SINGLE-IMPACT FICHE
SOIL AMENDMENT WITH BIOCHAR

IMPACT: SOIL WATER RETENTION

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 WATER RETENTION. It is based on 3 synthesis papers[1], including from 34 to 82 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 water retention 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 (increase in soil water retention) in 3 out of 5 results, while 1 result reported significant negative effect and 1 reported non-significant effect. These results were extracted from 2 meta-analyses targeting fine-textured soils.

Out of the 3 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**. Some synthesis papers may report effects for more than one impact or more than one effect for the same impact.

				Statistically tested			Non-statistically tested
Impact	Metric	Intervention	Comparator	Significantly positive	Significantly negative	Non-significant	
Increase soil water retention	Water retention	Soil amendment with biochar	No amendment	3	1	1	0

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 3 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 water retention. The references are ordered chronologically with the most recent publication date first.

Reference number	Population	Scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Ref7	Laboratory and field studies	Global	37	Soil amendment with biochar	No amendment	Soil water content: field capacity (FC), available water content (AWC), permanent wilting point (PWP), hydraulic conductivity constant at saturation (K sat)	Application of biochar significantly increases soil available water content. The increase in AWC was directly associated with increase in field capacity and permanent wilting point.	56%
Ref14	Field, greenhouse pot experiments	Global	82	Soil amendment with biochar	No amendment	Soil water content retained at field capacity (FC), wilting point (WP), and the plant available water content (AW).	Biochar, in general, significantly increased plant available water. Changes in soil water content retained at field capacity and wilting point showed an increase in the coarse- and medium-textured soils, but decreased for the fine-textured soils suggesting that the impact of	69%

[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
							biochar on soil water content may be soil type-dependent.	
Ref34	Field, greenhouse pot experiments and laboratory incubations	Global	34	Soil amendment with biochar	No amendment	Available water holding capacity (AWC)	Biochar amendment could significantly improve soil physical properties, such as available water content (by 15% grand mean).	62%

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 water retention	Water retention	Soil amendment with biochar	No amendment	Ref7, Ref14 and Ref34	Ref14	Ref14	

3. FACTORS INFLUENCING THE EFFECTS ON SOIL WATER RETENTION

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

Factor	Reference number
Biochar-Carbon application rate	Ref14
Biochar application rate	Ref7
Biochar application rates	Ref34
Biochar carbon content	Ref7
Biochar particle size	Ref7
Biochar specific surface area	Ref7
Experiment type	Ref7, Ref14 and Ref34
NA	Ref7, Ref7, Ref14, Ref14, Ref14, Ref14, Ref14, Ref14, Ref34, Ref34, Ref34, Ref34 and Ref34
Soil texture	Ref7 and Ref34

4. KNOWLEDGE GAPS

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

Ref Num	Gap
Ref7	The number of studies conducted in the field is small compared to the laboratory and green house studies. Our MA showed that there is a discrepancy between the results in the field and those conducted in the laboratory. Biochar undergoes aging which changes its properties. This can influence the effect of biochar on soil water properties over time. Most of the studies used in the MA were conducted for <2 years. Insufficient data was available for biochar surface functionality and hydrophobicity to be included in the MA. These two properties are also very important in controlling the ability of biochar to enhance soil water retention. Most of the studies used >30 t/ha biochar application rates. Considering the costs of biochar, this will unlikely result in a return on the investment.
Ref34	Few studies conducted over years following a biochar amendment, an analysis of aging influence in biochar's effect on soil physical properties could not be allowed in this study. Thus, long term field studies are urgently deserved for monitoring changes in biochar physical effects with years following a single amendment.

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
Ref7	Edeh, IG; Masek, O; Buss, W	2020	A meta-analysis on biochar's effects on soil water properties - New insights and future research challenges	Sci Total Environ. 643:926–35.	10.1016/j.scitotenv.2020.136857
Ref14	Razzaghi, F; Obour, PB; Arthur, E	2020	Does biochar improve soil water retention? A systematic review and meta-analysis	Geoderma 274:28–34.	10.1016/j.geoderma.2019.114055
Ref34	Omondi, MO; Xia, X; Nahayo, A; Liu, XY; Korai, PK; Pan, GX	2016	Quantification of biochar effects on soil hydrological properties using meta-analysis of literature data	Geoderma 274:28–34.	10.1016/j.geoderma.2016.03.029

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