FARMING PRACTICE
SOIL AMENDMENT WITH BIOCHAR

IMPACT: GHG EMISSIONS

Reference 27

Liu, Q; Zhang, YH; Liu, BJ; Amonette, JE; Lin, ZB; Liu, G; Ambus, P; Xie, ZB 2018 How does biochar influence soil N cycle? A meta-analysis Plant Soil 426:211–25 10.1007/s11104-018-3619-4

Background and objective

The amendment of soils with biochar has been suggested as a promising solution to regulate the soil N cycle and reduce N effluxes. However, a comprehensive and quantitative understanding of biochar impacts on soil N cycle remains elusive. 1) identify how and why the response of soil N cycle to biochar application varies across different biochar and soil properties; and 2) explore whether biochar production process entails hidden risk of extra pollutant N emissions. The study is expected to develop constructive biochar management for decreasing soil N losses without incurring negative side effects.

Search strategy and selection criteria

A literature search was performed through Web of Science, Google Scholar, Springer Link, Wiley Blackwell, and China Knowledge Resource Integrated (CNKI) databases using the keywords 'biochar', 'black carbon', 'soil', 'nitrogen'. 1) the research was on soil N cycle in response to biochar addition; 2) biochar was produced by pyrolyzing organic materials anaerobically (technology levels range from highly advanced facilities to simply equipped stoves); and 3) control and biochar treatments were subjected to the same management (e.g. same tillage, watering, fertilization, or residue addition).

Data and analysis

Mean effect sizes and the 95% bootstrapped confidence intervals (CIs) based on 9999 iterations for each grouping categories were generated based on a random-effect model. The total heterogeneity of effect sizes among studies (QT) was partitioned into within-group (QW) and between-group (QB) heterogeneity. A QB larger than a critical value suggests a significant difference between subgroups.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
208	Not specified	Soil amendment with biochar	No amendment	Metric: N_2O emission; Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	0.6875

Results

- Biochar addition significantly decreases soil N_2O emissions by an average of 32% ($P < 0.001$).
- Biochar made from manure or pyrolyzed at temperatures lower than 350 °C shows a weak and insignificant reducing impact on soil N_2O emissions.
- Given the average available 2.5 t ha−1 yr.−1 crop residues derived from arable land for biochar production and the average N content of 0.83% for crop residues, the N_2O emissions due to biochar production in the absence of pyrolytic syngas purification would amount to 0.35–0.81 kg N_2O-N ha−1 yr.−1, which can weaken or destroy the effectiveness of biochar in mitigating soil N_2O emissions. Therefore, the removal of N-containing components from pyrolytic syngas before transferring to end users, either by trapping and subsequent conversion to harmless (i.e., N_2) or useful (i.e., NH_4+) forms of N, or by in-stack catalytic conversion to N_2, is of great importance from a climate-change mitigation perspective

Factors influencing effect sizes

- Soil texture : The decreasing effect of biochar on soil N_2O emissions is maximized in loam soils.
- Soil organic carbon : The effect size is small and non-significant for soils with low organic carbon (≤5 g kg−1).
- Biochar application rate : Along with the increase of biochar addition rate, the magnitude of the reduction in soil N_2O emissions increases, reaching the maximum when biochar addition rate is higher than 40 t ha−1

Conclusion

Biochar addition significantly decreases soil N_2O emissions. However, N_2O emissions due to biochar production in the absence of pyrolytic syngas purification could weaken or destroy the effectiveness of biochar in mitigating soil N_2O emission.