, SW; Zhang, YJ; Zong, YJ; Hu, ZQ; Wu, S; Zhou, J; Jin, YG; Zou, JW	2016	Response of soil carbon dioxide fluxes, soil organic carbon and microbial biomass carbon to biochar amendment: a meta-analysis	GCB Bioenergy 8:392–406.	10.1111/gcbb.12265

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