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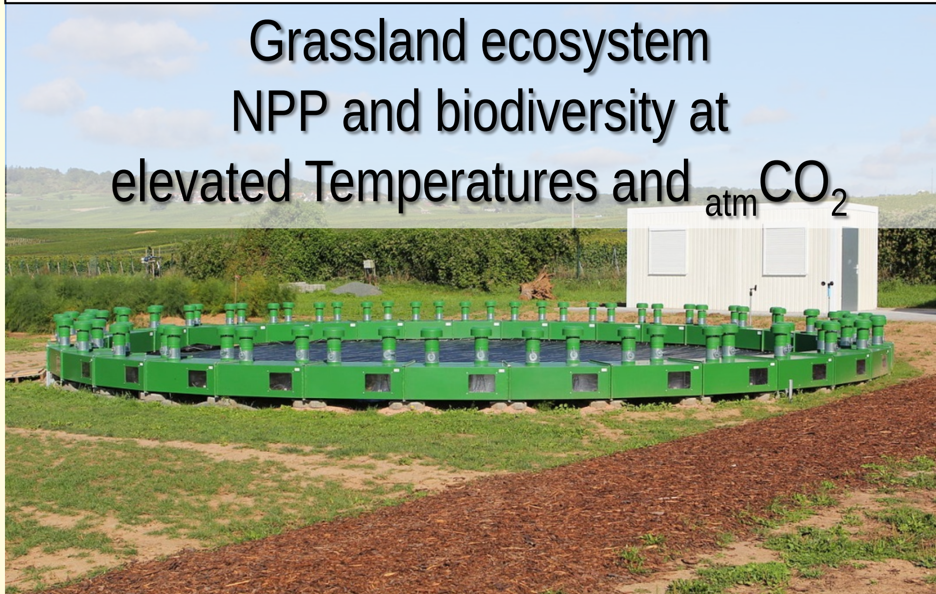
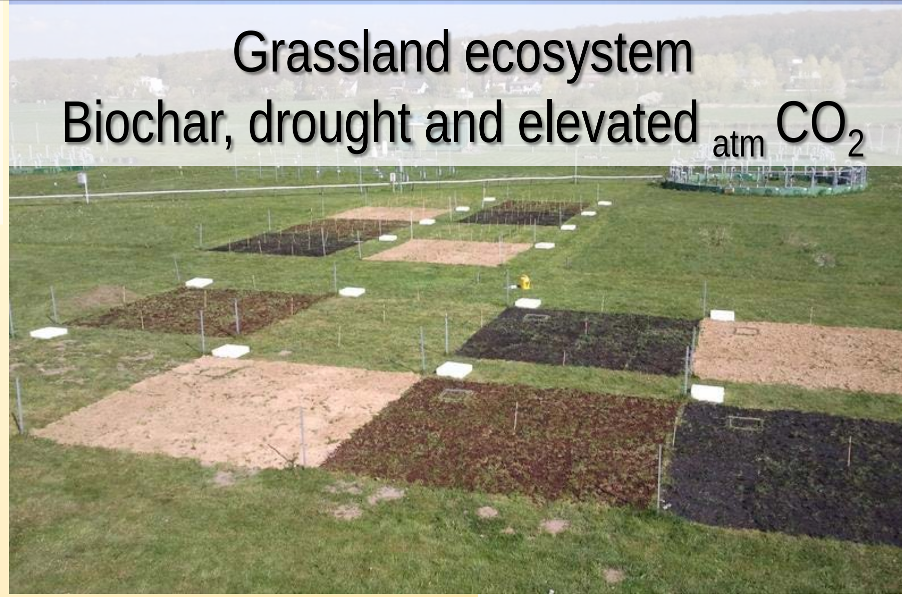
GIESSEN

Biochar soil amendment increases the resistance of *Chenopodium quinoa* to drought in sandy soils

Prof. Dr. Hans-Werner Koyro

FACE (Free Air Carbon Dioxide Enrichment)





Growth chamber
Biochar and drought

Open top chambers
drought and salinity at elevated $_{atm}CO_2$

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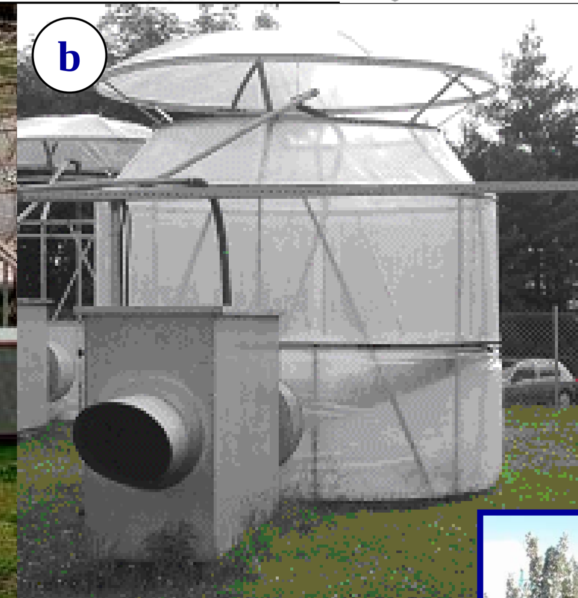
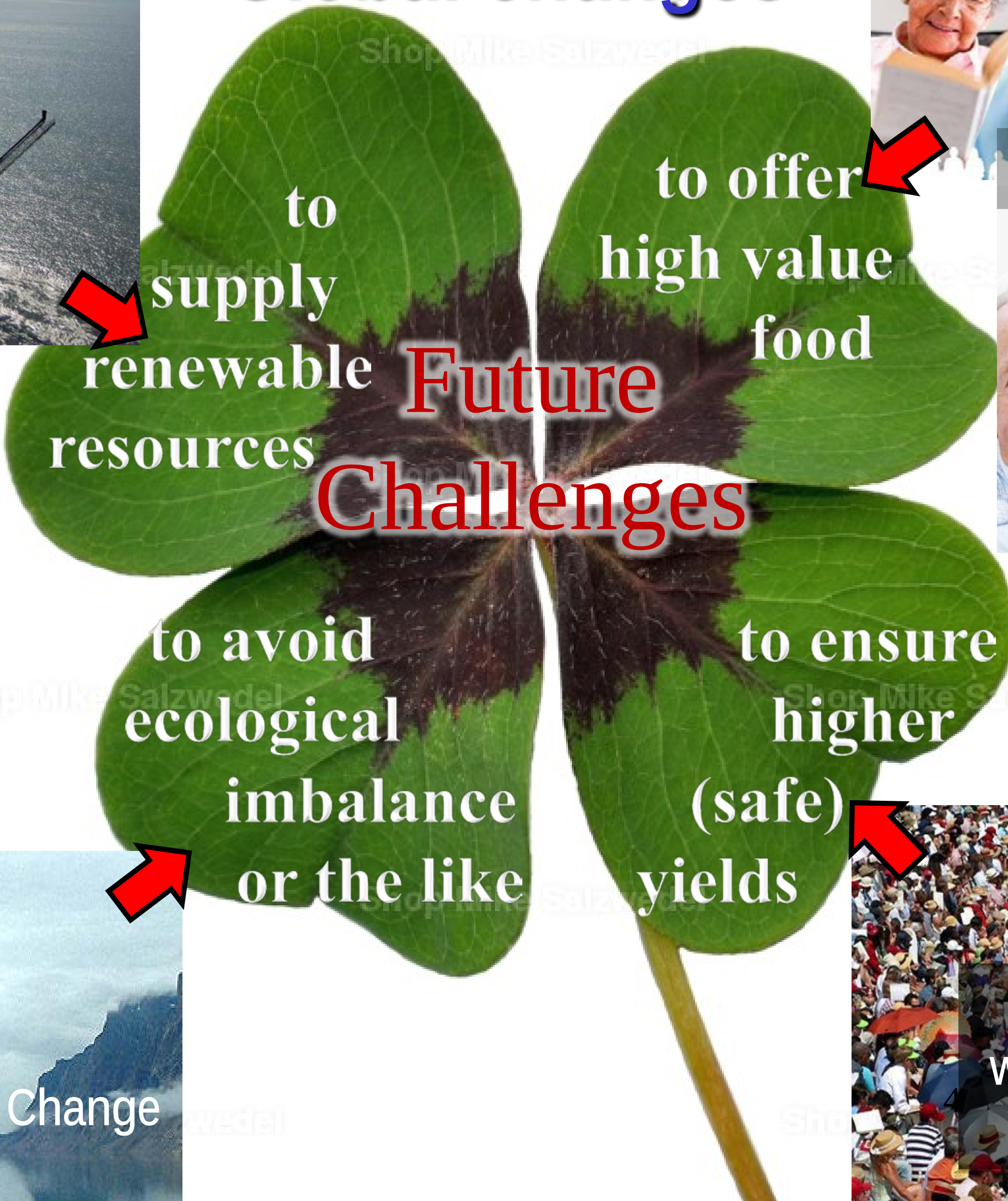


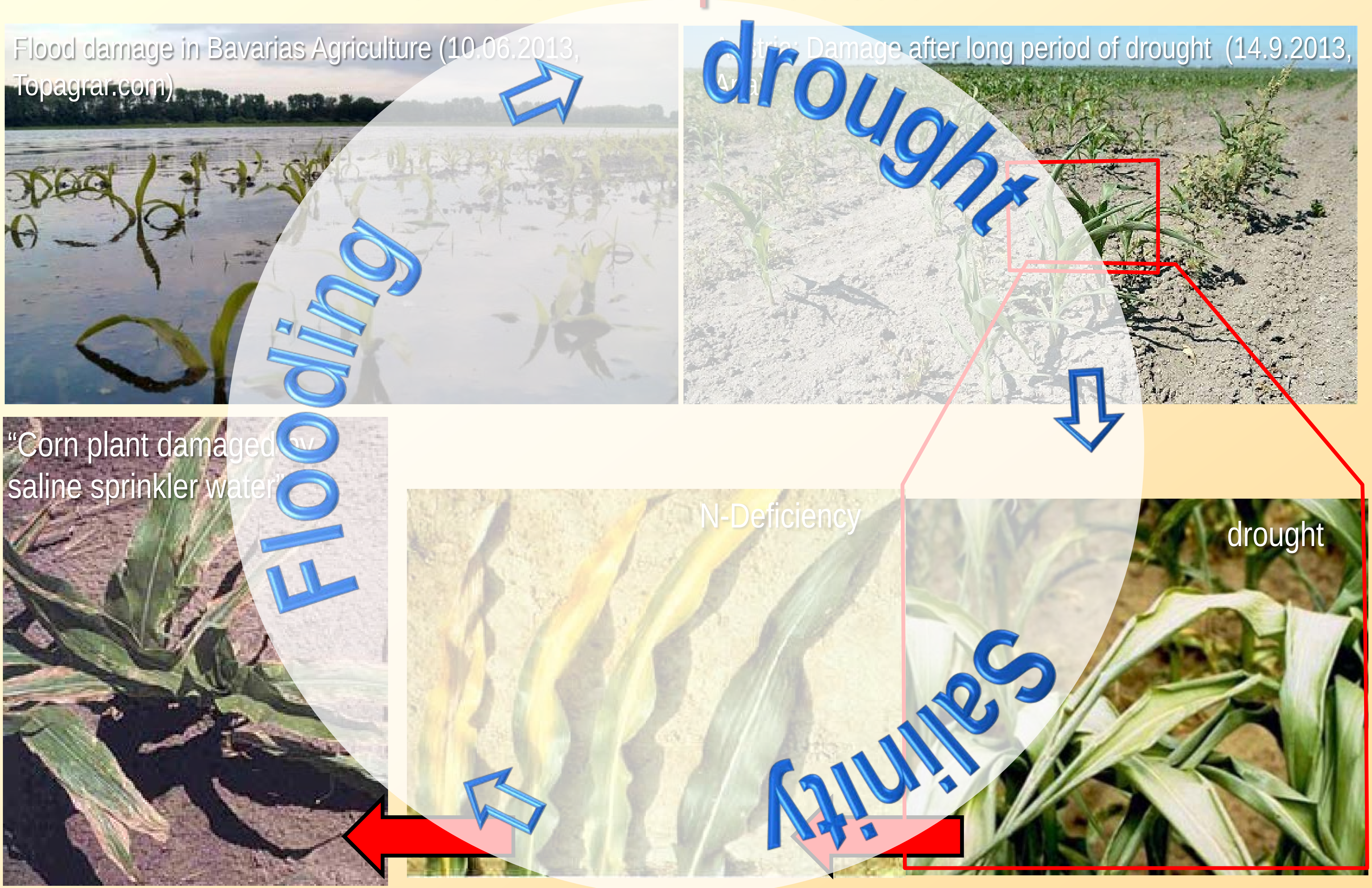
Chenopodium quinoa cv. Hualhuas

Atriplex nummularia

Global changes



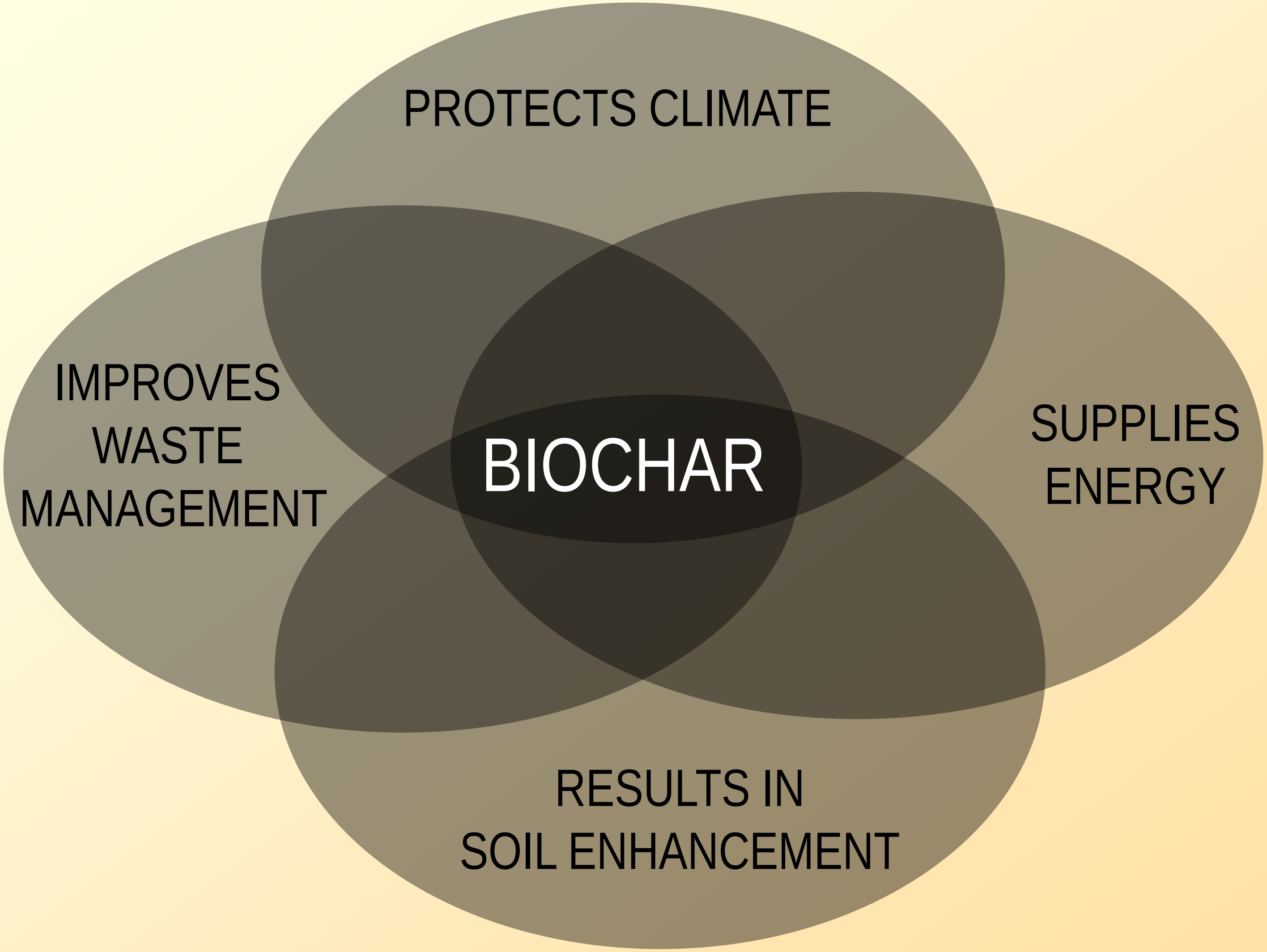
Impact of global climatic changes on biomass production



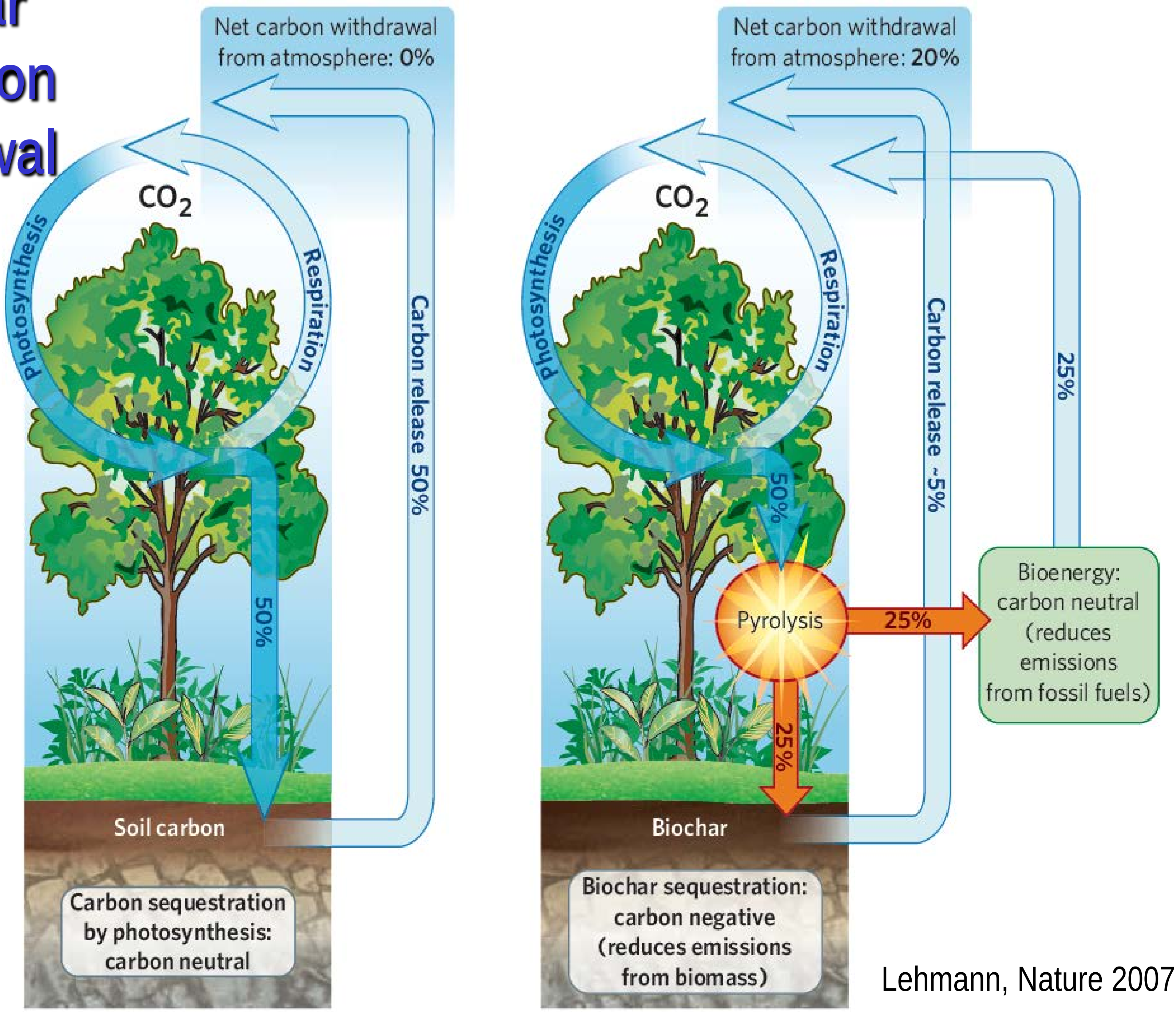
Soil-Plant-Atmosphere Continuum (SPAC)

- a) **Soil improvement** (such as amendment of biochar, compost and microorganismen) to improve germination, water and nutrient availability and reduce evaporation. This includes also the utilization of the GROASIS waterboxx and non-conventional domestic sewage or saline water resources
- b) **Improvement of atmosphere.** Increase of the atmospheric water potential or nutrient availability (CO_2)
- c) **Selection and breeding of adequate species** with low water consumption and high stress resistance (drought, salinity, heavy metal etc.)

To a) The potential benefits of biochar



BioChar net carbon withdrawal



Lehmann, Nature 2007

The impact of biochar on the plant response of Chenopodium quinoa Willd.

Control 50mg/l Cu 200mg/l Cu

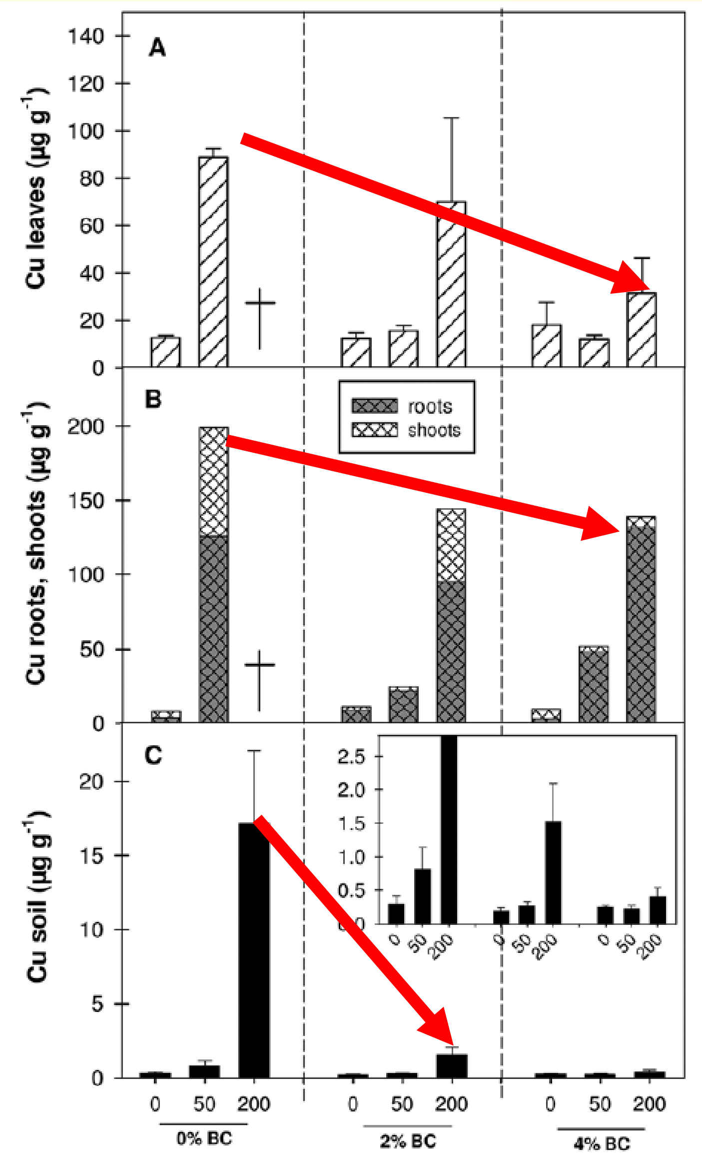


Fig. 4. Copper concentrations (mean + SD) of quinoa leaves (A), shoots and roots (B, composite samples), and potting soil (C) at the final harvest (insert: magnification of C). The Cu addition in mmol L^{-1} is given on the *x*-axis; below, the respective biochar (% BC) addition is denoted. Cross symbol: plant loss (death) 2 d after addition of 200 mmol L^{-1} Cu.

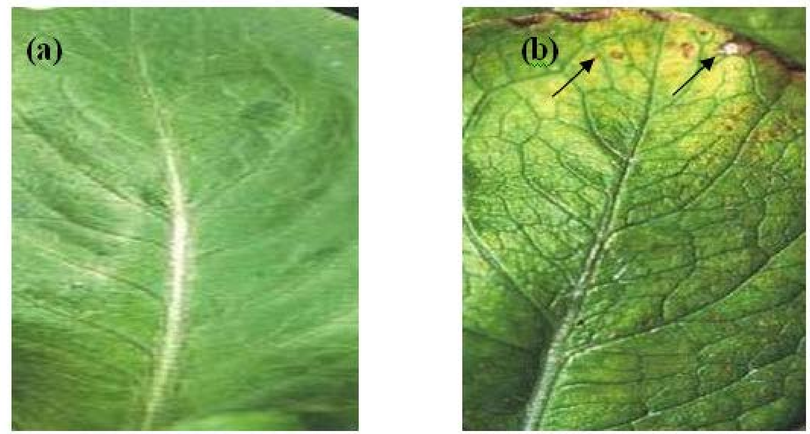
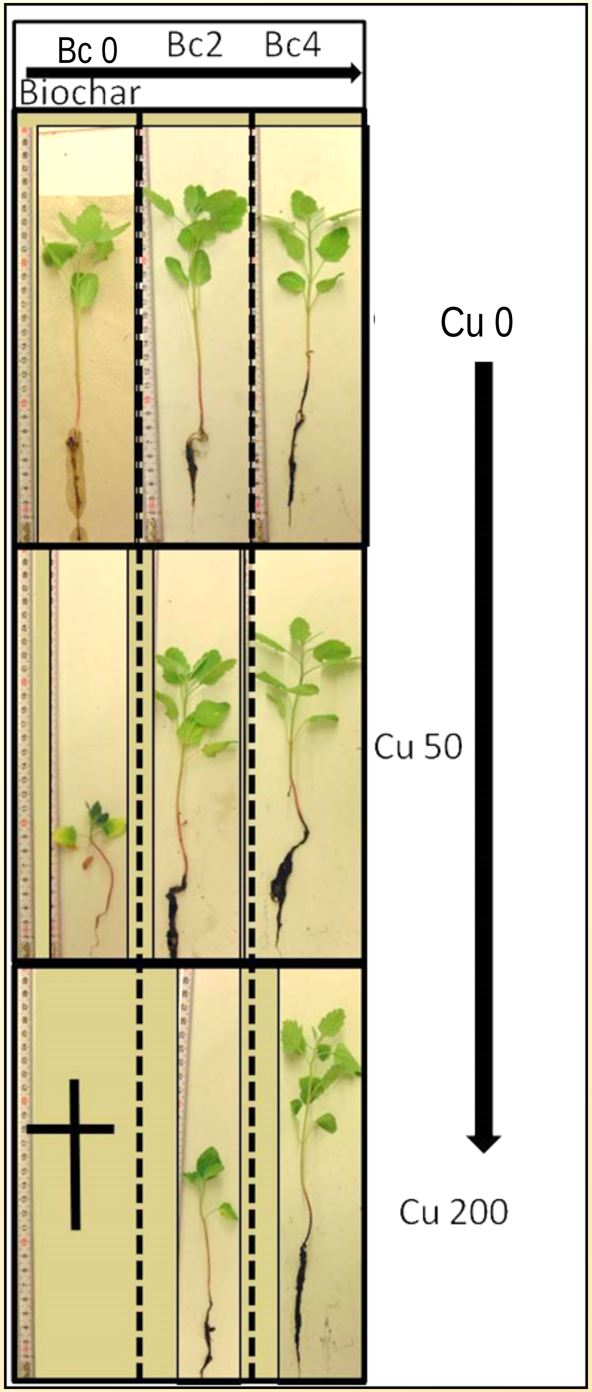
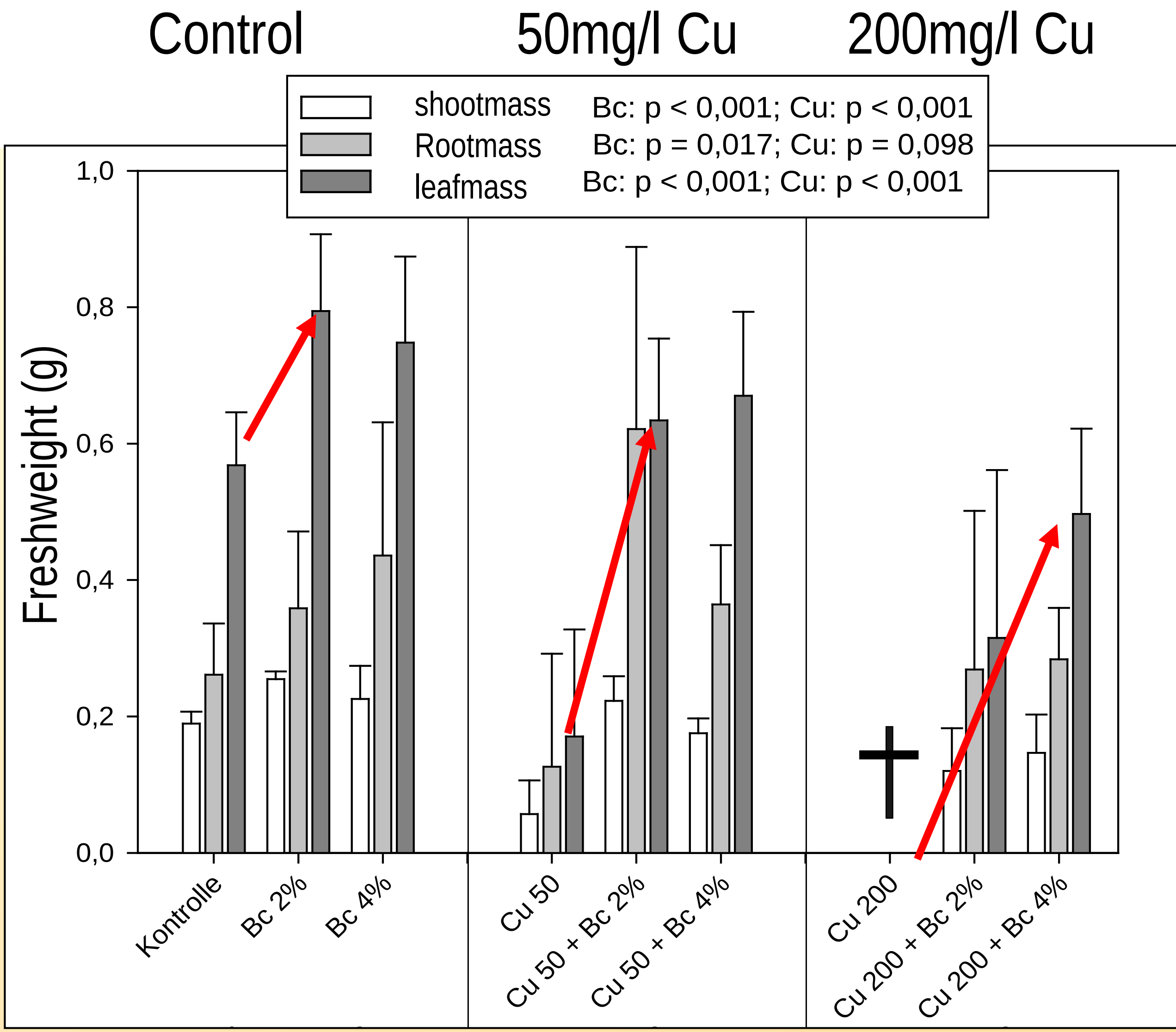


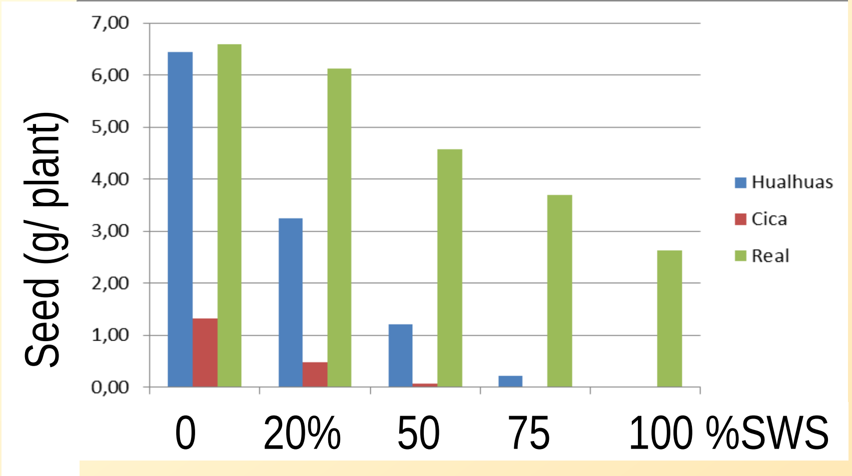
Fig 1. Small chlorotic stippling on the old leaves of the plant. (a) Control plants, (b) plants collected from urban and industrial areas. Arrows indicate Chlorotic and necrotic lesions on leaves

IPÖ (University of Gießen) Germany

The impact of biochar at Cu-Toxity on the plant response of quinoa







Chenopodium quinoa
September 2015 Gießen

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Impact of biochar addition on plant response under drought

→ Will Quinoa respond positively to biochar addition, and if so, what eco-physiological mechanisms are involved?

→ Will there also be a positive response under droughtness?

→ Is there a toxic biochar "dose", or is it "the more the better"?

Methods: fully randomized greenhouse study

Treatment factors

- Biochar application rates: 0, 100 and 200 t BC/ha * 20 cm depth (pot height)
- Water supply: 60% (control) and 20% (moderate stress) of control WHC

(n=4 pots / treatment; 9 weeks of study; daily water supply to target WHC; N fertilization: 100 kg N/ha in 3 application doses; final harvest; 2-way ANOVAs + Tukey test)

Measurements

<u>each pot (replicated)</u>

- H_2O consumption & osmotic potential
- Biomass, leaf area
- CN-, Chlorophyll- & Proline concentrations
- CO_2 respiration (plant; soil; both)

<u>one pot / treatment</u>

- A_{max}
- Light response curves
- RuBisCo concentration
- Transpiration
- WUE

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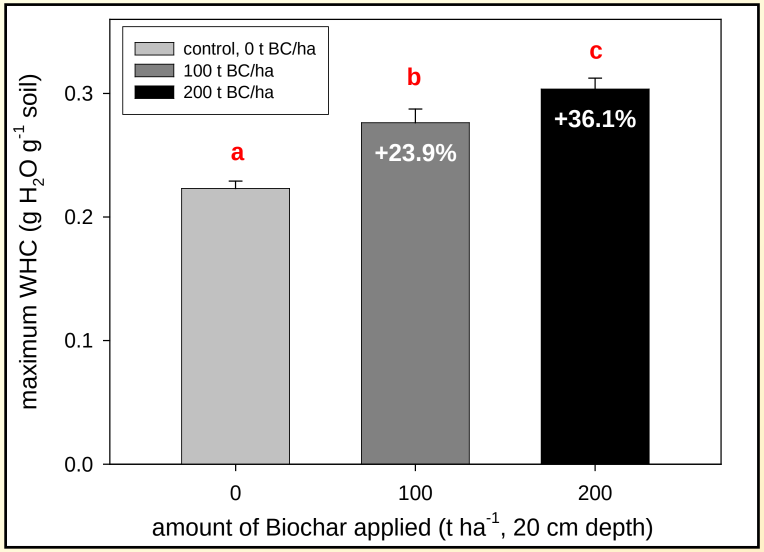
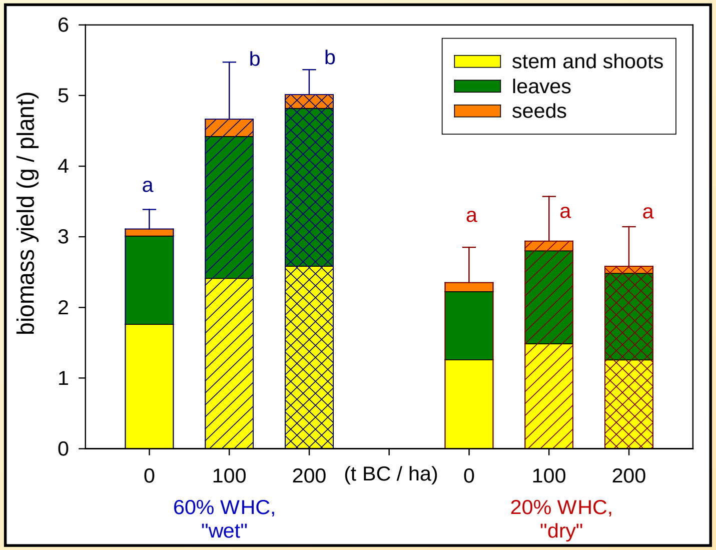
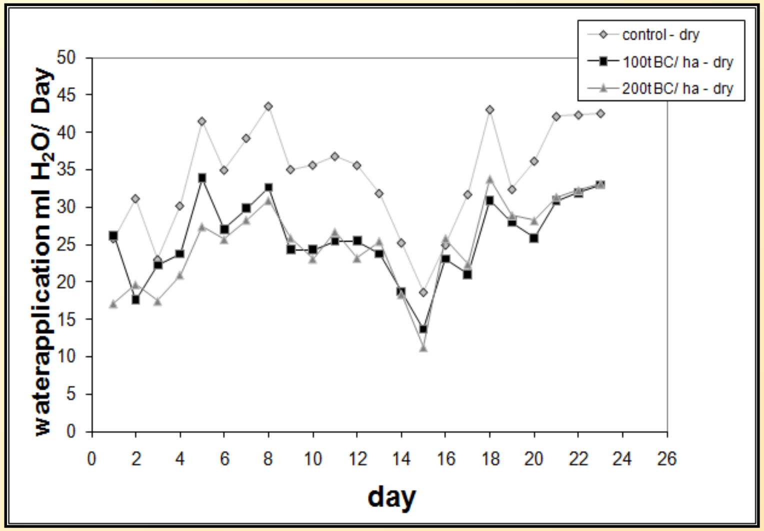
Results: BC effects on "soil water & water use"



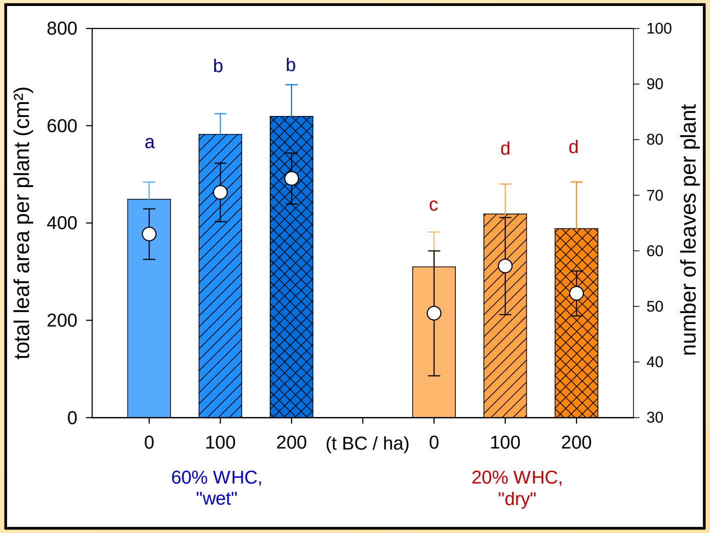
WHC significantly increased



Yield(s) significantly increased



water supply / consumption decreased



Total leaf area and No. of leaves increased

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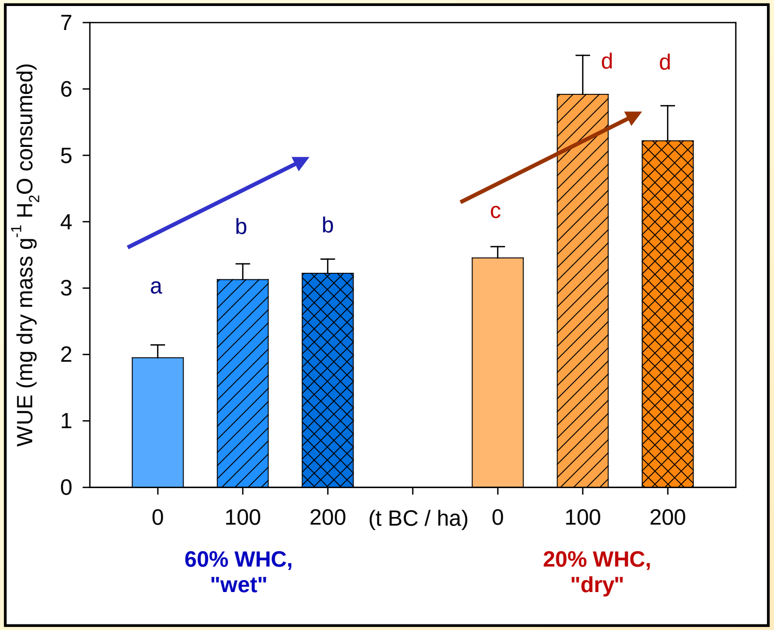
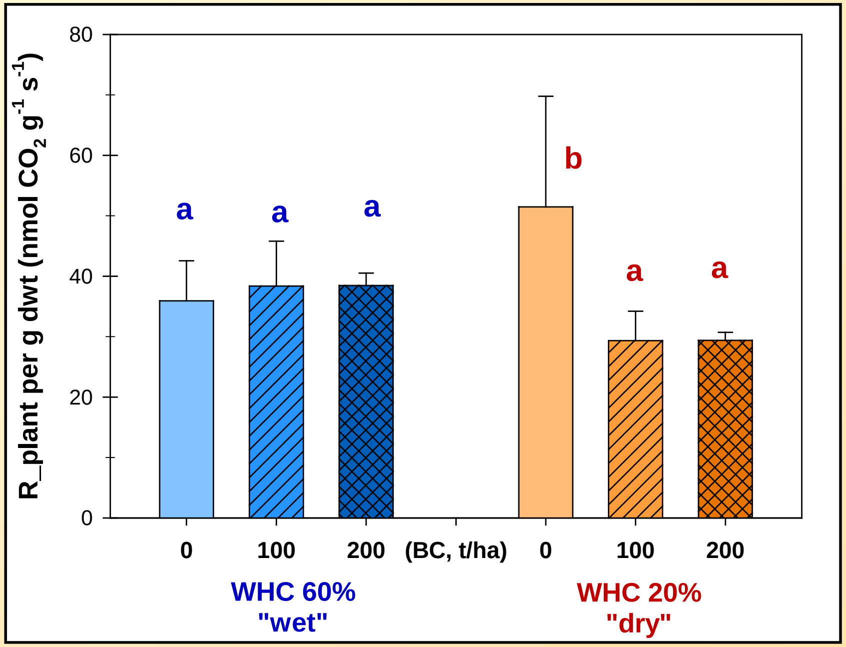
Results: BC effects on "soil water & water use"

~reduced water consumption plus ~higher yield + leaf area:



→ BC appl. increased WUE, significantly more with water stress



☞ CO_2-Respiration:

BC did not cause larger CO_2 loss by respiration despite larger plants, neither below- nor above-ground.

....note: the highest BC application (200 t) is not linearly better than 100 t !

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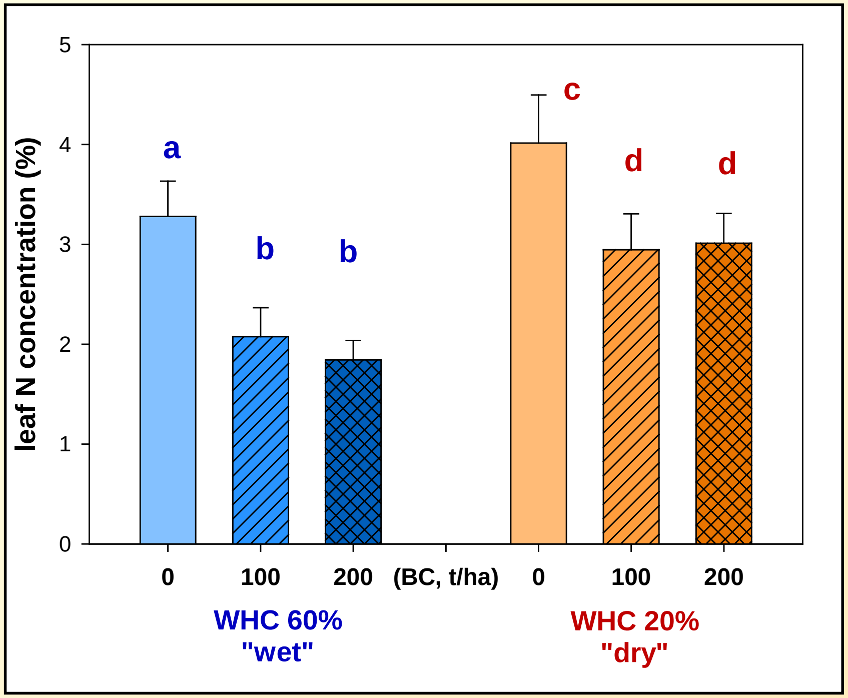
BC effects on " N use & photosynthesis"



Lower N concentration with BC-appl. In leaves was reflected by:

1. Significantly reduced relative chlorophyll (entire experiment)
2. Significantly reduced proline conc.
3. Reduced RuBisCO concentration
4. Reduced A_{max}, reduced $R_{leaf, dark}$
5. Reduced transpiration
6. Increased WUE_P

- N conc. in leaves: reduced with BC
- N total (all leaves per plant):..identical!

→ *Higher NUE with BC*

→ *Higher WUE_P with BC*

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Biochar - a promising tool… next: further field trials!

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Thank you for your attention!