FARMING PRACTICE
SOIL AMENDMENT WITH BIOCHAR

IMPACT: SOIL WATER RETENTION

Reference 14

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

Background and objective

Biochar is widely suggested as a soil amendment to improve soil physical properties for crop production. However, the heterogeneity between experiments in terms of biochar characteristics, experimental conditions and soil properties makes it difficult to compare and extrapolate results from different studies. The present study expands on the previous studies on biochar-soil water retention. The authors provide more insight into impacts of biochar on water content held at field capacity (FC) and plant available water content (AW) as done in the previous studies. In addition, the authors considered how biochar changes the water content held at wilting point (WP); i.e. including WP provides a complete picture and helps to improve evidence of how biochar application impacts AW.

Search strategy and selection criteria

The literature search for the work encompassed the period from 2010 to 2019 (Feb. 1). The search engines used were Web of Science, ScienceDirect, Google Scholar, and the International Biochar Initiative databases. The search terms included different combinations of the following words: "biochar", "hydrochar", "bio-char", "char", and "soil water content", "soil moisture content", "soil moisture release curve", "soil water characteristics", "soil water retention", "plant available water", "water holding capacity", "water retention capacity", "readily available water", and "soil hydraulic properties". The authors also went through the citations and the reference list of the selected papers. 1) published in English, 2) peer-reviewed, with full text available, 3) biochar information included, at least, feedstock, and the application rate, 4) soil information included, at least, soil type or textural class, 5) data on soil water retention variables were reported in numerical format or legible graphical format, and 6) data were not already included in a previous paper to avoid double counting.

Data and analysis

To investigate if biochar effect on soil water retention was affected by the initial soil properties and by how much, we conducted an analysis of co-variance (ANCOVA) using the R software package version 3.4.1. The criterion for statistical significance of the effect of soil textural group was $p < 0.05$. When an ANCOVA test showed a significant effect of soil textural group, further analyses were made to ascertain the differences in soil textural groups. This was done by performing a pairwise comparison using the general linear hypotheses (glht) function from the R multcomp package and the Tukey HSD (Honestly Significant Difference) test.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
82	Field, greenhouse pot experiments	Soil amendment with biochar	No amendment	Metric: Soil water content retained at field capacity (FC), wilting point (WP), and the plant available water content (AW).; Effect size: Standardized difference of the considered metrics between intervention and control	0.6875

Results

- Amendment of biochar significantly increased FC for the coarse-textured soils by 51%. The FC for the medium-textured soils marginally increased by 13% compared to the fine-textured soils in which FC remained unchanged (<1%) after biochar application.
- Application of biochar increased WP by as much as 47% for the coarse-textured soils, and 9% for the medium-textured soils. The percentage increase was significant only for the former textural group. Conversely, for the fine-textured soils, biochar reduced WP by 5%.
- Biochar application significantly increased AW in the coarse-textured soils (by 45%) compared to the medium- and fine-textured soils (21% and 14%, respectively).

Factors influencing effect sizes

- Experiment type : For the coarse-textured soils, FC increased by a higher percentage (by 71%) in the GH & pot studies compared to the field and lab-based studies (37% and 10%, respectively). For the coarse-textured soils, WP increased in the GH & pot and field studies by 85% and 16%, respectively, but slightly decreased in the lab-based studies (by ~2%).For the medium-textured soils, WP marginally increased in the GH & pot, and lab-based studies, but decreased in the field studies. For the fine-textured soil group, WP marginally decreased regardless of the experimental type. For coarse-textured soils, AW increased by a larger percentage (76%) in the GH & pot studies compared to the field- and the lab-based studies (27 and 21%, respectively). Medium-textured soils showed the opposite trend where increases for AW were larger for field-based studies (33%) compared to the GH & pot (8%) and lab studies (18%). For fine-textured soils, AW increased by 19% in the field and lab studies, and 13% in the GH & pot studies.
- Biochar-Carbon application rate : The percentage change in FC was strongly related to BCad ($r = 0.64$) for the coarse-textured soils, but the same strong relationship was not observed for the medium- and fine-textured soils. Unlike the coarse- and medium-textured soils, for the fine-textured soil, WP negatively correlated with BCad (Table 2). The correlation between percentage change in AW and BCad was moderately strong for the fine-textured soil ($r = 0.52$), followed by the medium-textured soils ($r = 0.21$) and weak for the coarse-textured soils ($r = 0.18$).

Conclusion

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.