SINGLE-IMPACT FICHE
SOIL AMENDMENT WITH BIOCHAR

IMPACT: SOIL WATER RETENTION

Data extracted in February 2021

Note to the reader: This fiche summarises the impact of soil amendment with biochar on SOIL WATER RETENTION. It is based on 4 peer-reviewed synthesis research papers[1], each of them including from 34 to 119 individual studies.

1.WEIGHT OF THE EVIDENCE

- CONSISTENCY OF THE IMPACT:
  Soil amendment with biochar, compared to no-biochar-amendment, led to a an overall positive effect (increase in soil water retention) in 4 out of 6 results, while 1 result reported a negative effect and 1 reported no-effect. (see **Table 1**). These results were extracted from 2 meta-analyses targeting fine-textured soils.

  Among the 4 reviewed synthesis papers, 1 include data collected in Europe, while 3 of them do not specify geographical locations of experiments. (see **Table 2**).

Table 1. Summary of effects. The effect with the higher score is marked in bold and the cell coloured. The numbers between parenthesis indicate the number of synthesis papers with a quality score of at least 50%. Details on quality criteria can be found in the next section.

Impact	Metric	Positive	Negative	No effect	Uncertain
Increase soil water retention		**4 (4)**	1 (1)	1 (1)	0

- QUALITY OF THE SYNTHESIS PAPERS: *The quality score summarises 16 criteria assessing the quality of three main aspects of the synthesis papers: 1) the literature search strategy and studies selection; 2) the statistical analysis; 3) the potential bias. Details on quality criteria can be found in this document* →.

As shown in the "Quality score" in **Table 2**, the quality level ranges from 56% to 81%. The least frequently satisfied quality criteria were "Number of studies at each step", "Individual effect sizes", "Dataset available" and "Publication bias analysed".

2. IMPACTS

The main characteristics and results of the synthesis papers are summarized in **Table 2**. Detailed results of each synthesis study are reported in the summary reports .

[1] Research synthesis papers include a formal meta-analysis or systematic reviews with some quantitative results

Table 2. Main characteristics of the synthesis papers reporting impacts of soil amendment with biochar soil water retention. The references are ordered chronologically with the most recent publication date first.

Reference	Population	Geographical scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Iam MU, Jiang F, Guo Z, Peng X. 2021	Not specified	Global	119	Soil amendment with biochar	No amendment	Soil aggregation (percentage of water-stable aggregates (WSA), mean weight diameter (MWD) or gravimetric mean diameter (GMD) by different sieving methods)	Overall, biochar as a soil amendment has the potential ability to enhance aggregation in soils and could be a sustainable strategy to improve soil structure. Biochar effects on soil aggregation varied with different properties of biochar, soil, and experimental conditions.	81%
Edeh, IG; Masek, O; Buss, W 2020	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%
Razzaghi, F; Obour, PB; Arthur, E 2020	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 biochar on soil water content may be soil type-dependent.	69%
Omondi, MO; Xia, X; Nahayo, A; Liu, XY; Korai, PK; Pan, GX 2016	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%

3. KNOWLEDGE GAPS

Edeh et al., 2020	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.
Omondi et al., 2016	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 performed in this study. Thus, long term field studies are urgently deserved for monitoring changes in biochar physical effects with years following a single amendment.

4. SYSTEMATIC REVIEW SEARCH STRATEGY

Keywords	TOPIC: (biochar OR charcoal OR "black carbon") AND TOPIC: (soil OR agriculture OR farming) AND TOPIC: ("meta-analy*" OR "systematic* review*" OR "evidence map" OR "global synthesis" OR "evidence synthesis" OR "research synthesis") or TITLE-ABS-KEY: (biochar OR charcoal OR "black carbon") AND TITLE-ABS-KEY: (soil OR agriculture OR farming) AND TITLE-ABS-KEY: ("meta-analy*" OR "systematic* review*" OR "evidence map" OR "global synthesis" OR "evidence synthesis" OR "research synthesis")
Search dates	No time restrictions
Databases	Web of Science and Scopus, run in February 2021
Selection criteria	The main criteria that led to the exclusion of a synthesis paper were if the paper: 1) does not deal with agronomic application of biochar; 2) does not synthetize pairwise comparisons on the agronomic effect of biochar; 3) the control of the pairwise comparison is not no-biochar; 4) deals with soil application of mineral- or organic-enriched biochar; 5) does not report results with the same fertilisation conditions between intervention and control; 6) is either a simple review, a non-quantitative systematic review, a meta-regressions looking only at factors influences, without mean effect sizes; 7) deals with other than agricultural soils in cropping systems, e.g. forest restoration; 8) is not written in English. Synthesis papers that passed the relevance criteria were subject to critical appraisal carried out on paper-by-paper basis. The search returned 130 synthesis papers potentially relevant for the practice object of our fiche. Searches for other farming practices added another 2 potentially relevant synthesis papers. From the 132 potentially relevant synthesis papers, 57 were excluded after reading the title and abstract,

	and 34 after reading the full text according to the above-mentioned criteria. Finally, 41 synthesis papers were selected for soil amendment with biochar, from which 4 were relevant for this impact.