# FARMING PRACTICE
# SOIL AMENDMENT WITH BIOCHAR

## IMPACT: CROP YIELD

### Reference 6

Dai, YH; Zheng, H; Jiang, ZX; Xing, BS 2020 Combined effects of biochar properties and soil conditions on plant growth: A meta-analysis Sci Total Environ. 713:136635. 10.1016/j.scitotenv.2020.136635

### Background and objective

Biochar application in agricultural soils can be highly beneficial to plant productivity. However, how plant productivity response (PPR) [% change of plant yield from control (without biochar application)] to biochar application is affected by biochar properties, soil conditions, and their combinations is still unclear. 1) investigate the general trend of plant productivity response (PPR) as affected by biochar or soil properties in biochar-amended soils, 2) examine how the PPR can be affected by biochar properties under specific soil conditions, and 3) to discuss the potential roles of biochar in plant growth improvement by modulating the soil properties and nutrient utilization.

### Search strategy and selection criteria

The literature, which reported the plant yields [e.g., total biomass, grain yield, aboveground biomass (shoot biomass) and/or underground biomass (root biomass)], was collected mainly from two online databases, i.e., Web of Science and Springer Link. Only one indicator of plant productivity was selected following the sequence of total biomass, grain yield, aboveground biomass (shoot biomass) and underground biomass (root biomass) if more than one indicator was reported in a given study. The time horizon of data for inclusion of literature in the databases was up to November 2017. 1) the study must be the original research with quantitative results of the change of plant productivity due to biochar application; 2) the reported results must comprise the means and standard deviation (SD), or standard error (SE) in some cases; 3) the study design had to include at least three replications. From the selected studies, only treatments for pairwise comparison between groups with biochar application and corresponding control group without BC application were extracted.

### Data and analysis

The MetaWin 2.1 software was employed to calculate the effect size and the 95% CIs of each categorical group, and the random effects model was selected according to the results of the heterogeneity test. The groups with less than three pairwise comparisons were excluded from each analysis. Resampling tests were generated from 999 iterations. The funnel plot statistics and Fail-safe N technique (Rosenthal's method) were employed to test the effects of publication bias and the robustness of the meta-analysis.

| Number of papers | Population | Intervention | Comparator | Outcome | Quality score |
|---|---|---|---|---|---|
| 153 | Not specified | Soil amendment with biochar | No amendment | Metric: Crop yield metrics: Total biomass, grain yield, aboveground biomass (shoot biomass) and/or underground biomass (root biomass); Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control | 0.6875 |

### Results

- The grand mean of plant productivity response was estimated to be 16.0 ± 1.3%, regardless of biochar/soil conditions. Nine biochar properties were selected to investigate the effect of biochar on PPR, including: CEC: cation exchange capacity; SA: surface area; TC: total carbon; BD: bulk density; TOC: total organic carbon content; TN: total N content.
- Except for the groups of BC-pH (<7), BC-ash (<10), and BC-C/N (100–200), most of the biochar groups demonstrated positive effects on plant growth, and the increased plant productivity ranged from 3.32% in the group of BC-TOC (>60) to 84.3% in the group of BC-TC (<30%).
- The greater increase in plant productivity was found in the groups with lower categorized values than those of higher categorized values in the cases of BC-CEC, BC-TC, BC-BD, and BC-TOC, whereas the contrary trend was recorded in case of the BC-ash group. Compared to the grand mean of PPR, the extent of plant productivity improvement can be enhanced in the groups of BC-pH (7–8), BC-ash (>25), BC-TC (<30), and BC-BD (<0.3), while weakened in the groups of BC-CEC (20–30), BC-ash (10–25), BC-SA (>200), BC-BD (>0.3), and BC-TOC (>60).
- The results of regression analysis demonstrated that the PPR was positively correlated with biochar properties including CEC and ash, while was negatively correlated with biochar properties including TC, BD, and TOC. Other biochar properties, including pH, SA, TN, and C/N, showed non-significant correlations with PPR.

### Factors influencing effect sizes

- Biochar pH : Only the BC-pH (<7) group showed a significant decrease in plant productivity (–12.3%). Notably, the total number of studies in the low BC-pH group (<7) was 53, only accounting for 4.74% of the total amount of tested biochars (1110), reflecting that most of the biochars used for improving plant productivity were alkaline. For the BC-pH groups, the highest increase in plant productivity was recorded in case of the BC-pH (7–8) group (29.4%), which was significantly higher than that for other groups.
- Biochar ash content : PPR was positively correlated with biochar properties including ash.
- Biochar Cation exchange capacity : PPR was positively correlated with biochar properties including CEC.
- Biochar total carbon and total organic carbon : PPR was negatively correlated with biochar properties including TC and TOC
- Soil pH : The plant growth would be improved much higher by the biochars applied in the soils with low pH compared to other soil groups.

## Conclusion

The meta-analysis in the present study showed that the grand effect of biochar on plant productivity was estimated to be 16.0 ± 1.26%, regardless of biochar properties and soil conditions. However, the efficiency of biochar in improving plant growth could be greatly affected by the combined effect of biochar properties and soil conditions.