High nitrogen supply alleviates reduced sugarbeet growth caused by hydrochar application

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Introduction

The process of hydrothermal carbonization (HTC) converts biomass into a carbon (C) rich product named hydrochar. It is assumed to have beneficial effects on soil properties and plant growth, but detailed studies are lacking. The objective of our study was to investigate the effect of hydrochar incorporated into arable soils on (i) soil mineral nitrogen (N_{min}) content and (ii) sugarbeet (*Beta vulgaris* L.) growth.

Material and Methods

- A greenhouse trial (Cambisol, 1 kg pot^{-1}) was conducted with sugarbeet as test plant (5 plants pot^{-1}).
- Two hydrochars (equivalent to 30 t ha^{-1}) processed from sugarbeet pulp (C/N 38) and draff (C/N 16) at 190 °C over 12 h were tested against an untreated control (nutrients were in optimal range for early sugarbeet growth).
- Mineral N fertilizer level was varied: 0, 100, 200 mg N kg^{-1} soil.
- Four weeks growing period (15 °C, 8 h artificial light, 80% maximal soil water holding capacity).
- Soil and plant analyses: N_{min} at the beginning and the end of the trial, seedling emergence, single plant yield, N uptake.

Results

- Seedling emergence was not affected by hydrochar treatment and N fertilizer level (data not shown).
- Both hydrochars reduced initial sugarbeet growth (Fig. 1) and N uptake (Fig. 2), especially when hydrochar-S wide in C/N ratio (38) was combined with a low N fertilizer level (typical N deficiency symptoms occurred).
- Higher N supply partly (100 mg N kg^{-1} soil) or completely (200 mg N kg^{-1} soil) compensated for the reduced seedling growth (Fig. 1).
- At the N_0 fertilizer level, no extractable N_{min} was present at the end of the trial in hydrochar-S treatment, while in hydrochar-D even more N_{min} was extracted than in the control (Tab. 1), thus suggesting re-mineralization of previously immobilized N when hydrochar-D with a low C/N ratio (16) was applied.

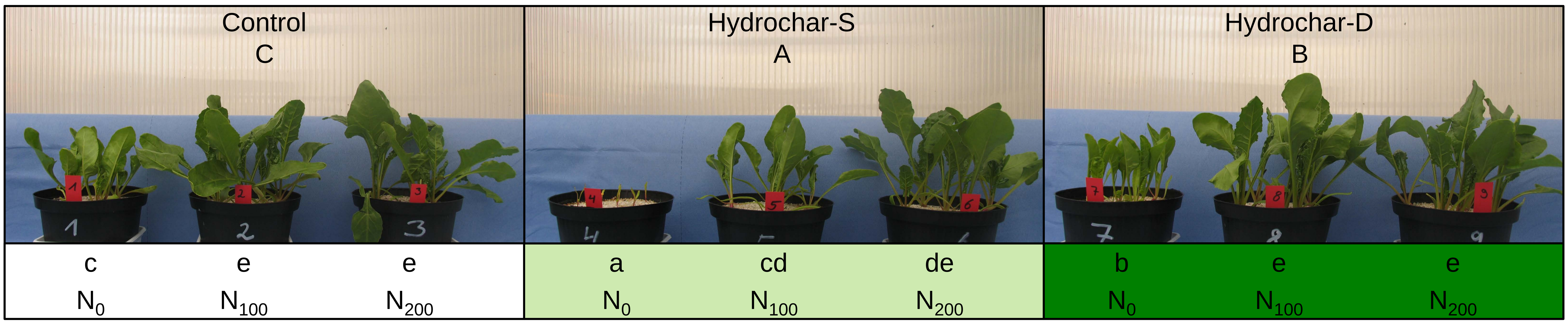

Fig. 1. Effect of hydrochar (H) derived from sugarbeet pulp (S) and draff (D), respectively, and nitrogen (N) fertilizer level (0, 100, 200 mg N kg^{-1} soil) on sugarbeet growth. ANOVA (H ** | N ** | HxN **): Individual means (lower case letters) and hydrochar means (upper case letters) with the same letter are not significantly different ($p \leq 0.05$).

Tab. 1. Soil mineral nitrogen (N_{min}) content at the start and at the end of the trial as affected by hydrochar derived from sugarbeet pulp (S) and draff (D), respectively and N fertilizer level (0, 100, 200 mg N kg^{-1} soil).

Hydrochar	N_{min}-Start: mg N kg^{-1} soil				N_{min}-End: mg N kg^{-1} soil			
	N_0	N_{100}	N_{200}	Mean	N_0	N_{100}	N_{200}	Mean
Control	55^a	117^{bc}	252^e	141^b	0.7^a	0.7^a	29.7^c	2.4^a
Hydrochar-S	52^a	148^c	215^d	138^b	0.9^a	1.2^a	7.4^b	1.8^a
Hydrochar-D	67^a	111^b	192^d	123^a	4.8^b	4.8^b	57.1^c	10.9^b
Mean	58^a	125^b	220^c		1.5^a	1.4^a	23.2^b	

ANOVA: For main effects, means within rows (N fertilizer level) and columns (hydrochar) and for the interaction, individual means across rows and columns with the same letter are not significantly different ($p \leq 0.05$)

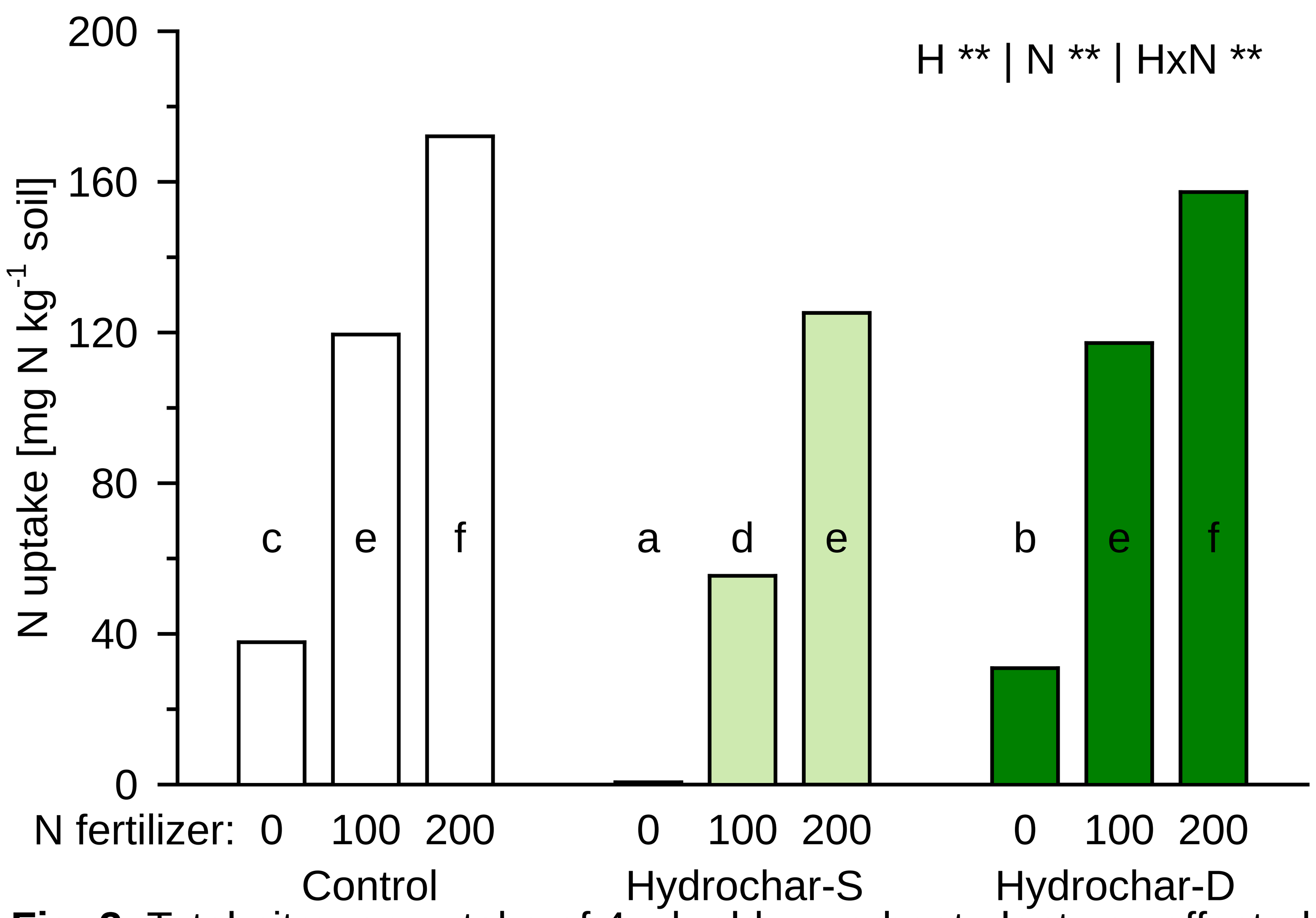

Fig. 2. Total nitrogen uptake of 4-wk-old sugarbeet plants as affected by hydrochar (H: sugarbeet pulp (S) and draff (D)) and nitrogen (N) fertilizer level. ANOVA (H ** | N ** | HxN **): Individual means with the same letter are not significantly different ($p \leq 0.05$).

Conclusions

Our results suggest that hydrochar can decrease plant available N due to N immobilization. Other potential causes for the reduced N availability and observed early growth reduction need to be studied more detailed.