FARMING PRACTICE
SOIL AMENDMENT WITH BIOCHAR

IMPACT: SOIL PHYSICO-CHEMICAL QUALITY

Reference 2

Islam MU, Jiang F, Guo Z, Peng X. 2021 Does biochar application improve soil aggregation? A meta-analysis Soil Tillage Res 209:104926 10.1016/j.still.2020.104926

Background and objective

Soil aggregation has the ability to stabilize and protect soil organic matter (SOM) from decomposition, improve available water holding capacity, soil infiltration, and hydraulic conductivity (Haynes and Naidu, 1998; Six et al., 2002). Well-aggregated soil not only increases crop production but also mitigates climate change through long-term C sequestration in soil Evaluate the combined effects and magnitude for soil aggregation across the properties of biochar and soil and experimental conditions.

Search strategy and selection criteria

An extensive literature search was conducted mainly using ISI Web of Science, Science Direct, Google Scholar, and China Knowledge Resource Integrated Database. Keywords "biochar" and "soil aggregat* were used for the online literature searching until May 2020 with no limit on publication year. 1) studies needed to report soil aggregation as a percentage of water-stable aggregates (WSA), mean weight diameter (MWD) or gravimetric mean diameter (GMD) by different sieving methods; 2) studies needed to have at least one pair of data (without biochar as the control and biochar amended soils as the treatment); 3) studies needed to include at least three replications for each treatment.

Data and analysis

The effect size and the 95 % CI of each categorical group were calculated using the Meta packages of the statistical software R (Version 3.4.2). The frequency distribution of effect size was plotted to reflect the variability of biochar effects on soil aggregation among different studies by a Gaussian function. The restricted maximum likelihood estimation (RMLE) method was used to determine the between-group variability (Qb) and P value. The fail-safe N technique was used to test publication bias. Egger's test of the intercept quantifies the funnel plot asymmetry and performs a statistical test. Egger's test was non- significant (P = 0.3576), which means that there was no publication bias in this meta-analysis.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
119	Not specified	Soil amendment with biochar	No amendment	Metric: Soil aggregation (percentage of water-stable aggregates (WSA), mean weight diameter (MWD) or gravimetric mean diameter (GMD) by different sieving methods); Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	0.8125

Results

- Overall, the use of biochar substantially increased soil aggregation by an average of 16.4 ± 2.5 %, regardless of biochar and soil properties and environmental conditions.
- Cereal crop straw and manure sources had the lowest positive effects by 12.5 % and 14.8 % among all other sources of biochar feedstock. While the source of grain residues and wood had the greatest positive effects on aggregation by 18.9 % and 20.2 %, respectively, but there was no significant difference between grain residue and wood biochars.
- Biochar produced at low (< 350 °C), medium (350–600 °C), and high (> 600 °C) pyrolysis temperatures resulted in aggregation increased by 17.3 %, 18.8 %, and 20.8 %, respectively.

Factors influencing effect sizes

- Biochar pH : The highest increase was observed when the biochar pH did not exceed 8. However, the increase in soil aggregation did not vary significantly from higher biochar pH (8–10) and (> 10) by 18.4 % and 18.8 %.
- Biochar application rate : Biochar application increased soil aggregation by an average of 9.54–23.4% when the rate of biochar used across studies ranged from < 20 t ha−1 group to > 40 t ha−1 group. The result of regression analysis also demonstrated that there was a linear increase in soil aggregation with an increase in the amount of biochar used (P < 0.0001).
- Soil type : There was no significant difference in the increase in soil aggregation with biochar addition between paddy soil (14.8 %) and upland soil (15.2 %) .
- Duration of treatment : Soil aggregation was very significantly increased by 14.3 % and 20.3 % respectively in the medium (1–3 years) and long (> 3 years) duration of field experiments. The increase was, however, insignificant in the short-term experiments (less than one year). In addition, a significantly positive correlation between field duration and the response ratios (lnRs) of soil aggregation to biochar application also suggests that long-term biochar application can contribute to aggregate stability in a great effect.
- Metric type : The increase in wet aggregate stability (18.2 %) with biochar addition was significantly different from that in dry aggregate stability (4.05 %)

Conclusion

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.