FARMING PRACTICE
SOIL AMENDMENT WITH BIOCHAR

IMPACT: CROP YIELD

Reference 31

Jeffery, S; Abalos, D; Prodana, M; Bastos, AC; van Groenigen, JW; Hungate, BA; Verheijen, F 2017 Biochar boosts tropical but not temperate crop yields Environ. Res. Lett. 053001. 10.1088/1748-9326/aa67bd

Background and objective

Applying biochar to soil is thought to have multiple benefits, from helping mitigate climate change, to managing waste to conserving soil. Biochar is also widely assumed to boost crop yield, but there is controversy regarding the extent and cause of any yield benefit. Previous studies had a strong numerical bias towards the tropics. This current analysis allows geographical partitioning because it has similar numbers of pairwise comparisons from the two main climatic zones: ≤35th degree latitude including the tropics and subtropics (hereafter called 'tropics') and >35th degree latitude including the temperate and the boreal (hereafter called 'temperate').

Search strategy and selection criteria

Web of Science, Scopus and Google Scholar were searched using 'biochar AND crop productivity OR crop production OR crop yield'. The cut-off date for inclusion of studies in the database was 31 December 2014. To maximise the number of publications on which this analysis was based, all studies that reported quantitative results and fulfilled the following criteria were included (i.e. both pot and field experiments). 1) report means and a measure of variance from which standard deviation could be calculated (when no measures of variance were given, efforts were made to obtain these from the corresponding authors); 2) the study design had to include replication (n ≥ 3) and randomisation; 3) only treatments from each study were included if a 'control' could be identified in which all factors, such as soil amendments, were the same as the biochar 'treatment', but without the application of biochar. All reported auxiliary variables for both soil and biochar properties were recorded in the database.

Data and analysis

A categorical meta-analysis was applied using a random effects model with 9999 iterations using MetaWin Version 2 statistical software.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
111	Temperate and Tropical soild	Soil amendment with biochar	No amendment	Metric: Crop yield; Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	0.8125

Results

- Overall, biochar increased crop yield by a grand mean of 13%.
- The authors found biochar amendment to soils in temperate regions to significantly decrease crop yield, averaging approximately −3% at a median biochar application rate of 30 t ha−1. Even when only considering field experiments, to exclude any forcing of negative effects in pot studies, the authors find no effect of biochar on crop yield.
- This contrasts with soils in tropical regions where crop yields significantly increase by approximately 25% (figure 1) at a median biochar application rate of 15 t ha−1.

Factors influencing effect sizes

- Soil pH : The yield stimulation was highest for soils with lower initial soil pH, prior to biochar application, and the effect systematically declined as initial soil pH increased. This pattern was observed for tropical data and not for temperate soils. This suggests that, to a large extent, the yield-stimulating property of biochar derives from an effect of soil liming. The pH of biochars applied in the studies we synthesized was high (median pH = 9.0), consistent with a larger liming effect on the acidic tropical soils (median pH = 5.7) compared to the more neutral temperate soils (median pH = 6.9).
- Biochar nutrients content : In the generally nutrient-poor tropical soils, addition of Nutrient-rich biochars produces more than three times the increase in crop yield than that by addition of nutrients-poor biochars, i.e. 70% vs. 19%. This contrasts with temperate soils where yields show no stimulation following application of either nutrients-poor (−3%) or of nutrients-rich biochars (−1%).
- Pedo-climatic zone : In the tropics, biochar increased yield through liming and fertilization, consistent with the low soil pH, low fertility, and low fertilizer inputs typical of arable tropical soils. We also found that, in tropical soils, high-nutrient biochar inputs stimulated yield substantially more than low-nutrient biochar, further supporting the role of nutrient fertilization in the observed yield stimulation. In contrast, arable soils in temperate regions are moderate in pH, higher in fertility, and generally receive higher fertilizer inputs, leaving little room for additional benefits from biochar

Conclusion

Overall, biochar increased crop yield by a grand mean of 13%. However, biochar has, on average, negative or no effect (for field tests only) on crop yield in temperate latitudes, yet elicits a 25% average increase in yield in the tropics. The results show that biochar can be a useful tool to improve crop yield in nutrient-poor and acidic soils.