Effects of Modified Biochars on the Growth of Maize (*Zea mays* L.)

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Objectives

- Evaluate the fertilizing effect of (modified) biochars since biochar applications have been shown to either elevate plant productivity or impair soils' nutrient status.
- Identify biochar induced effects on plant functional traits and plant productivity to derive mechanistic knowledge required to develop tailor-made chars.
- Observe the effect of a possible nitrogen immobilization following char application, as certain biochar compounds are hypothesized to reduce nitrogen availability.
- We hypothesize that biochar application affects i) soil pH and nutrient availabilities and thus ii) plant productivity and traits.

Method

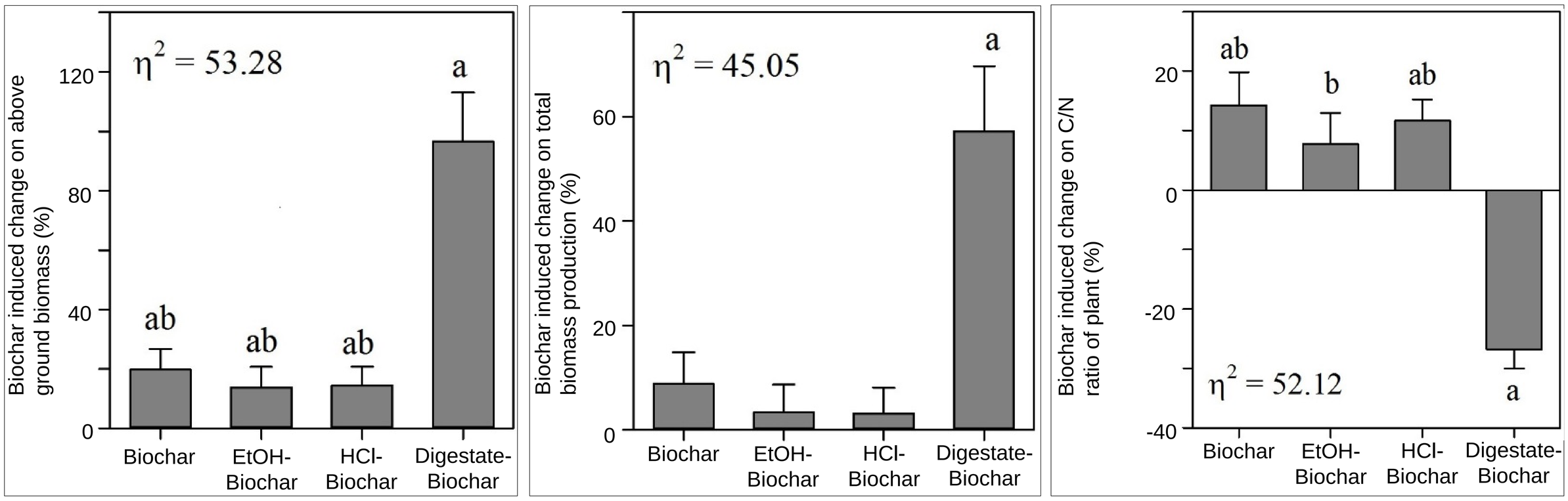
- Biochar was produced from whole maize cobs at University of Hohenheim using a self-purging pyrolysis reactor. The biochar was modified using i) washing (with either ethanol or HCl) and ii) loading (with digestate, a nutrient-rich byproduct of the biogas production) processes. Non-modified char served as the positive control.
- Maize was grown on a sand/biochar mixture for a period of 35 days. Unamended nutrient-deficient substrate served as the negative control.

Results

Shoot biomass: highest yield observed with loaded biochar

Plant productivity: loaded biochar doubled total biomass production

C/N ratio (plant tissue): loaded biochar decreased C/N ratio



Relative biochar induced changes on above ground biomass (left), total biomass production (middle) and plant C/N ratio (right) in dependence of the unamended control. We performed separate non-parametric ANCOVA's using Euclidian distance measures with time as a covariate to assess how biochar amendment affects plant functional parameters. We took 8 replicates at three harvests each (21, 28 and 35 days of plant growth). Small letters indicate significant differences ($p<0.05$) between groups (small letter "a" indicates differences between treatment and the unamended control). The η^2 values indicate the relative effect sizes of each explaining factor on plant parameter variation. Data is shown as means and their standard error.

- Biochar applications increased total C and N concentrations in all mixtures. Plant-availability of Mg was significantly reduced in non-modified biochar, ethanol-washed biochar and loaded biochar.
- Biochar amendments affected plant functional traits, as all chars induced a significant increase in above ground biomass production.
- Nutrient loaded biochar enhanced nitrogen uptake while other biochars reduced or maintained nitrogen uptake relative to those of the control treatments. In consequence, C/N ratios in plant tissue tended to increase for all biochar treatments except digestate loaded chars, which induced a significant decline of C/N ratios.
- Nutrient loaded biochar doubled biomass production of emerged maize plants, although soil N content did not significantly increase among treatments.

Discussion

- Our results suggest that plant productivity remained unchanged after application of biochar and its washed forms. Contrastingly, nutrient loaded biochar induced a significant increase in productivity due to markedly improved plant nutrient uptake that affected biomass productivity and allocation.
- This experiment indicates that establishing loaded chars as efficient nutrient carriers might circumvent N-immobilization processes associated with an impaired C/N balance following char application.
- Future research is required to develop biochar concepts that facilitate prolonged improvements of plant productivity of emerged maize plants.