JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Hochschule Geisenheim University

DFG Deutsche Forschungsgemeinschaft

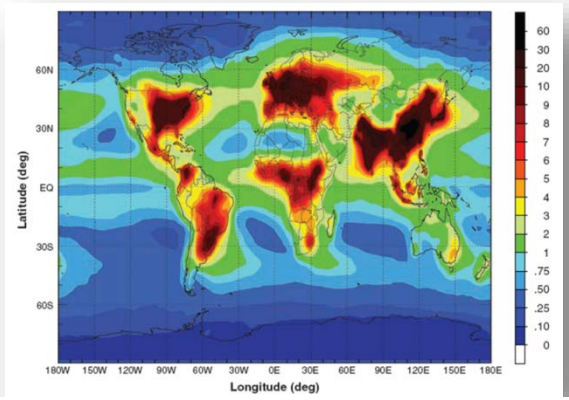
cost eBRN

Biochar als Stickstoff-Fänger?

Unerwartete Ergebnisse und erste mechanistische Einsichten

C. Kammann with contributions from

N. Messerschmidt, H.-P. Schmidt, G. Haider, J. Mengel, S. Linsel, T. Clough, O. Löhnertz, D. Steffens, H.-W. Koyro, C. Müller und P. Conte



Galloway et al. 2008 (Science)

BC Studies – Lab, Greenhouse, Field

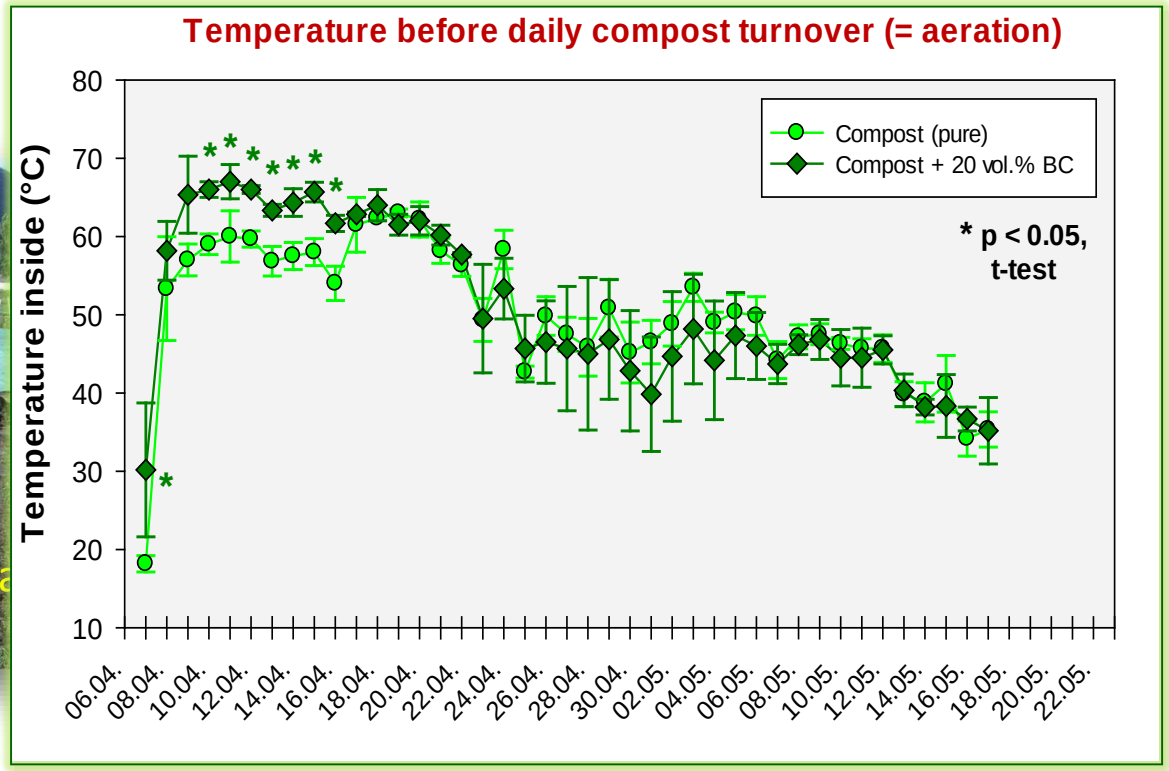
….N retention?

BC-Kompostierung: Temperatur & N_2O

ithaka institute

Aerobic quality composting (n=3), ±20 Vol.% Biochar

N = 3; 20 vol.% BC



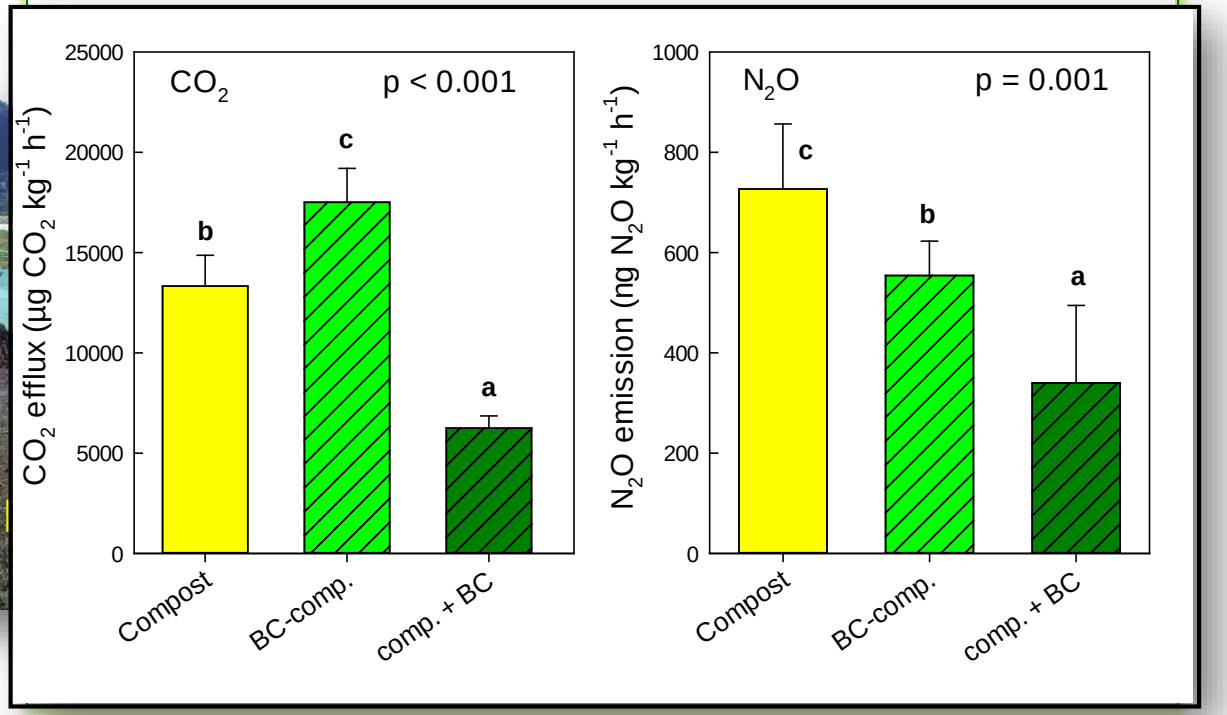
BC-Kompostierung: Temperatur & N_2O

ithaka institute

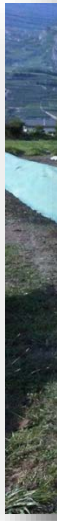
Aerobic quality composting (n=3), ±20 Vol.% Biochar

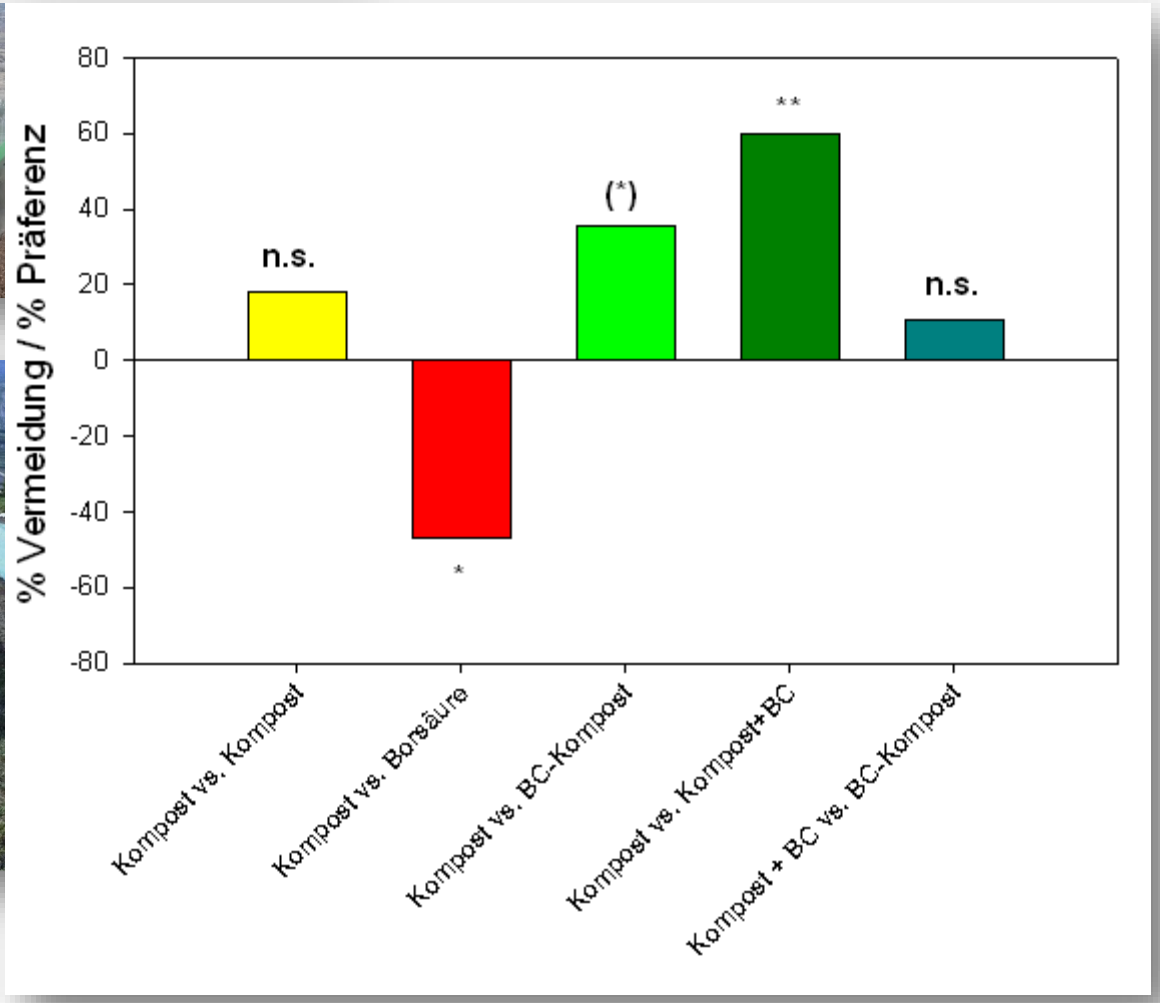
N = 3; 20 vol.% BC

Temperature before daily compost turnover (= aeration)



BC-Kompostierung: Regenwurm- u. Pflanztests positiv





ISO–17512

BC-Kompostierung: Regenwurm- u. Pflanztests positiv

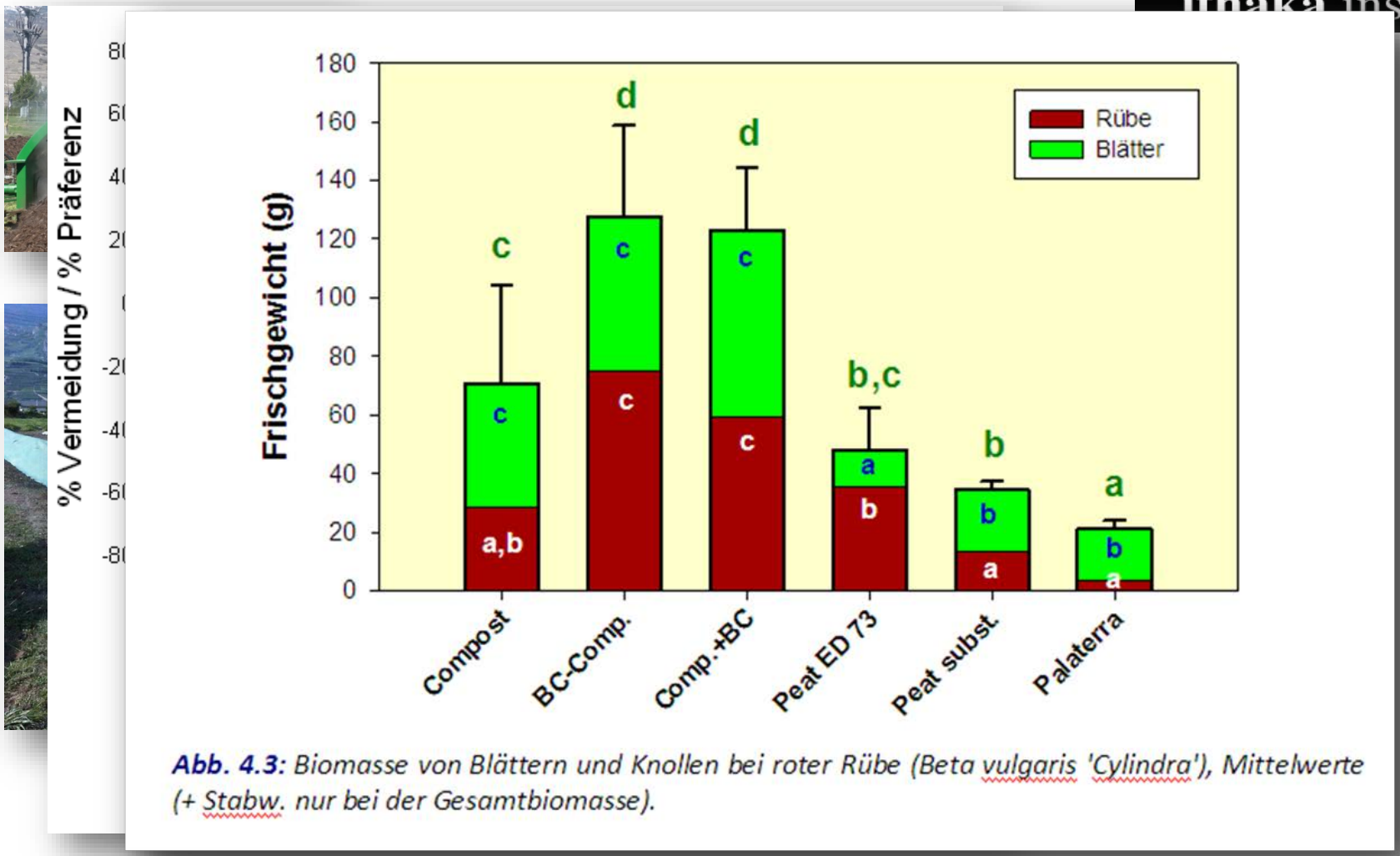


Abb. 4.3: *Biomasse von Blättern und Knollen bei roter Rübe (Beta vulgaris 'Cylindra'), Mittelwerte (+ Stabw. nur bei der Gesamtbiomasse).*

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BC-Kompostierung: “Alterung” – und Nährstoffbeladung?

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Aerobic quality composting (n=3), ±20 Vol.% Biochar

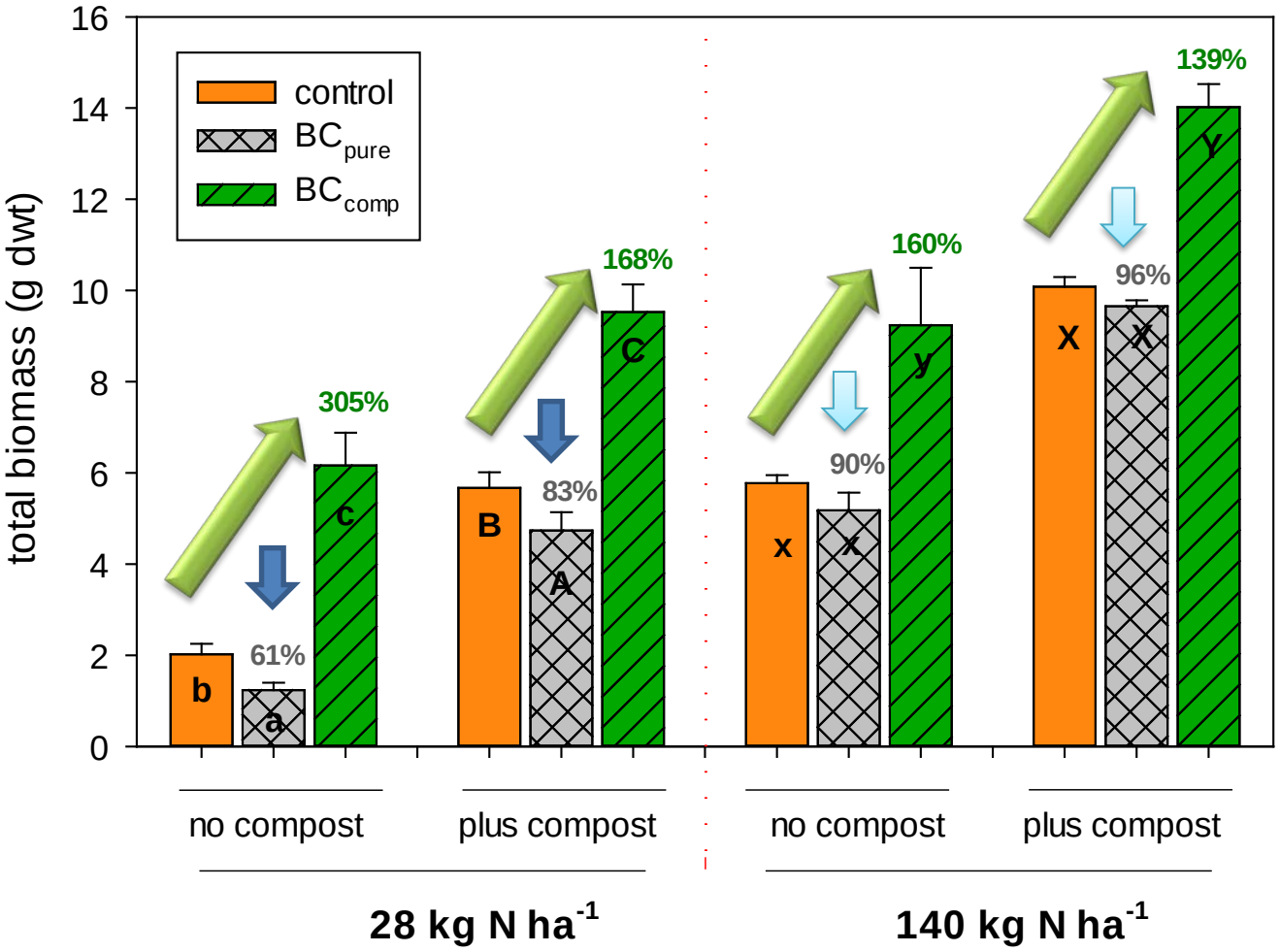
3 mm < BC particles < 5mm

3 Faktoren

1. Kompost-Addition (± 2% w/w)
2. N-Düngung (28 vs 140 kg N/ha)
3. **Kontrolle**, **BC_{pure}** **BC_{comp}** (± 2% w/w)

→ Gewächshaus, Gefäßversuch (*Quinoa*)

Pflanzenwachstum: BC_{comp} >> BC_{pure}!



Different letters = significant biochar effects within bar group; 3-way ANOVA, p<0.05

(Kammann et al., in prep.)

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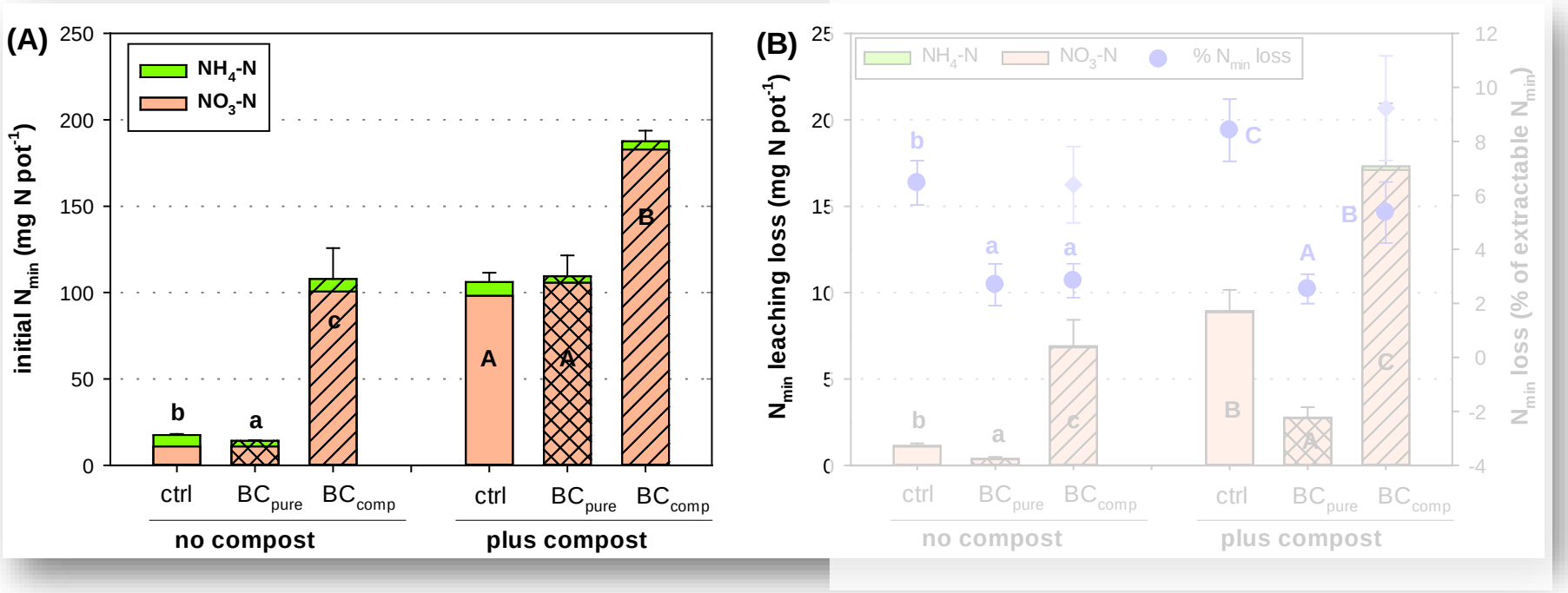
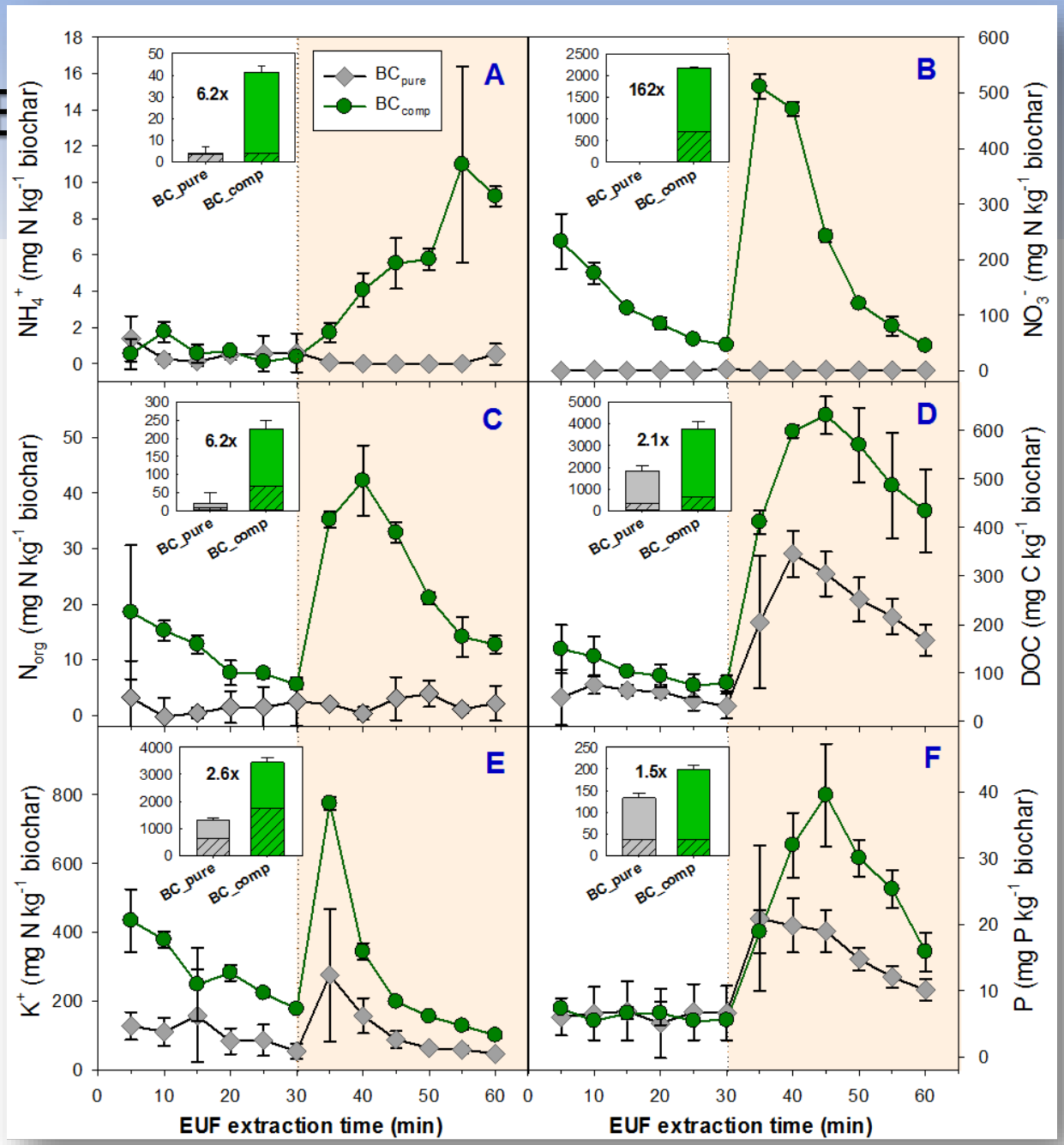
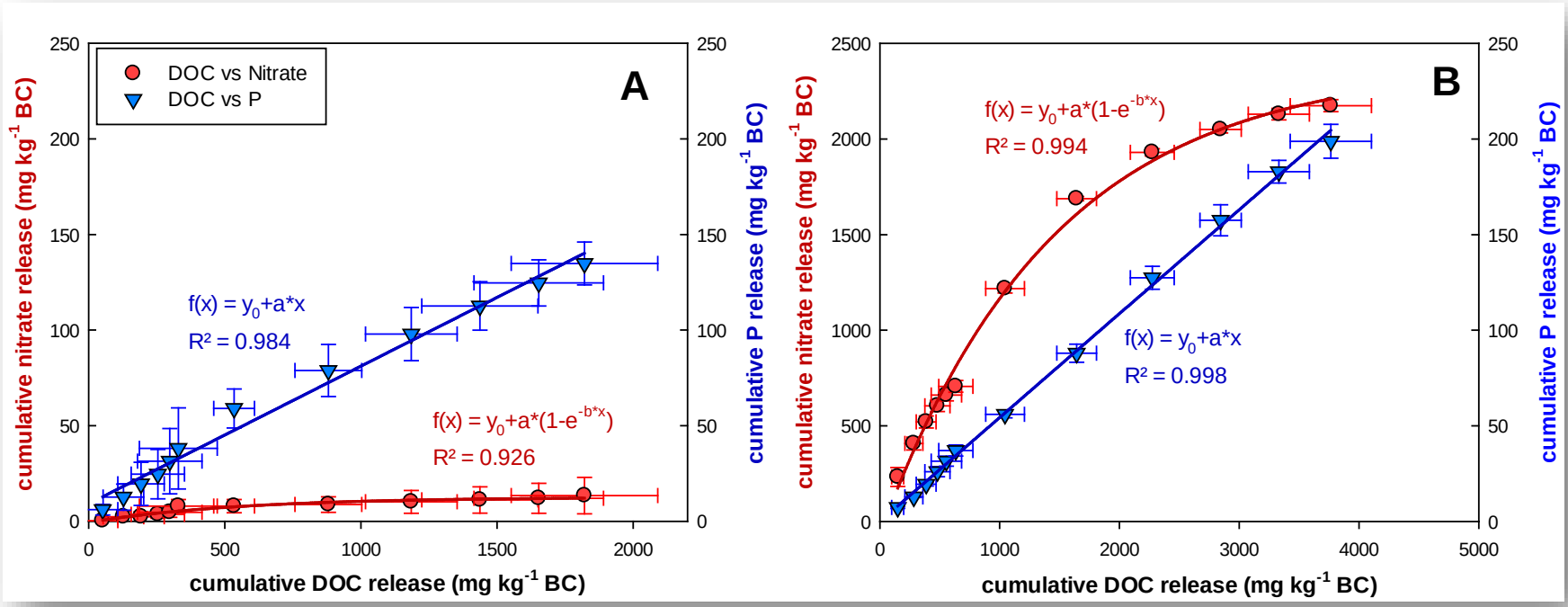
BC_{comp} >> BC_{pure} – Nährstoffeffekte?




A
B
C
D
E
F
BC_pure
BC_comp
6.2x
162x
6.2x
2.1x
2.6x
1.5x
NH4+ (mg N kg-1 biochar)
NO3- (mg N kg-1 biochar)
Norg (mg N kg-1 biochar)
DOC (mg C kg-1 biochar)
K+ (mg N kg-1 biochar)
P (mg P kg-1 biochar)
EUF extraction time (min)
EUF extraction time (min)

N- und P-Sorption: Korrelation mit C_{org} ?



Nitratfreisetzung: Funktion der Partikelgröße?

Pflanzexperiment: s0 = 3 – 5 mm

		%N	%C
BC-pure	Mean	0,43	81,02
	Stdev	0,06	0,20
	CV	13,3	0,2
BC-comp	Mean	1,04	75,00
	Stdev	0,030	1,596
	CV	2,8	2,1

S1: 2 – 5 mm
S2: 5 – 6.2 mm
S3: 6.2 – 8 mm

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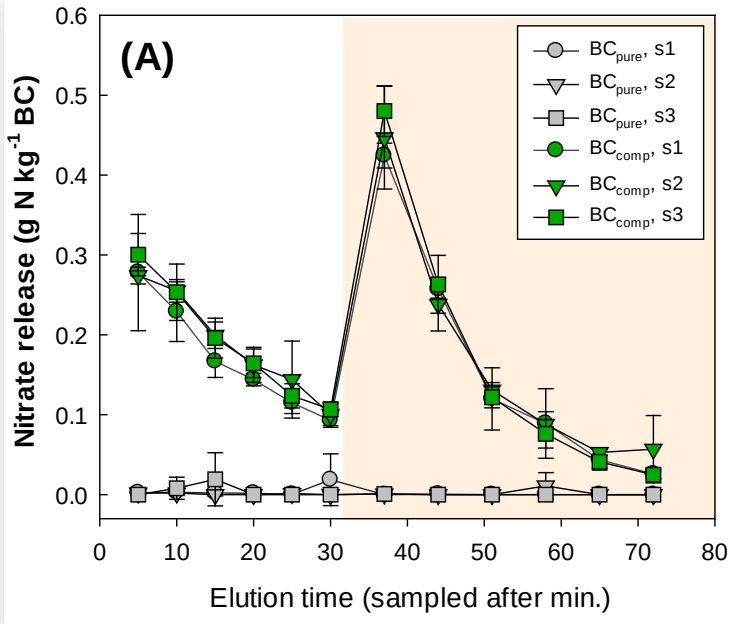
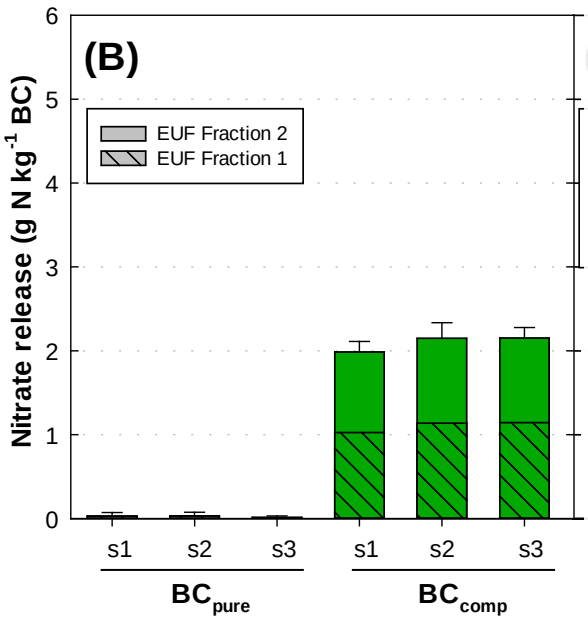
Nitratfreisetzung: Funktion der Partikelgröße?





"Abwasch"…!

1. H_2O – 1 h,
2. H_2O – 24 h
3. 2M KCl – 1 h
4. 2M KCl – 24 h

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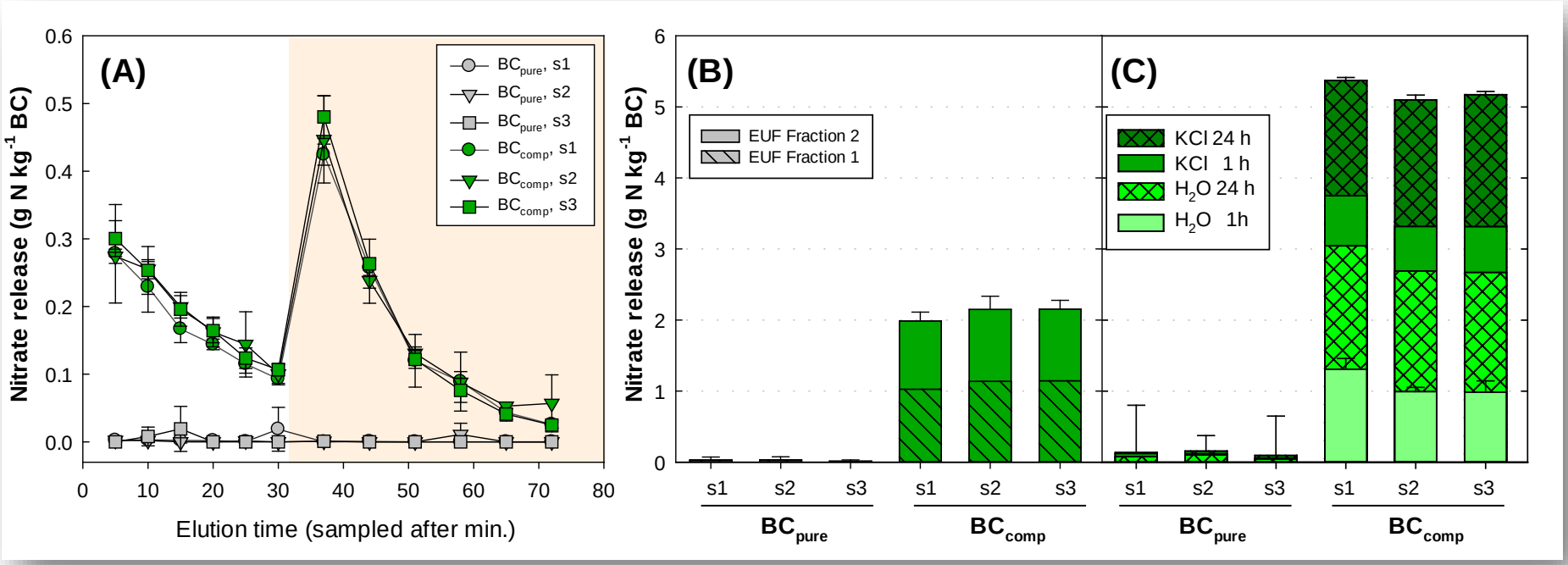
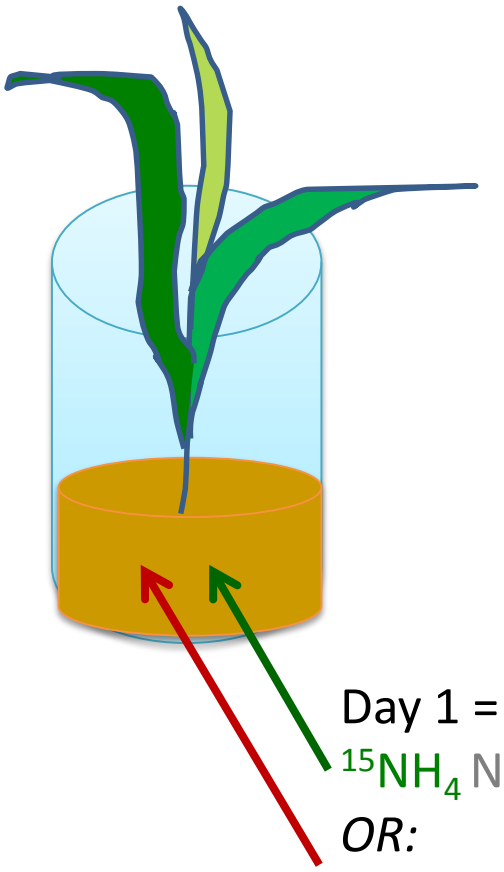
Nitrat-Bindung: Mehr als gedacht….



^{15}N *labeling tracing* Studie mit Gerste



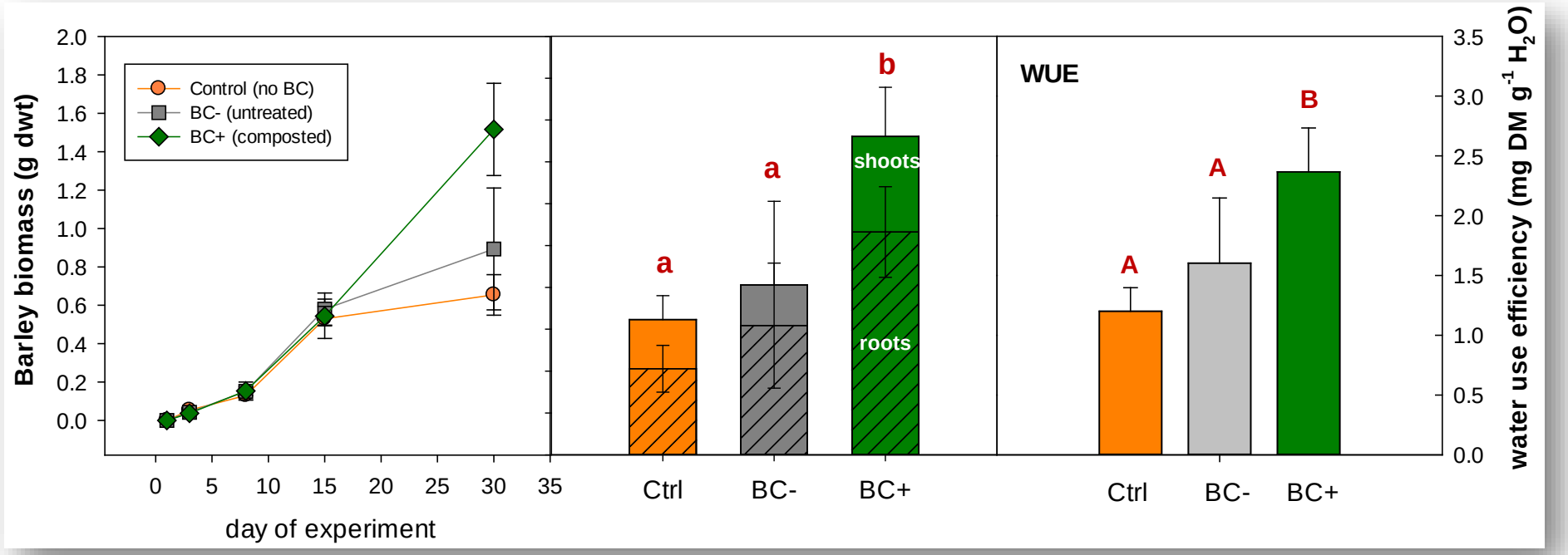
METHODEN

- *200g Sandboden Lufa 2.2*
- *WHC 65%*
- *+ 3 Gersten-Keimlinge*
- *Beprobung Tag 1, 3, 8, 15, 30*
- *Ernte: KCl-extr.; plants; BC particles; N_2O fluxes; alle: N Konzentrationen & ^{15}N*

TREATMENTS

Control, **BC_{pure}** and **BC_{comp}** (± 2% w/w)

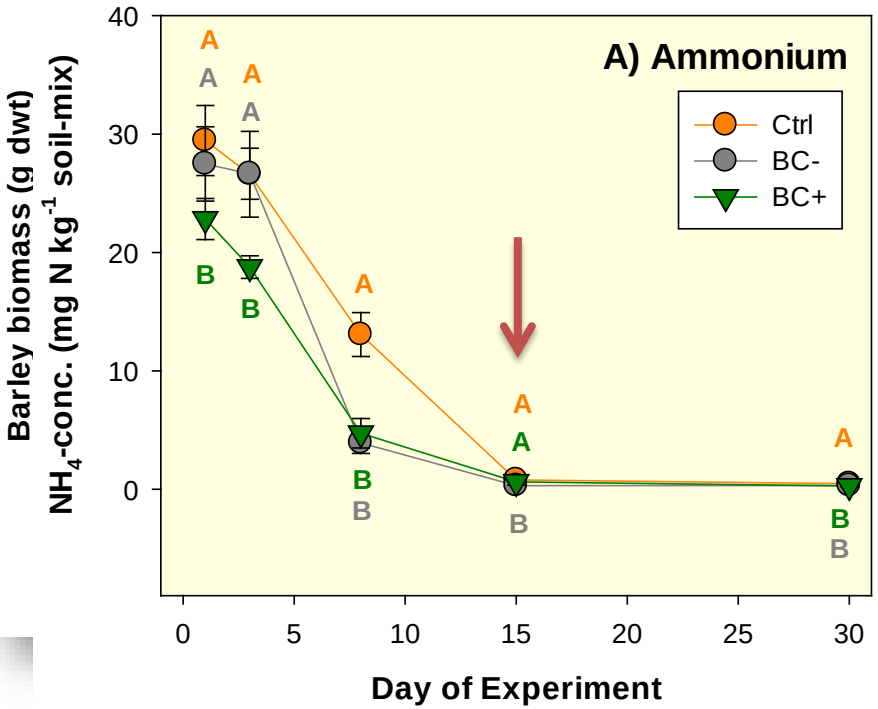
Gerste-Biomasse und WUE_{prod}



→ *Biomasse gesteigert mit BC-comp…*

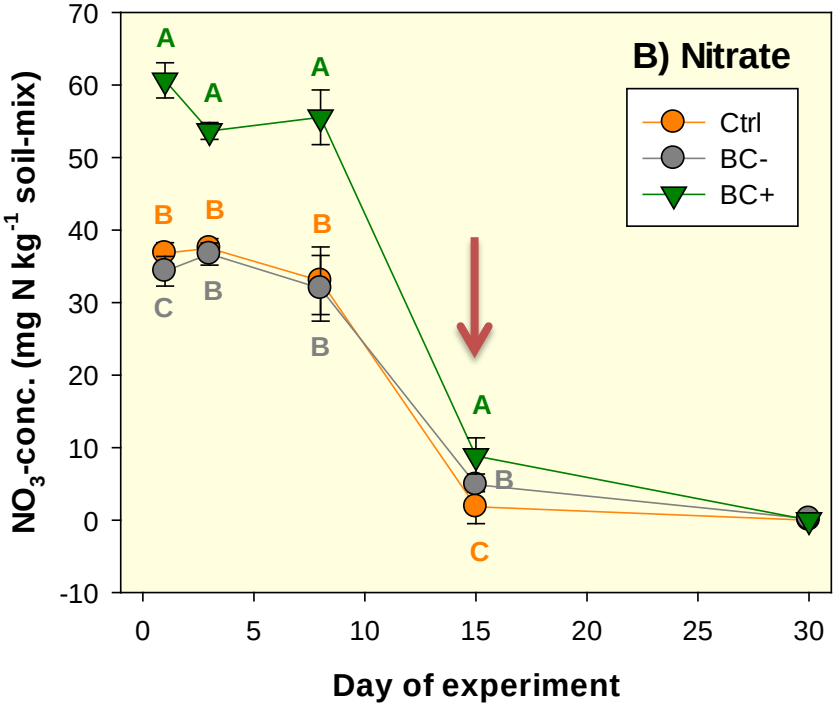
→ *…erst nachdem N-min "verbraucht" war!*

Gerste-Biomasse und N_{min} Verbrauch



^{15}N-species effect (2-way ANOVA):

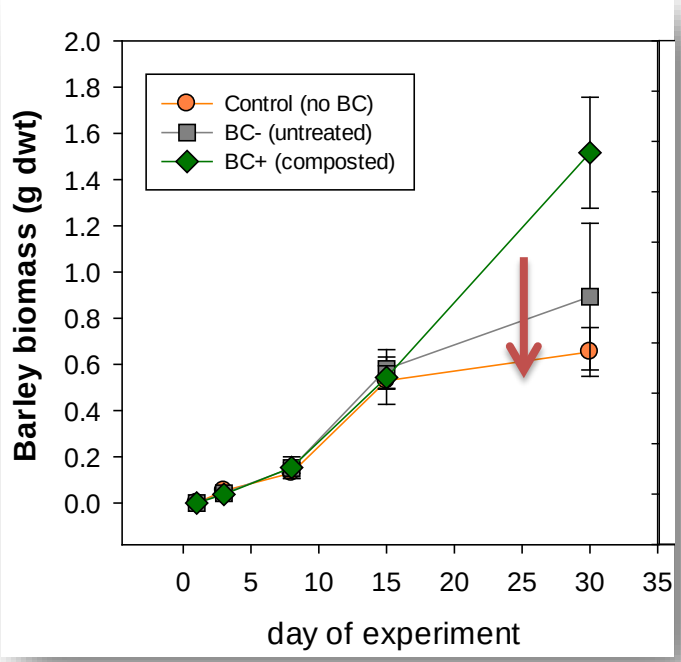
day1	day 3	day 8	day 15	day 30
n.s.	n.s.	n.s.	n.s.	n.s.



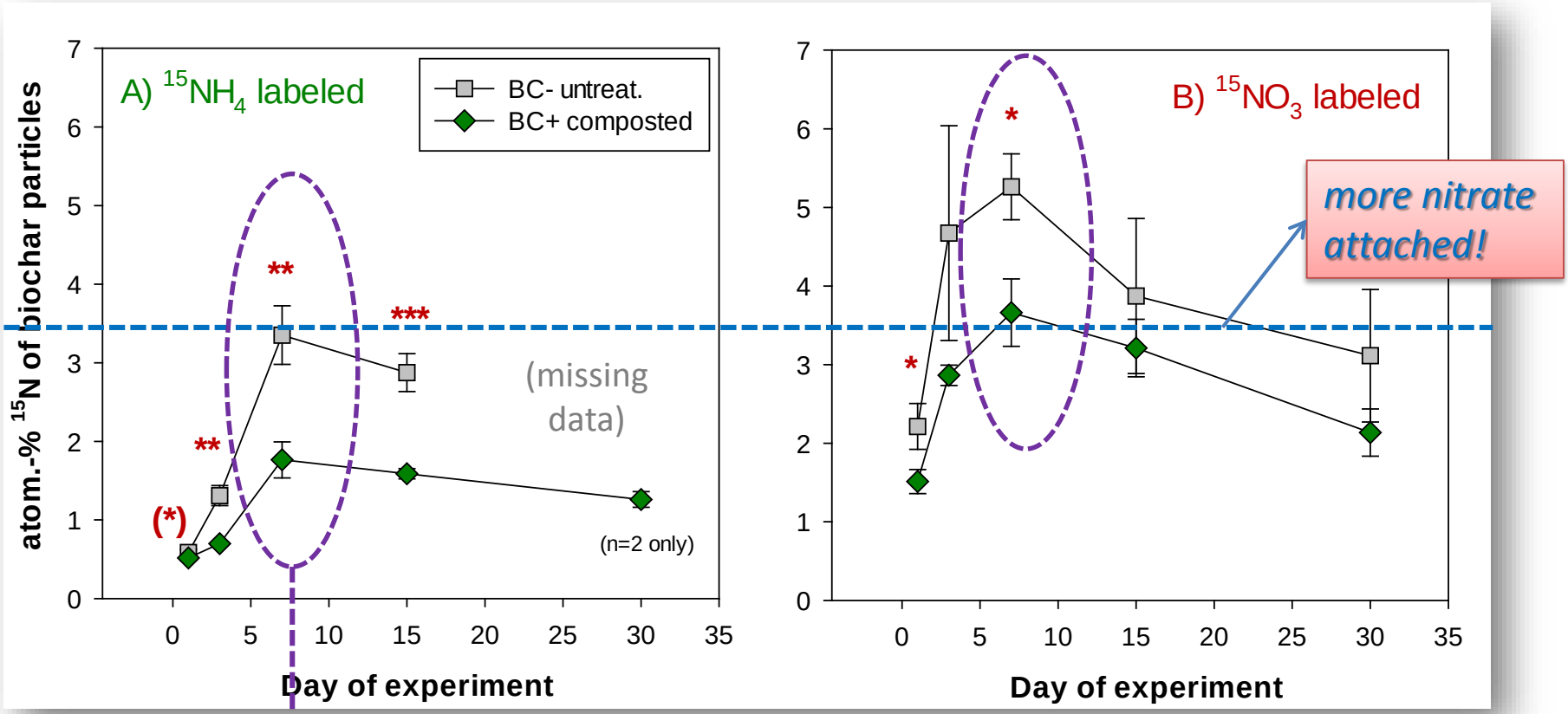
^{15}N-species effect (2-way ANOVA):

day1	day 3	day 8	day 15
n.s.	n.s.	n.s.	n.s.

Gerste-Biomasse und N_{min} Verbrauch



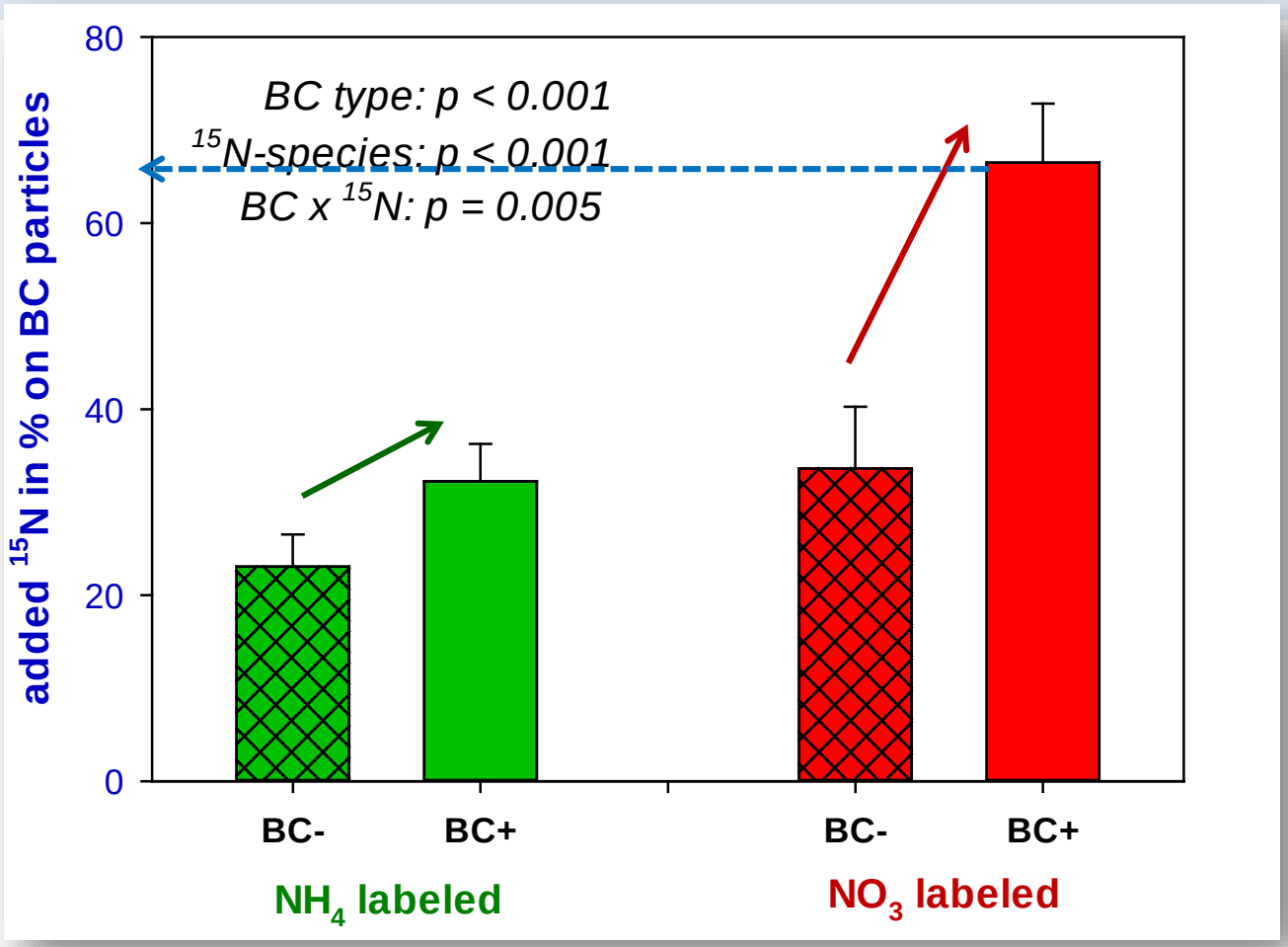
^{15}N auf Biochar-Partikeln….? *Yes…!*



Wie viel ist dies vom zugefügten ^{15}N ….?

^{15}N auf Biochar-Partikeln….? *Yes…!*

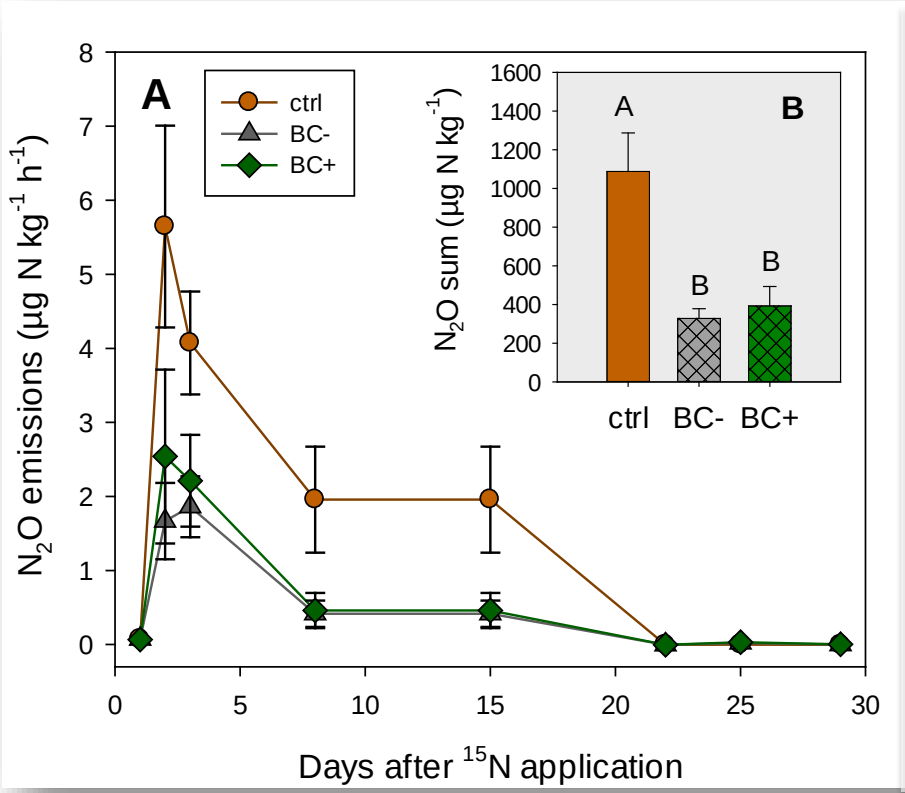
….und nicht nur etwas, sondern viel!

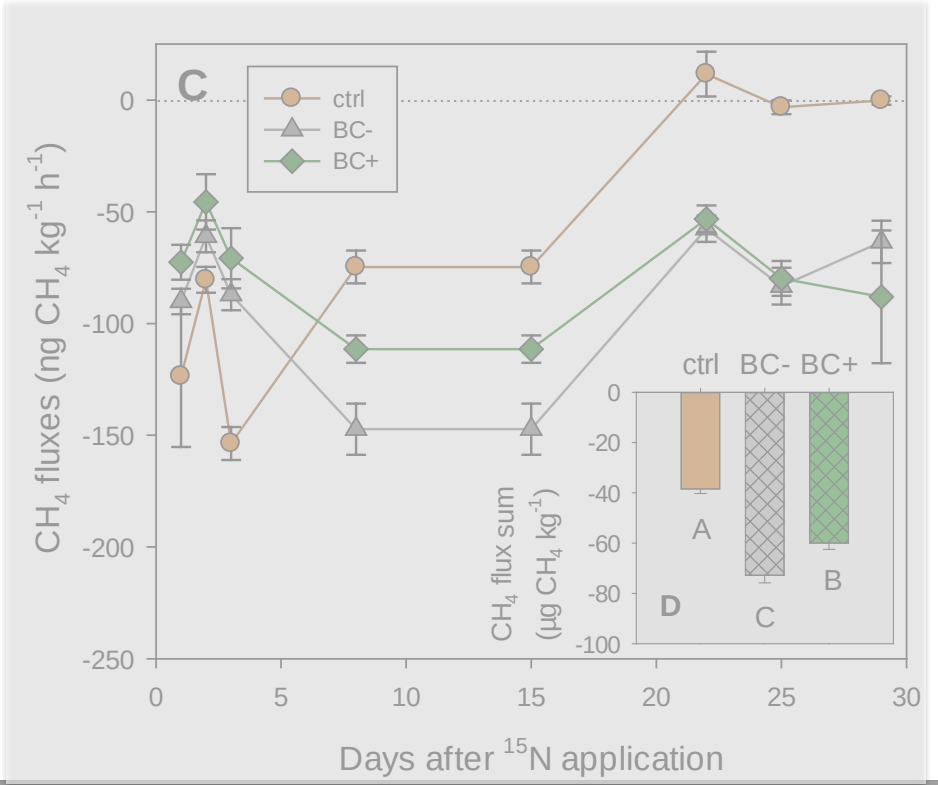


DAY 8 (3rd sampling)

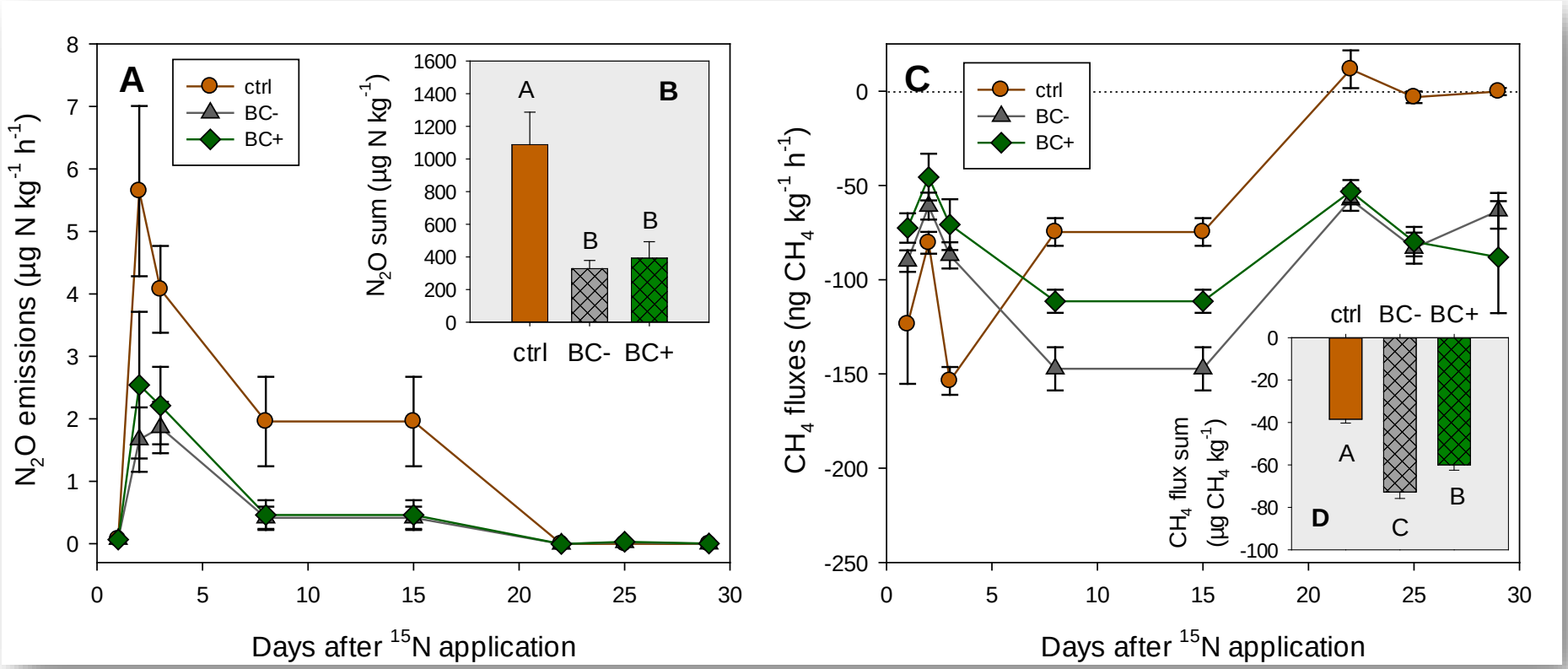
→ *Biochar-Partikel mit DOC + Nitrat: Denitrification hot spots….?*

N_2O Emissionen dennoch reduziert

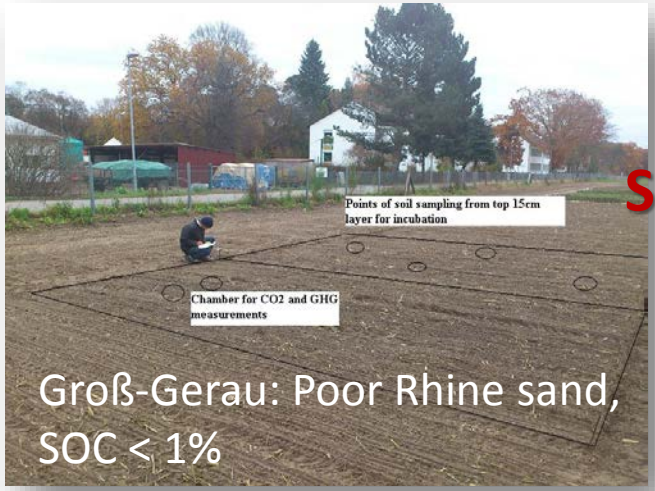




N_2O Emissionen dennoch reduziert



Feldstudie Groß-Gerau, Sandboden: N-Retention im Biochar-Horizont…



Subsoil

Start April 2012:

- F1: 0, 15 and 30 t/ha biochar
- F2: +/- irrigation

Biochar: 0-15 cm

Soil profile sampling 20th February 2014

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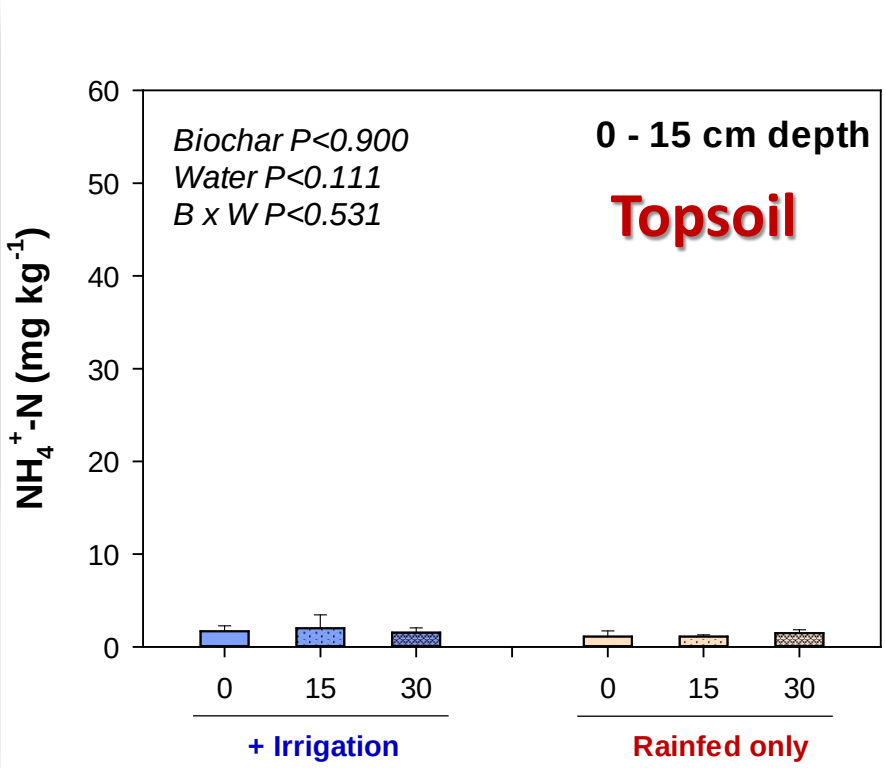
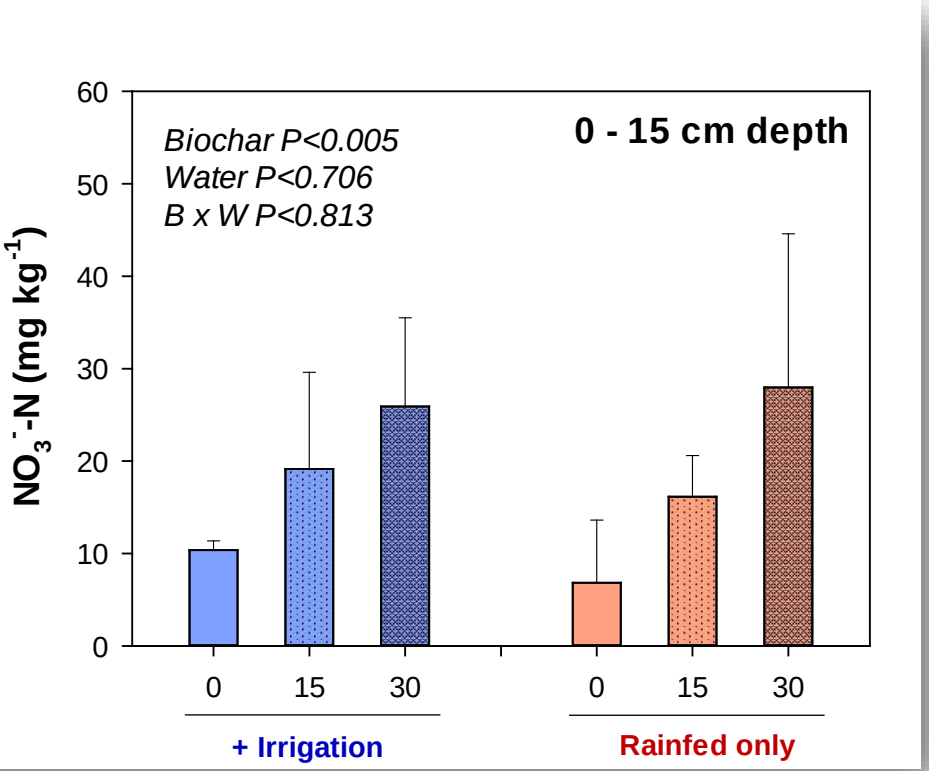
Feldstudie Groß-Gerau, Sandboden: N-Retention im Biochar-Horizont…

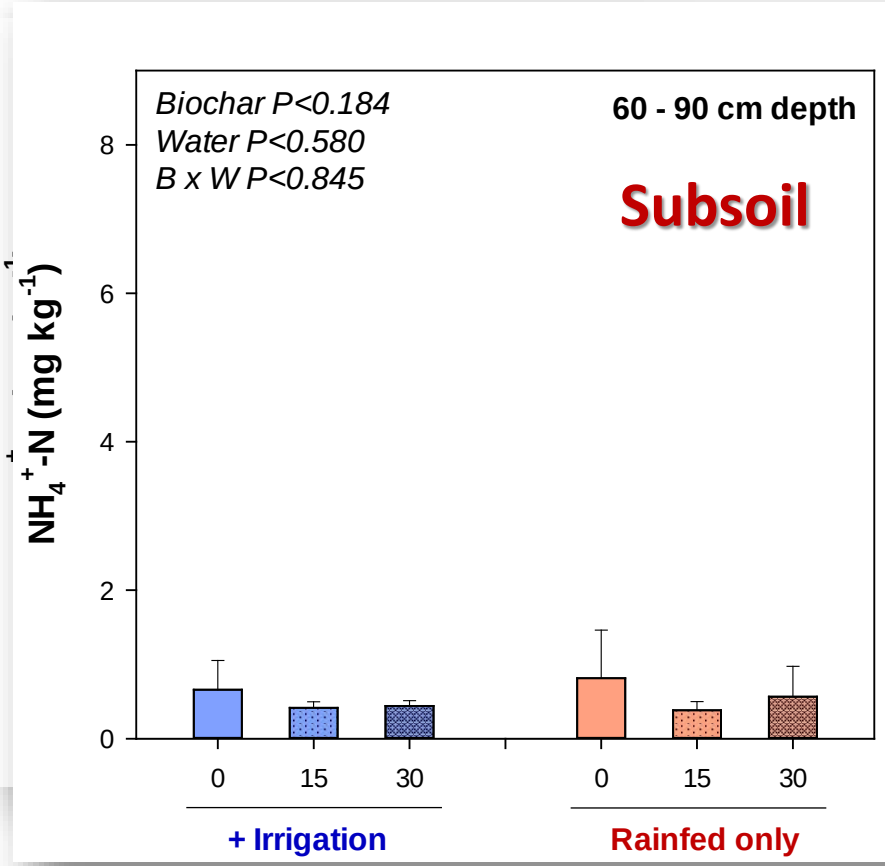


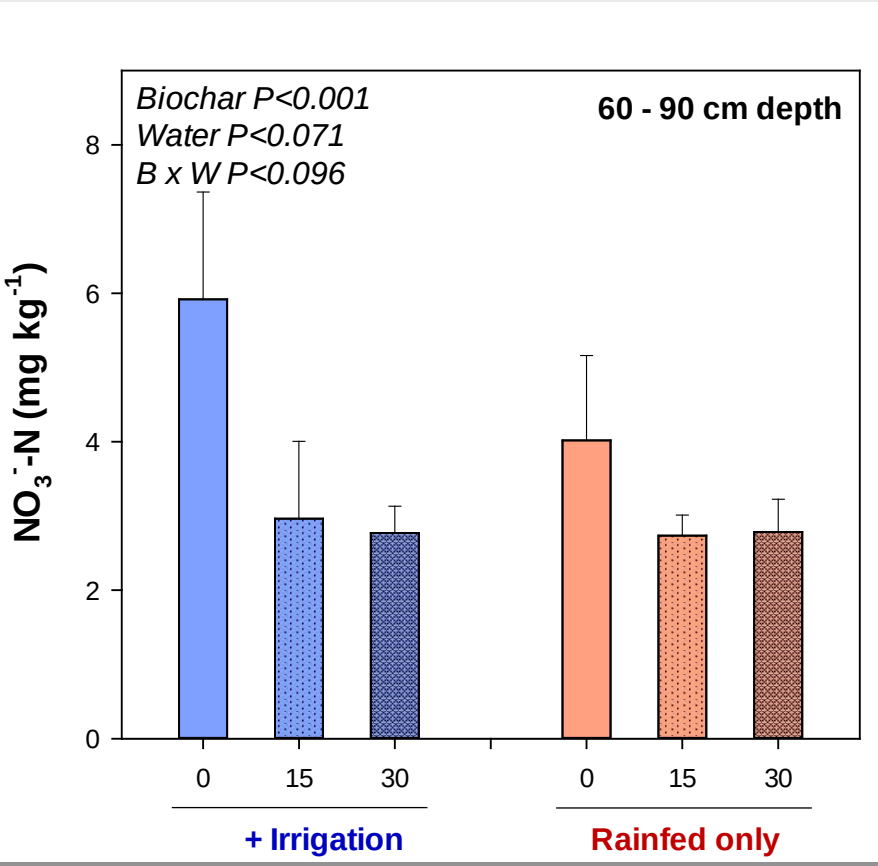


Biochar: 0-15 cm

Soil profile sampling 20th February 2014

Feldstudie Groß-Gerau, Sandboden: N-Retention im Biochar-Horizont…





Biochar: 0-15 cm

Soil profile sampling 20th February 2014

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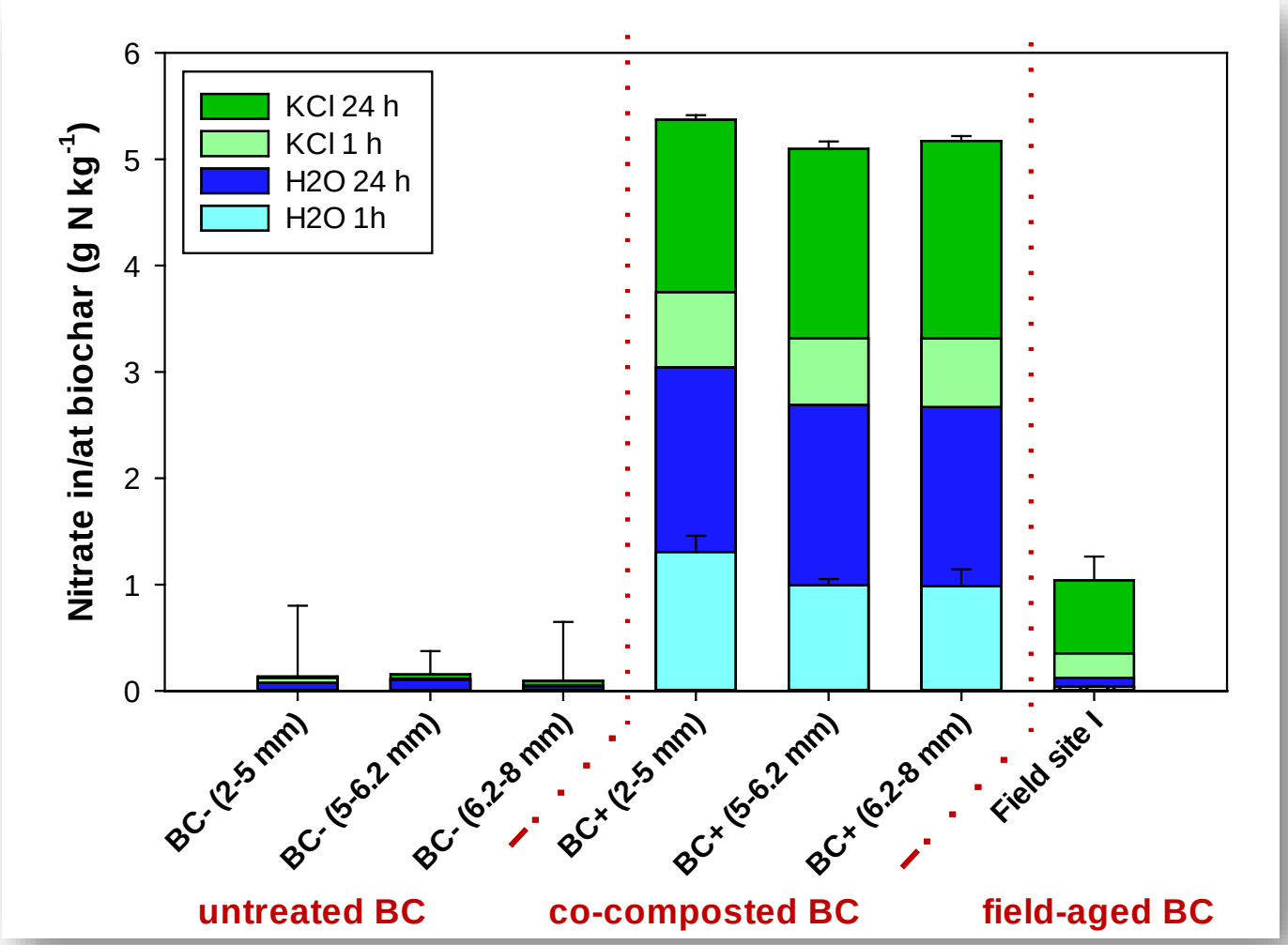
Feld-BC: "Beladung" schlechter als bei BC_{comp}



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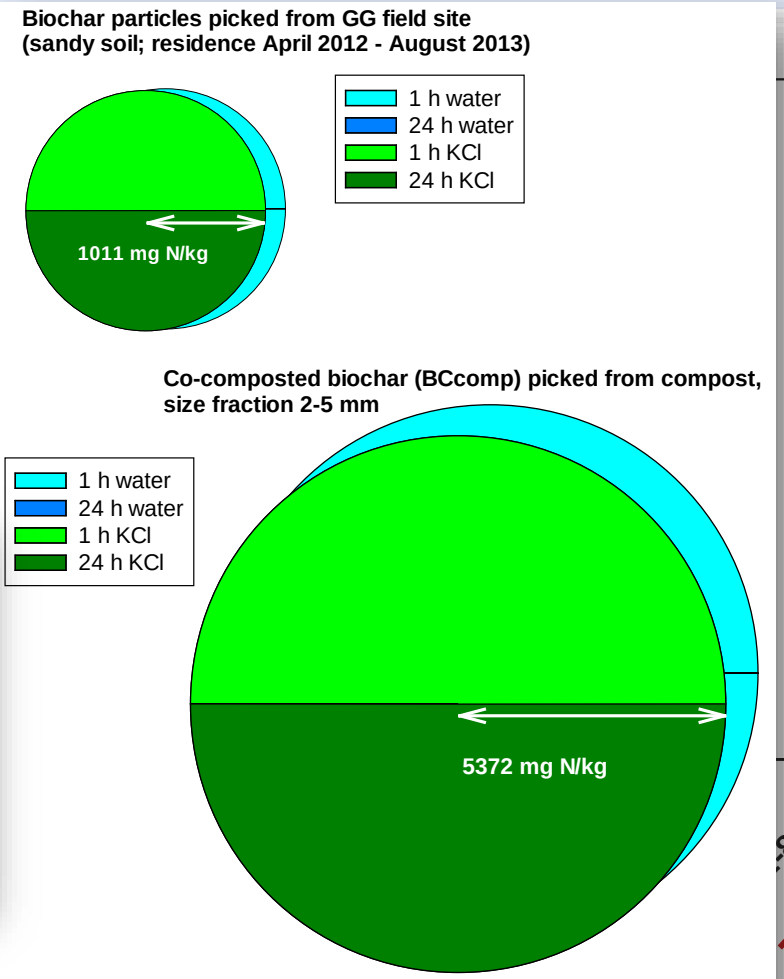
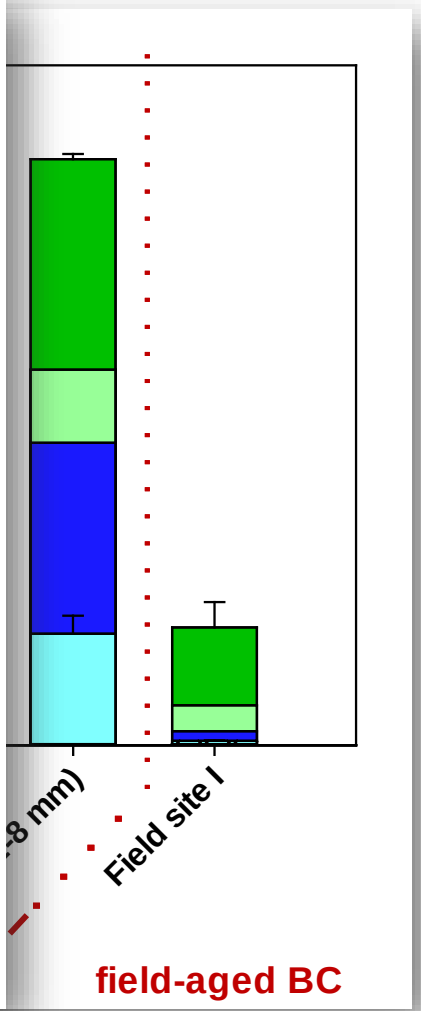


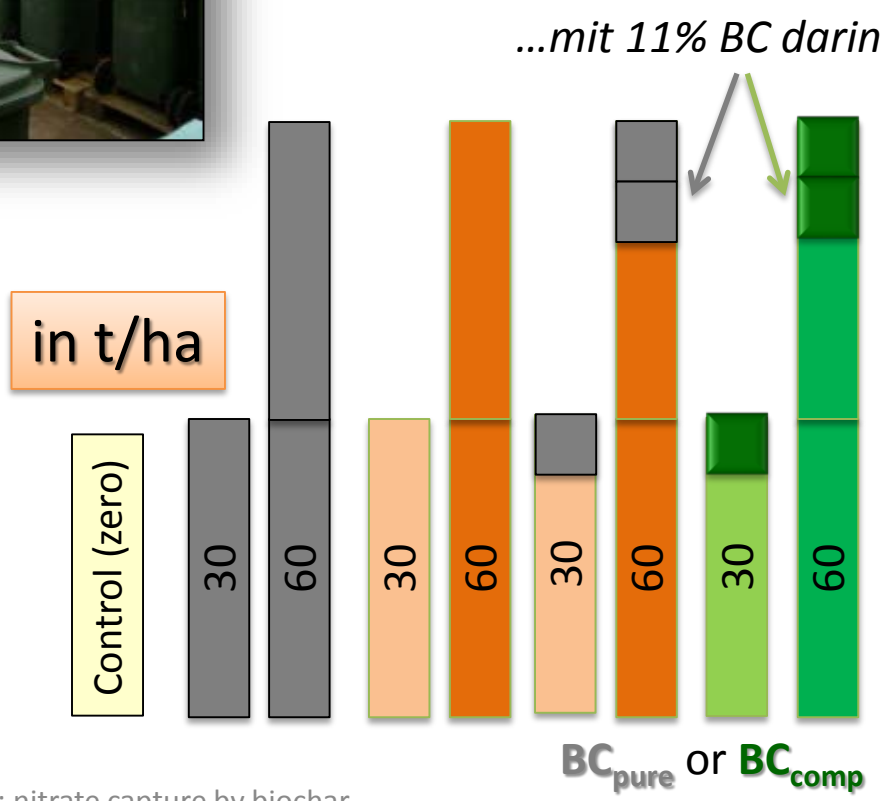


Containerversuch zur Verminderung von Nitrat-Leaching

- Riesling Klon 198-30 Gm,
- Unterlage SO 4, Klon 47 Gm
- 3-jährige Pflanzen, 10-12 Augen
- Sandig-armer Ober- u. Unterboden

Experimenteller Set-up:

- Substrat-Vergleiche
- Zugabemenge Vergleich (erlaubte vs hohe Menge Kompost(substrat))



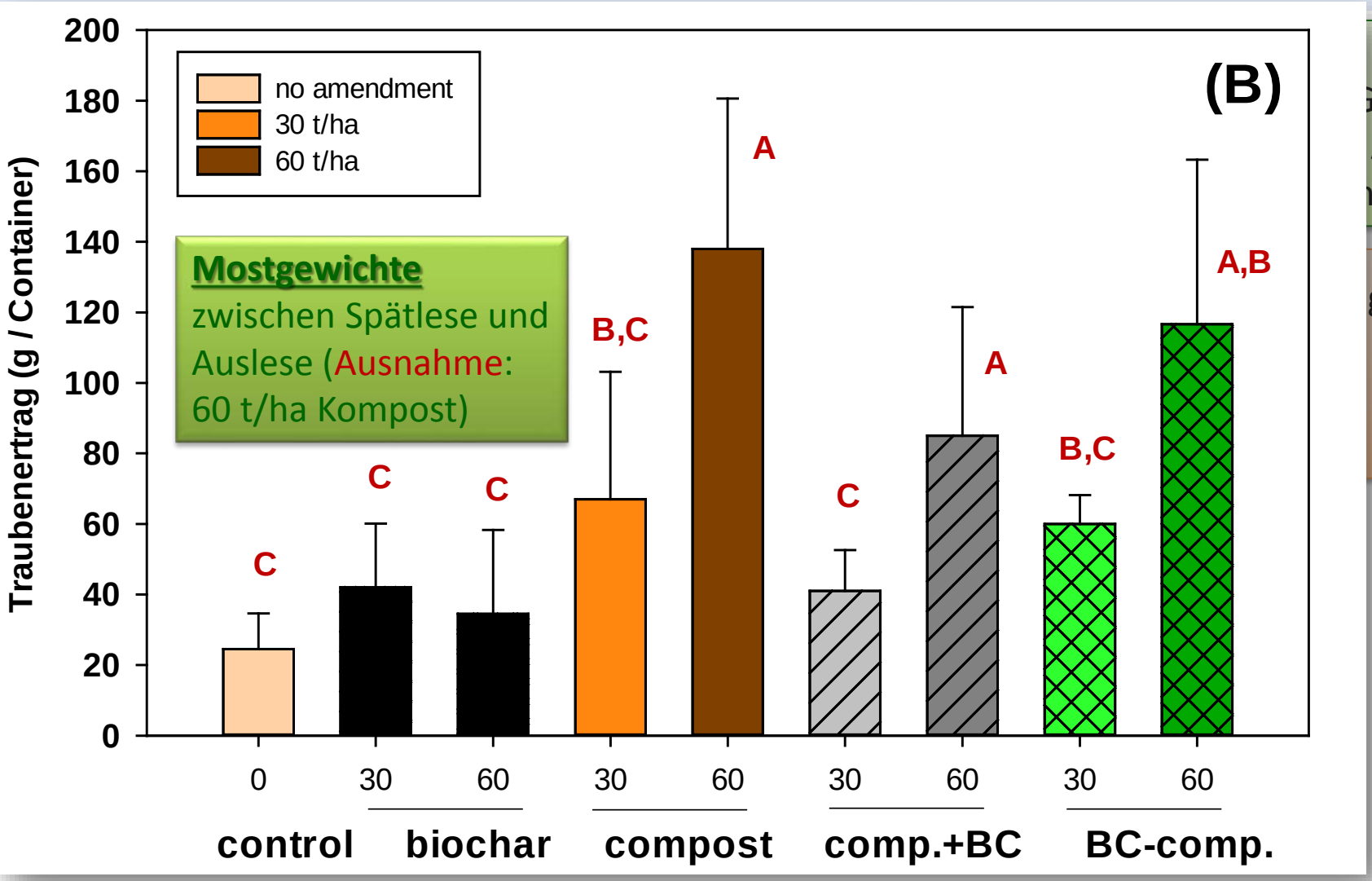
Steigerung des Traubenertrags

Mostgewichte
zwischen Spätlese und Auslese (Ausnahme: 60 t/ha Kompost)

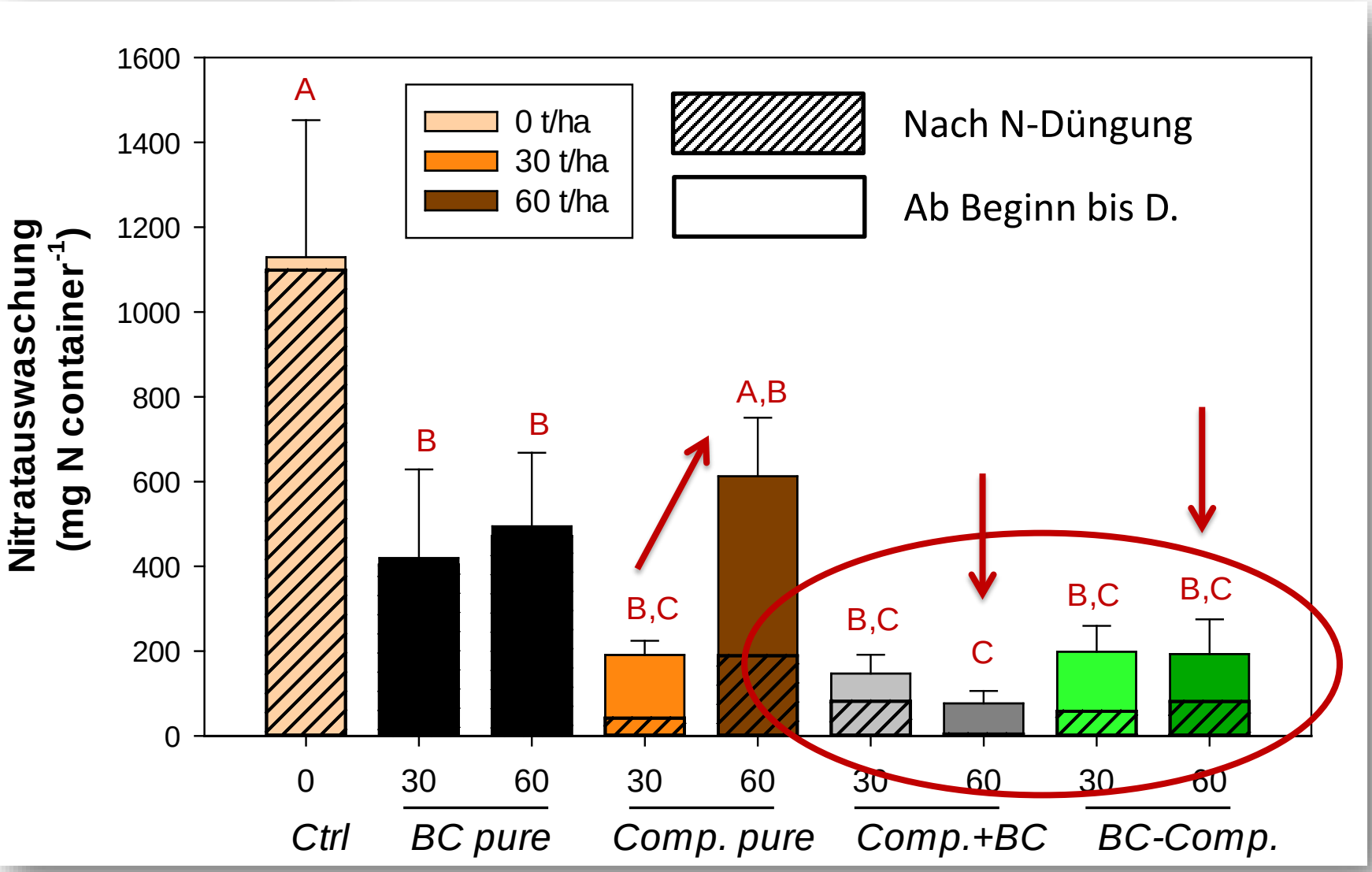
- Riesling Klon 198-30 Gm,
- Unterlage SO 4, Klon 47 Gm
- 3-jährige Pflanzen, 10-12 Augen
- Sandig-armer Ober- u. Unterboden

- Volldünger 40 kg/ha (1.2 g/Cont.)
- KristalonTM, YARA, Oslo
- N-P-K-Mg (19-6-20-3)

Steigerung des Traubenertrags



Nitrat-Leaching: Die Kombination machts…!

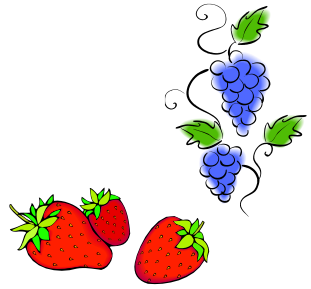


Fazit: Biochar als N-Fänger UND –Träger!

- Biochar "fängt" mineral. Stickstoff (*"nitrate capture"*)

- Biochar kann Pflanzenwachstum steigern….
  - → *…wenn Nährstoff-beladen*
  - → *…wenn sorbiertes Nitrat wenigstens teilweise Wasser-ablösbar*

- Kompostierte Kohle (BC_{comp})….
  - *…war besser in "nitrate capture" als pure Kohle*
  - *…reduzierte noch immer die N_2O-Emissionen*
- Kohle-Komposte reduzierten effektiv die Nitrat-Auswaschungen: *höhere Kompostgaben möglich?*



Fazit: Biochar als N-Fänger UND –Träger!

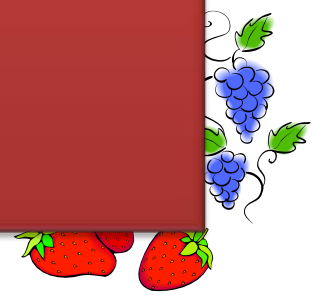
„Compost the (nutrient-rich) best,

and pyrolyze the (C-rich) woody rest

– and bring both together

in a beneficial marriage

by composting!



Biochar als N-Träger?

VIELEN DANK...

And many thanks go to….:
Nicol Strasilla, Ruben Seibert, Philipp Trulley, Gerhard Mayer, Roger Cresswell, Mario Tolksdorf and many others!
Funding sources DFG, DAAD, Uni Gießen, HS Geisenheim, EU COST Action Biochar

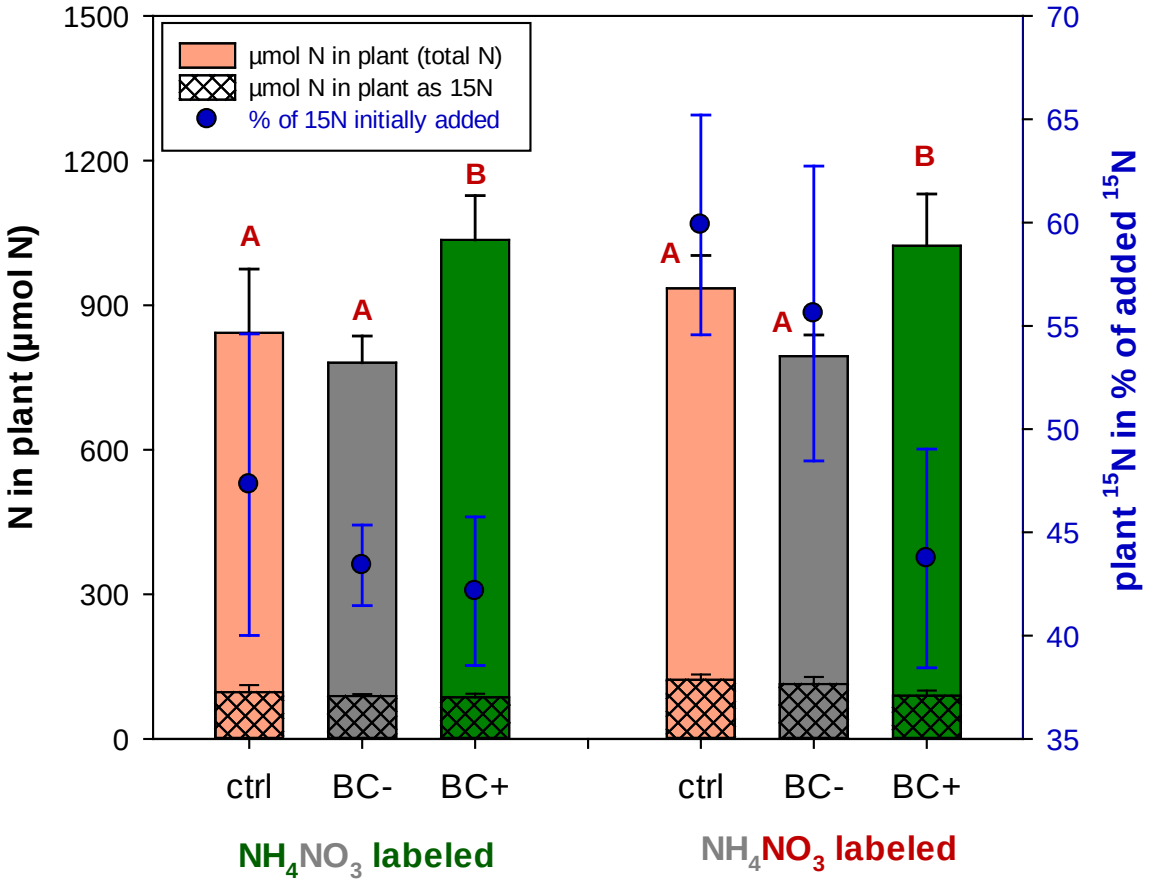
….FÜR IHRE AUFMERKSAMKEIT!

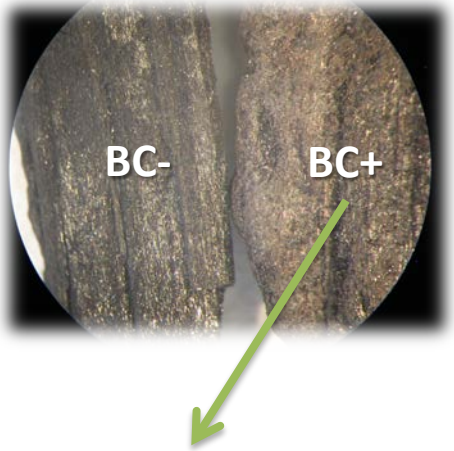
...FRAGEN...

…wie immer: Neue Fragen!

….Nitrat-Bindungsmechansimus…?
Wie viel Nitrat "geht"…? Andere Nährstoffe, andere Anionen…? Auswaschungsschutz vs. Pflanzenverfügbarkeit, vs. N_2O-Emissionen….?
Biochar-Optimierung…?
BC-Kompost-Produkte?

^{15}N Aufnahme in Gerste-Pflanzen





BC_{comp}:
^{14}N-Nitrate delivery - dilution of ^{15}N!

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BC-Kompost: B. vulgaris stärkste Reaktion

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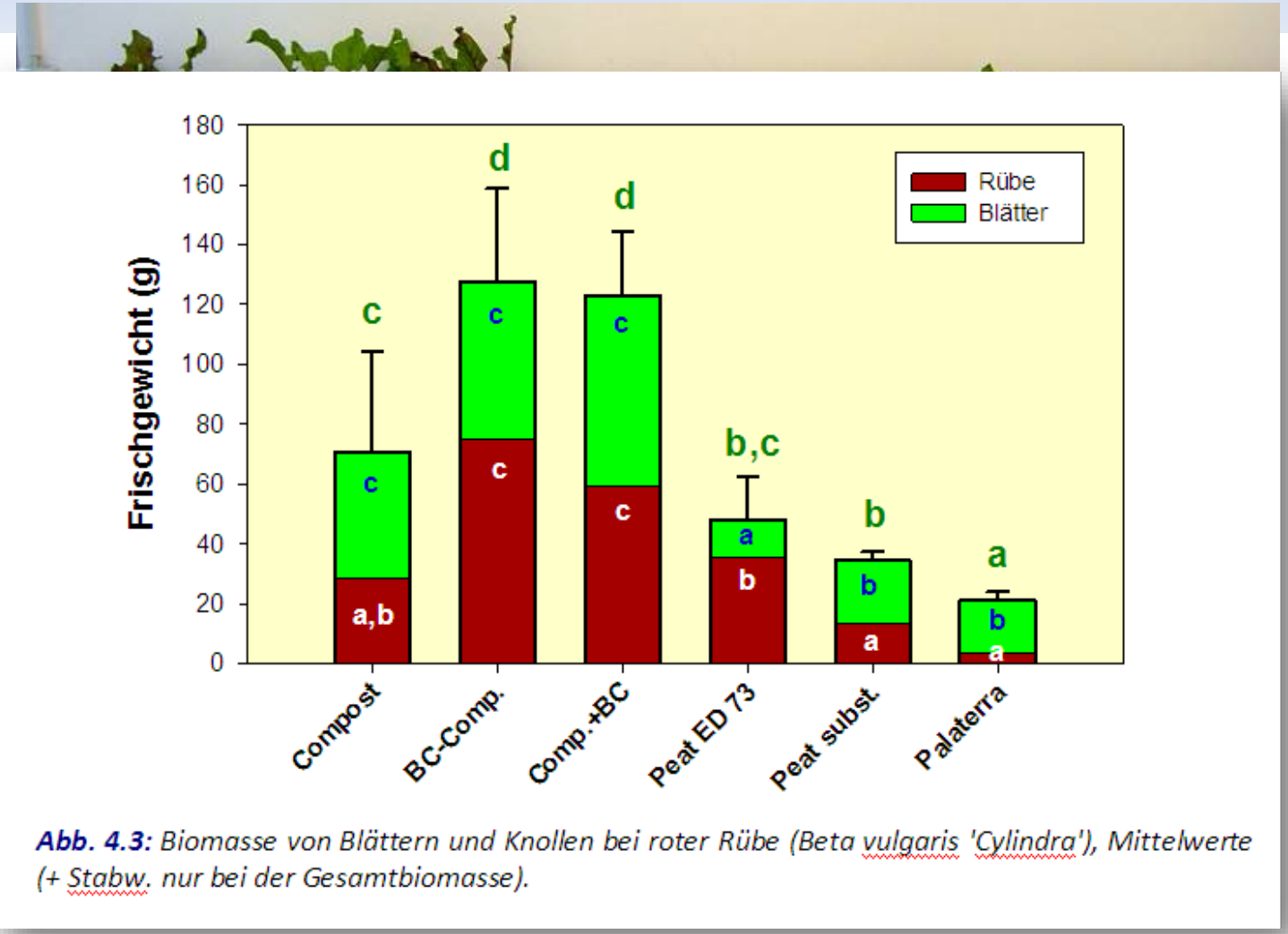
B. vulgaris stärkste Reaktion



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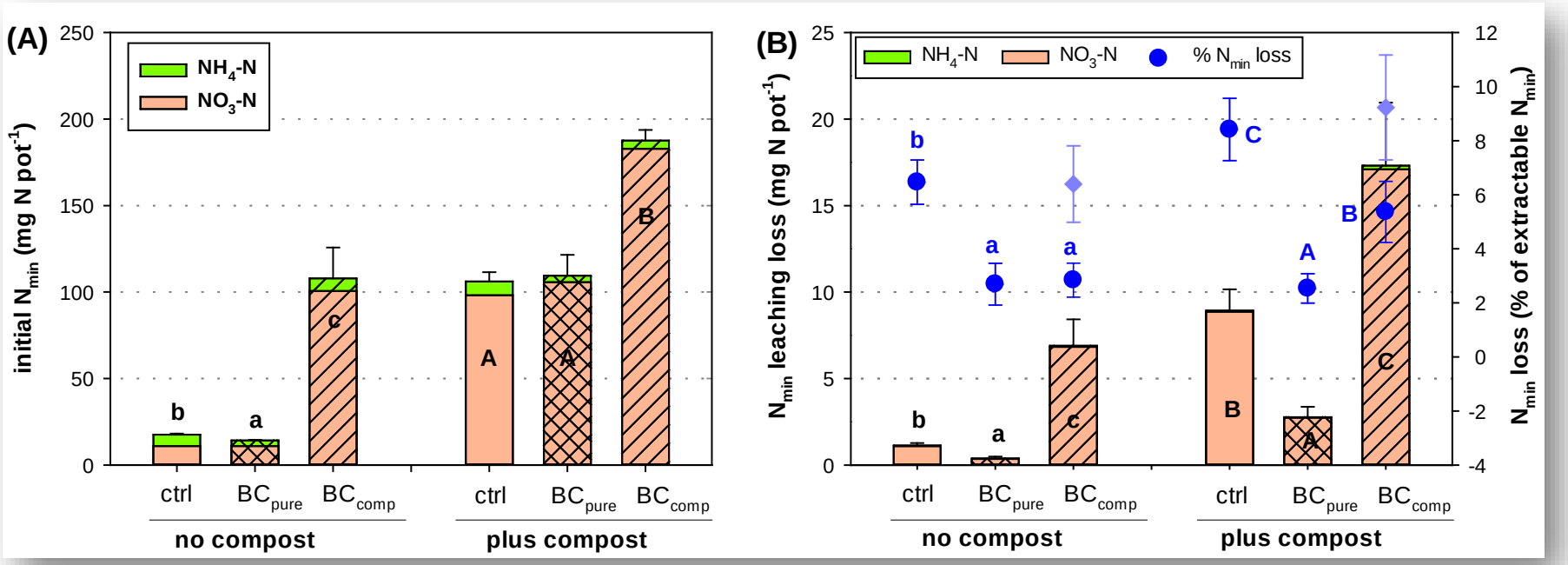
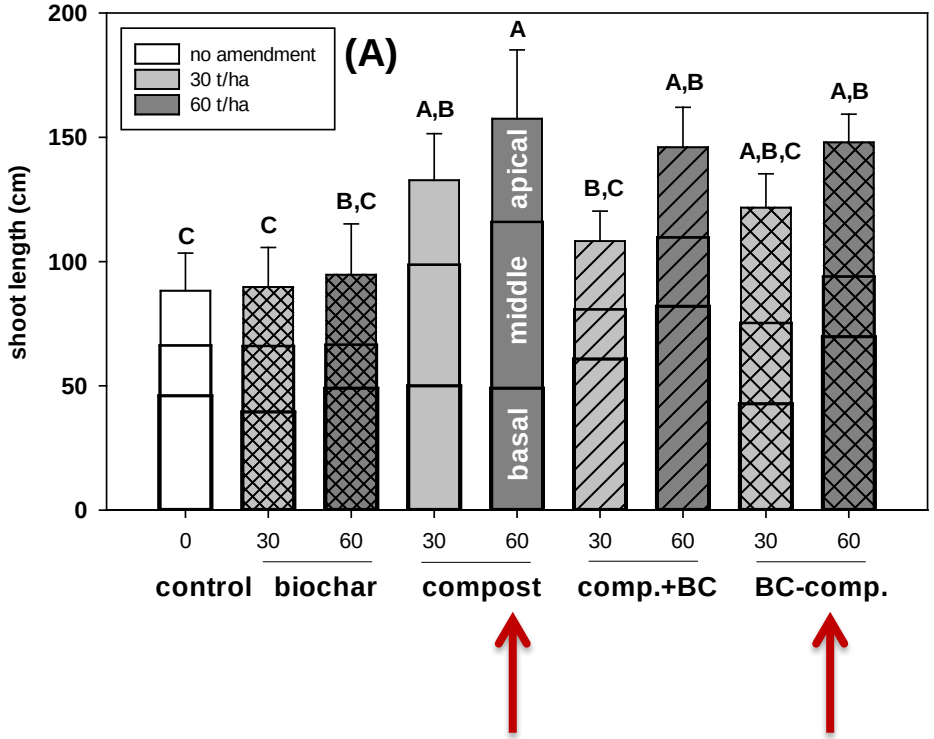
BC_{comp} >> BC_{pure} – Nährstoffeffekte?



Sproßwachstum der Reben

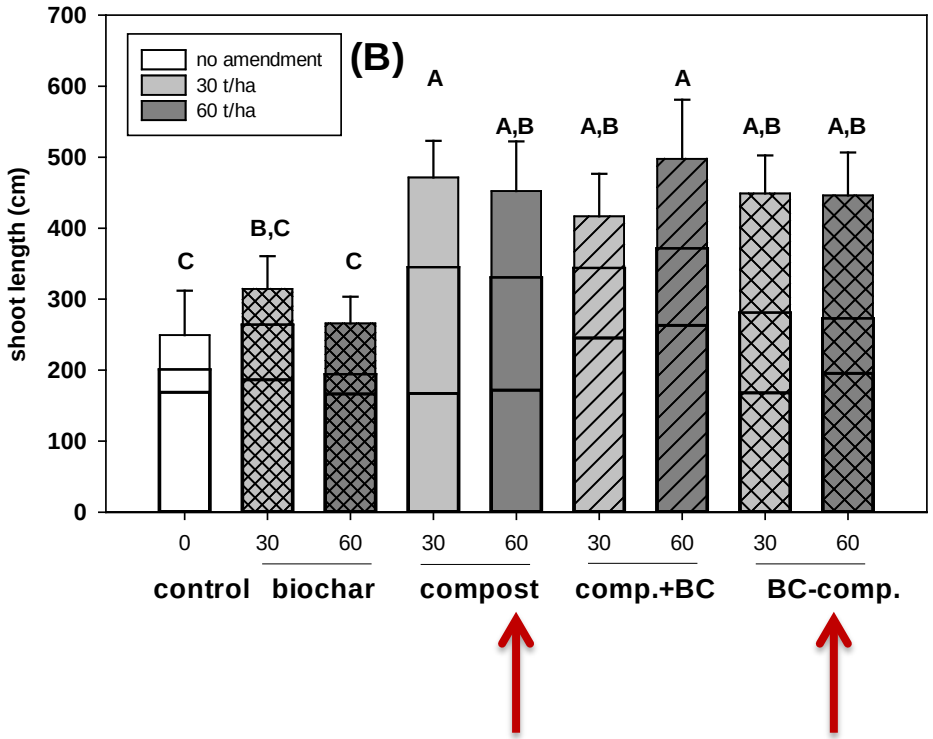
Bis Juli

Total shoot length in July



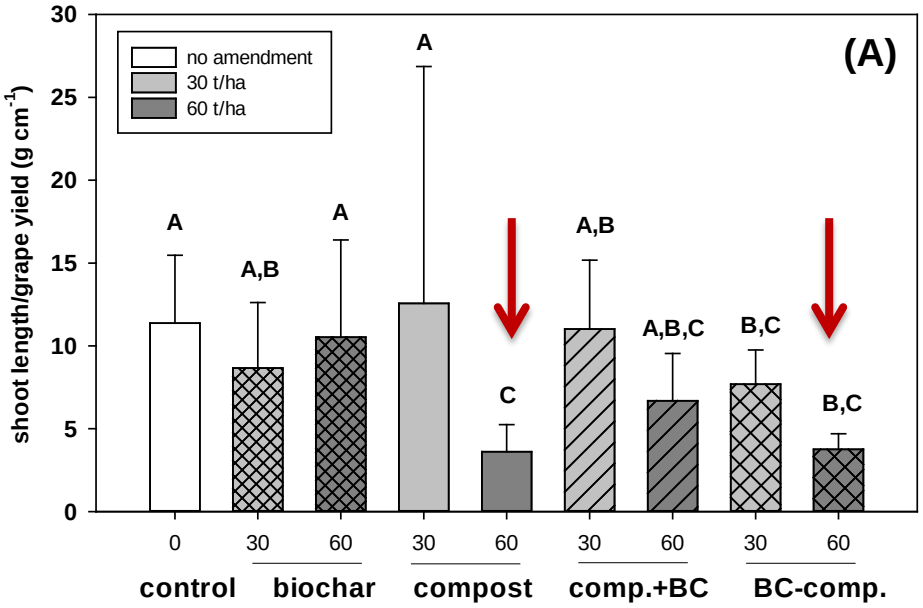
Bis Dezember

Total shoot length in December

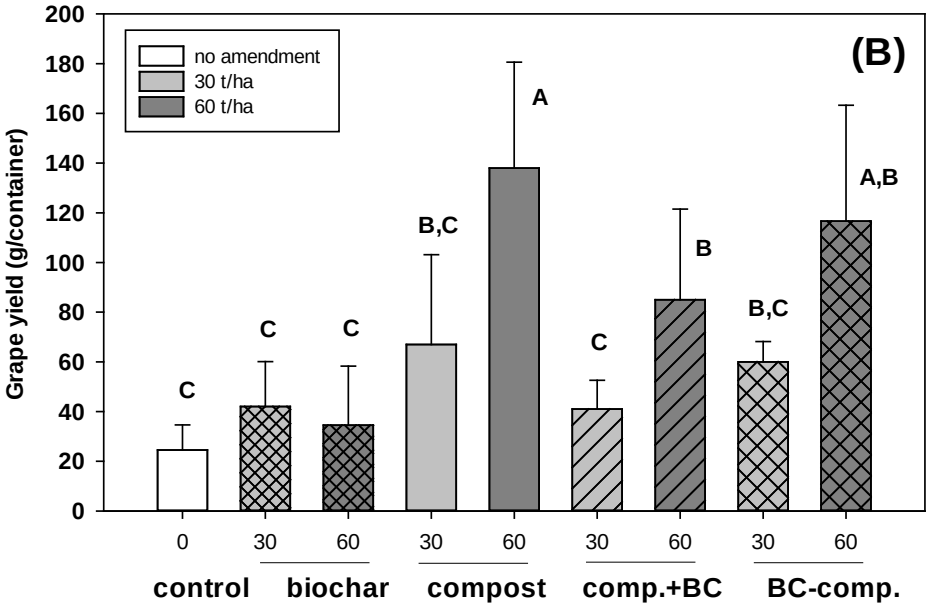


Sproßwachstum vs. Ertrag der Reben

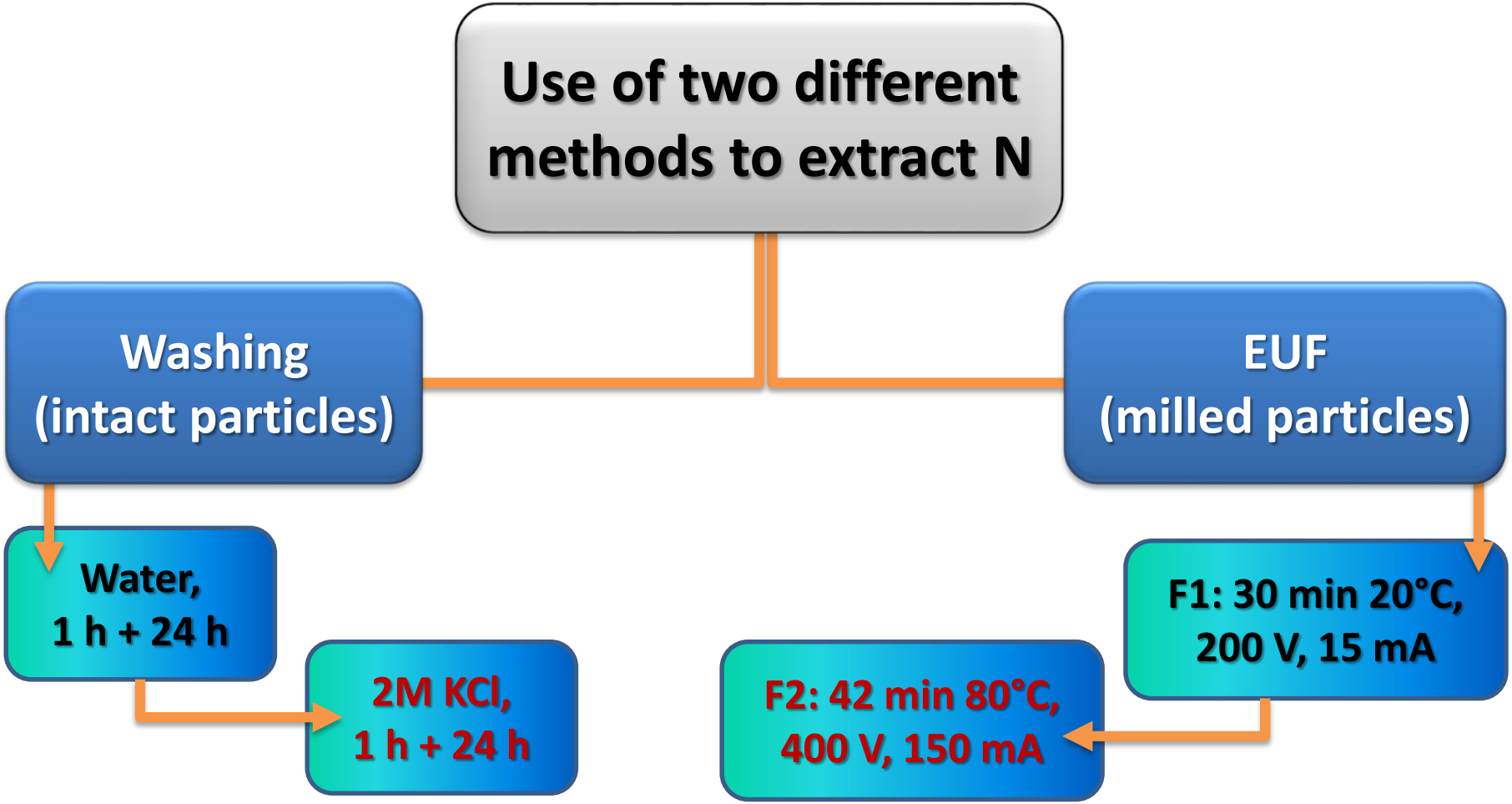
Shoot/grape ratio



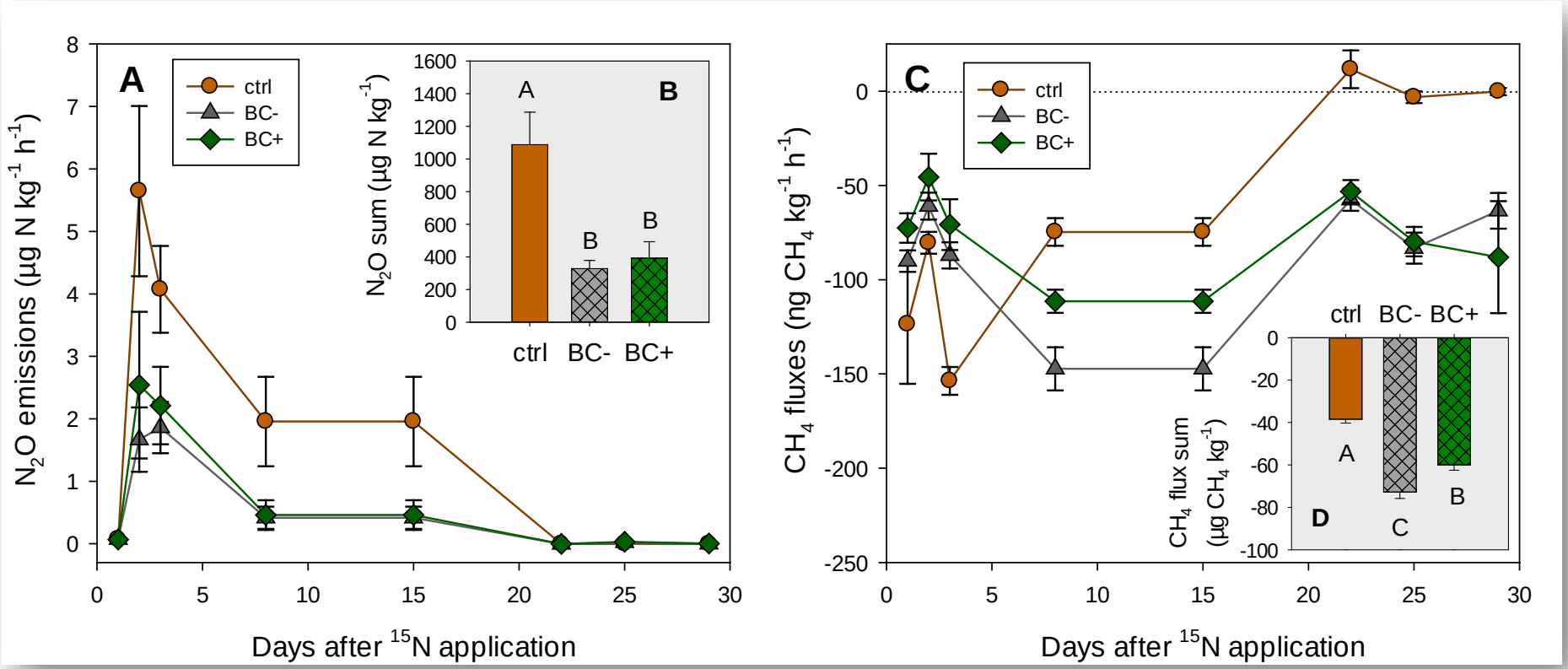
Traubenertrag



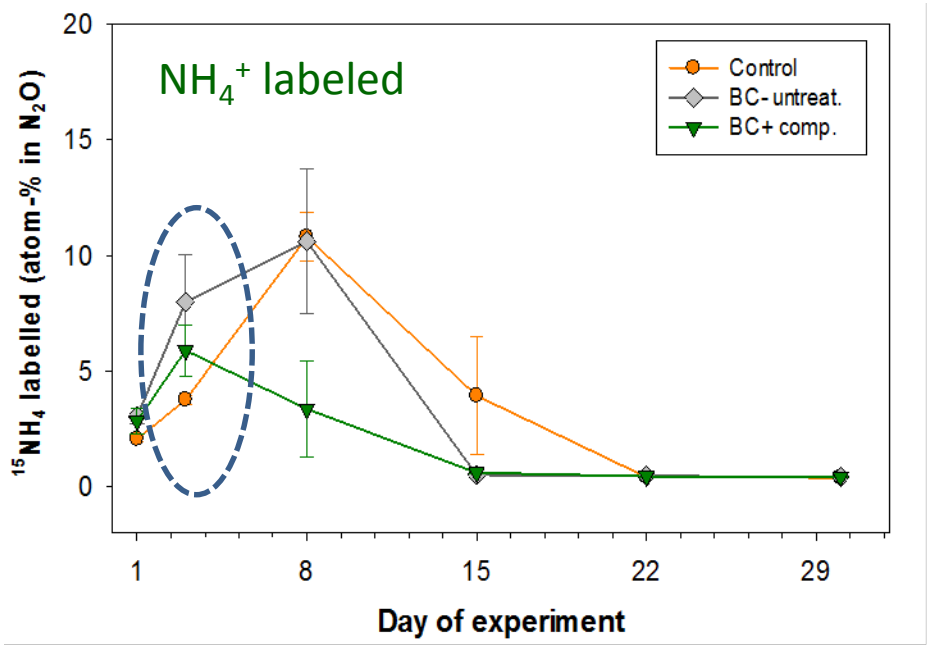
Biochar and Nitrate: Investigating a strange "relationship" (methods)

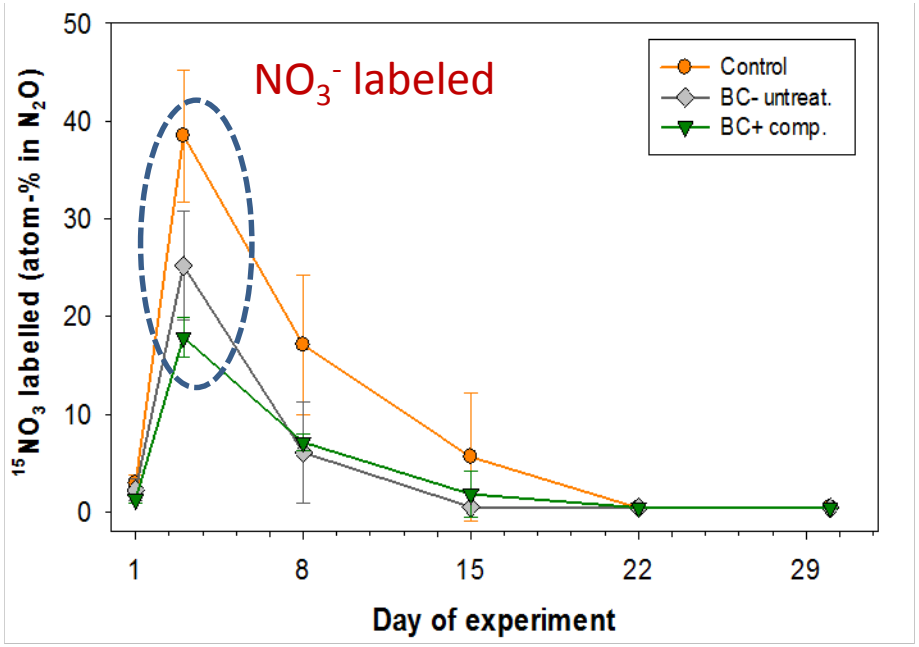


N_2O Emissionen dennoch reduziert



N_2O_{NIT} increased, N_2O_{DENIT} reduced





^{15}N in N_2O reflects lower ^{15}N in nitrate, but not lower soil nitrate concentrations. (These were highest in the BC+ treatment.)

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Field study II: Large yield stimulation with low or no N!

Start April 2012:

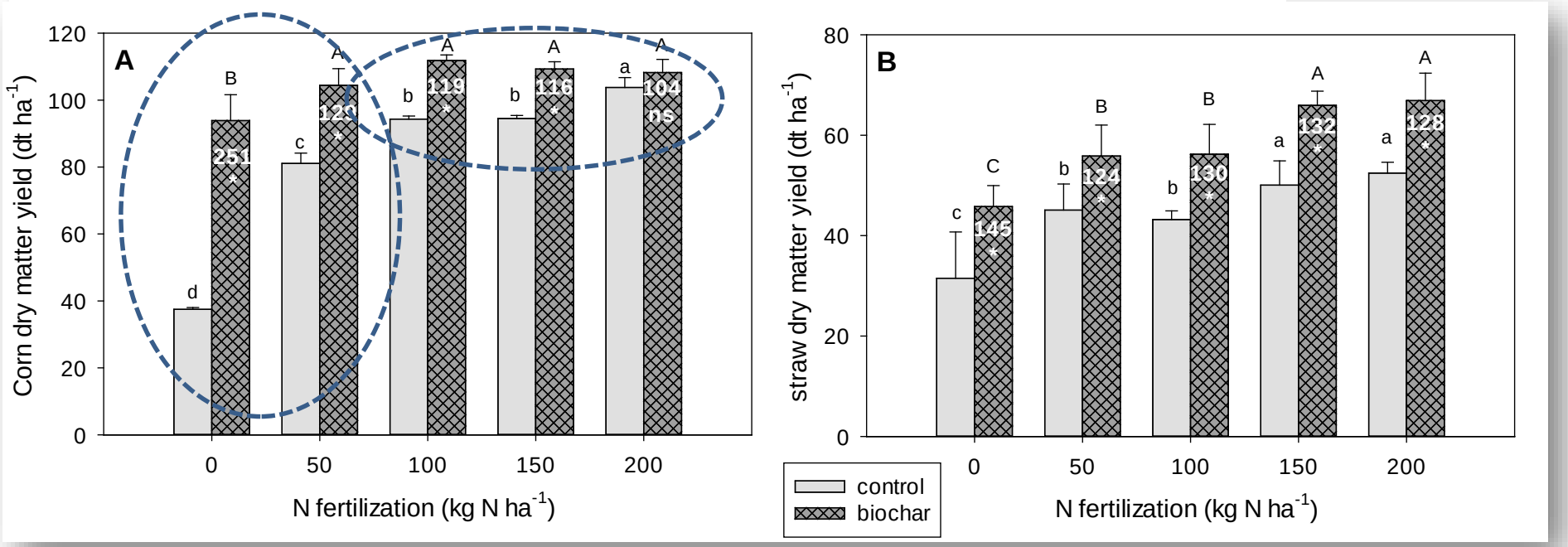
- F1: 0 and 30 t/ha biochar
- F2: 0, 50, 100, 150 and 200 kg N/ha

Biochar: 0-15 cm

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Field study II: Large yield stimulation with low or no N!

2nd year, 2013: Winter wheat corn (A) and straw (B) yields



- F1: 0 and 30 t/ha biochar
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Biochar: 0-15 cm

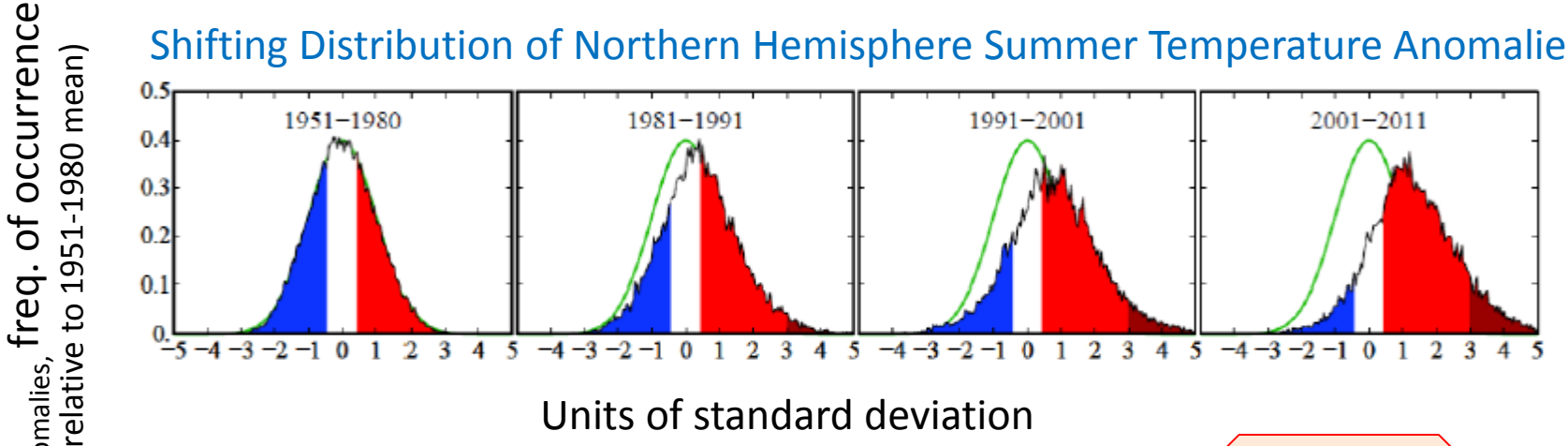
…Warum plötzlich Biochar….?

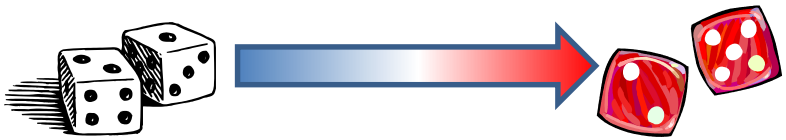
Loaded Climate Dice: global warming is increasing extreme weather events.

Extreme summer heat anomalies now cover about 10% of land area, up from 0.2%.

This is based on observations, not models. *Hansen et al., PNAS 2012*

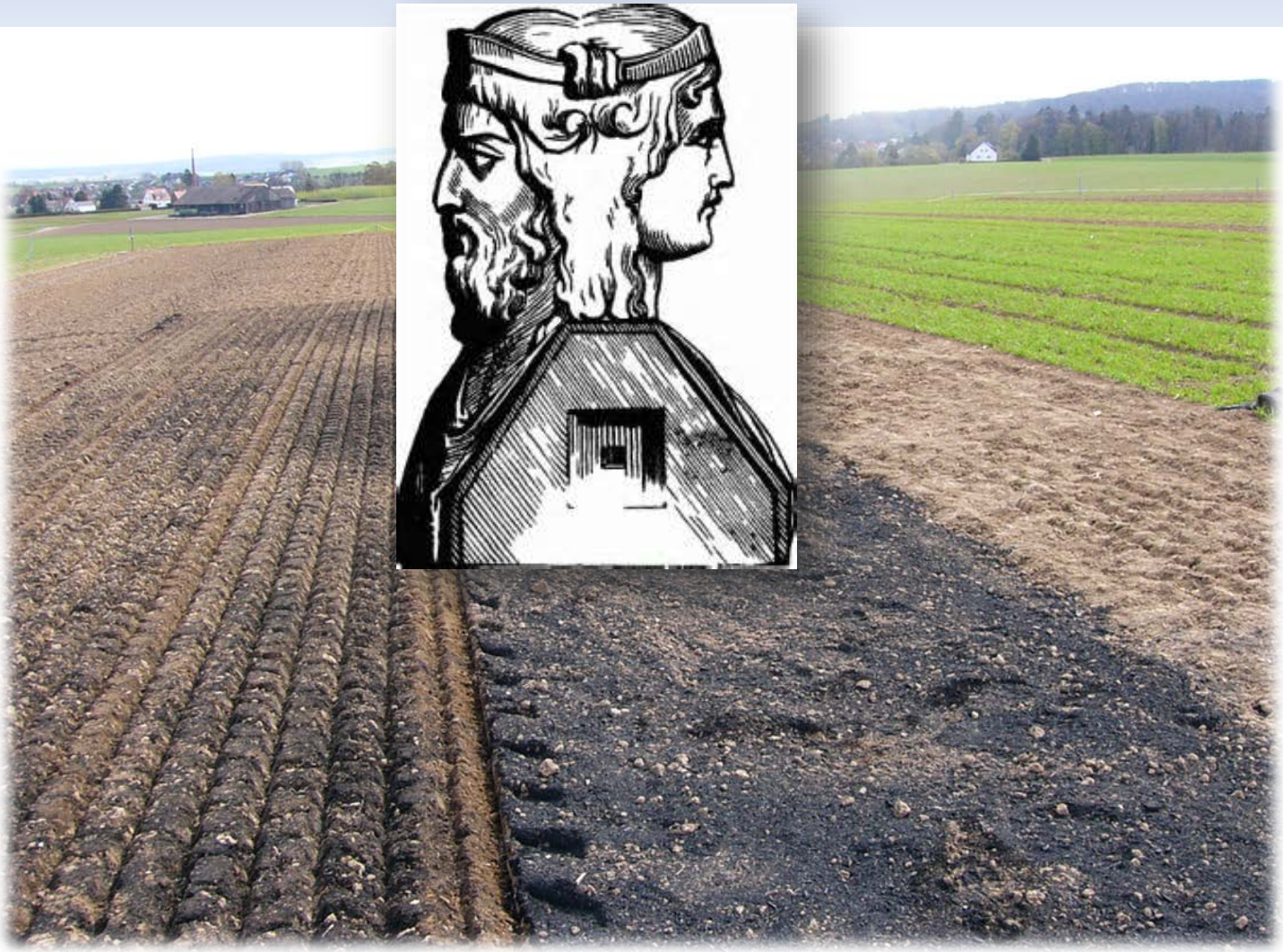
Shifting Distribution of Northern Hemisphere Summer Temperature Anomalies





CAUTION!
You enter the Anthropocene Era!

Biochar – Risiko oder Chance?
…oft ein Janus-Kopf!



Die zwei Seiten der Pflanzenkohle

(Potentielle) Risiken:

- **Kontaminationen**
  - Schwermetalle
  - PAK; VOC‘s….
- **Starke Adsorption organ. Substanzen**
  - PAK, KW
  - Herbizide/Pestizide
- **Nährstoffadsorption (?)**
- **Handling**
  - Staubbildung
  - Entzündungsgefahr
  - Gesundheitsgefahren (?)
- **Albedo (?)**
- **Absolute Mengen**

(Potentielle) Chancen:

- **Reduktion THG-Emissionen**
  - N_2O (298x CO_2/100y)
  - CH_4?
- **Starke Adsorption….**
  - Remediation kontamin. Böden
  - R. kontamin. organ. Substrate
- **Nährstoffadsorption (?)**
  - Auswaschung
  - Mineralisierung
  - Immobilisierung
  - Nährstoffnutzungseffizienz
- **Albedo (?)**
- **C-Sequestrierung**
  - Stabilität
  - Humusauf- vs. –abbau?

Die zwei Seiten der Pflanzenkohle

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§§ Regulations

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Chance!

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Chance!