FARMING PRACTICE
SOIL AMENDMENT WITH BIOCHAR

IMPACT: WATER USE

Reference 8

Gao, Y; Shao, GC; Lu, J; Zhang, K; Wu, SQ; Wang, ZY 2020 Effects of biochar application on crop water use efficiency depend on experimental conditions: A meta-analysis F Crop Res. 249:107763 10.1016/j.fcr.2020.107763

Background and objective

It is essential to develop optimal strategies that reduce water consumption of crops without depressing crop yield i.e. increasing water use efficiency (WUE) to ensure water availability and satisfy the increasing global food demands. WUE refers to the ratio of biomass increment and accumulated water use. That is for the individual whole plant. From the leaf scale, WUE means H_2O loss per net CO_2 uptake. Authors' purpose was to determine the effect of biochar application on WUE and find out how to promote WUE.

Search strategy and selection criteria

The authors conducted an extensive literature search without restrictions on language via Web of Science, Science Direct and China National Knowledge Internet for articles published before December 2019. During the search, following keywords in the topic were focused on: 1) 'biochar' and 'water use efficiency'; 2) 'biochar' and 'water productivity'; 3) 'biochar' and 'water consumption'; 4) 'biochar' and 'photosynthesis'. 1) compared water use efficiency (WUE) between treatments with and without biochar application and ensured that all other treatment factors were the same; 2) each treatment had several repeated samples. In this study, considering that WUE was a continuous variable, in addition to the number of repetitions, authors needed standard deviations (SD) to calculate the variance. The most common reason for discarding studies was no obtainable or computable SD. Another common reason was that compared to the control, biochar-based fertilizer rather than biochar was applied in experimental treatments.

Data and analysis

In view of the significant heterogeneity (I2>75 %), authors used the package 'meta' of R software (http://www.R-project.org) to build a random effect model for calculation of a summary effect.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
43	Not specified	Soil amendment with biochar	No amendment	Metric: Plant water use efficiency; Leaf water use efficiency; Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	0.8125

Results

- Compared to the control, biochar application increased PWUE and LWUE by 18.8 % and 20.0 % (95 % CI: 16.3 %–21.3 %, 13.9 %–26.4 %) on average.
- As biochar application rate turned from 21–29 t ha−1 to greater than or equal to 30 t ha−1, the increase in WUE changed from insignificant to significant.

Factors influencing effect sizes

- Soil pH : There was a statistically significant difference in WUE responses between soils with pH < 7 and pH > 8. No significant increase in PWUE only occurred in soils with pH < 7, while except soils with pH > 8, the remaining groupings both showed a statistically significant positive effect on LWUE.
- Biochar pH : WUE responses were generally significant positive but overall small (not more than 20 %) when applying biochar with pH < 9 or between 9 and 10, and it made no statistically difference between the two groups. Much greater WUE increases were found in experiments with biochar pH > 10 (PWUE: 67.6 % on average; LWUE: 64.5 % on average), a significant increase compared to remaining groups.
- Biochar K content : Application of biochar with a K content of 1–1.5 % led to highest positive effect on WUE.
- Biochar C content : All biochar C content categories showed a statistically significant increase in WUE with the exception of the category of biochar containing more than 80 % C. Biochar with a C content above 80 % even showed negative effects on PWUE although not significant. There was also a trend whereby WUE responses depressed with increasing C content of biochar. Compared to evident differences in PWUE between all biochar C content categories, there existed an insignificant difference in LWUE between two higher biochar C content categories.
- Biomass precursor : Applying biochar made from herbaceous material, the mean increase in PWUE was 17.7 %, an evident increase compared to that when wood biochar was applied.

Conclusion

This analysis showed a statistically significant 18.8 % and 20.0 % increase in plant water use efficiency and leaf water use efficiency, respectively, following biochar application, indicating the potential benefits of biochar application in adapting to climate change.