BAY KLIMAFIT 2
Projektverbund · Starke Pflanzen im Klimawandel

An appropriate choice of the boron fertilizer species under boron deficiency results in an advantageous performance of *Brassica napus* plants on well-watered but not on water-limited conditions

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Project aim

Determination of how different chemical B species affect inflorescence- and biomass parameters and B uptake in *Brassica napus* grown under water-limited conditions.

Boron deficiency and drought stress: a vicious circle

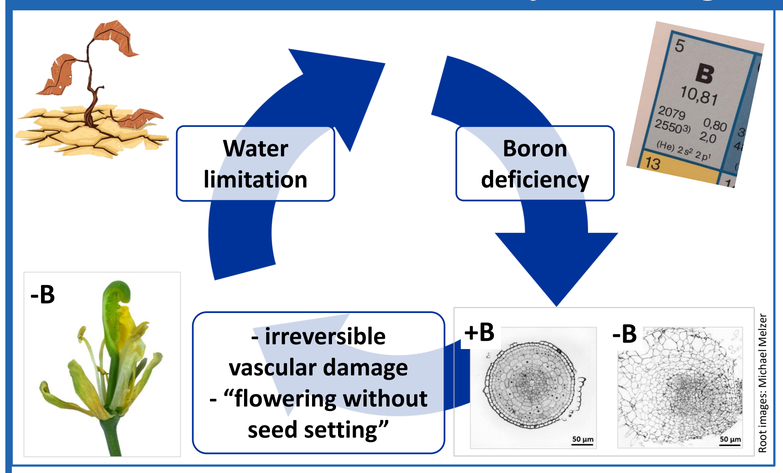


Fig. 1: Drought increases the severity of Boron deficiency symptoms in *B. napus*, a Boron (B) deficiency sensitive crop[1,2]

Typical Boron (B) deficiency symptoms are a disturbed cell differentiation or a "flowering without seed setting" phenotype (Fig. 1, 2)[1]

The highly soluble boric acid is the predominant plant available B species in soils.

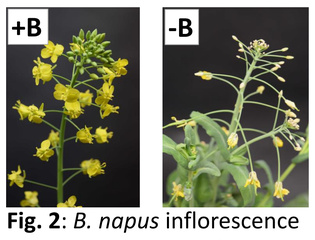


Fig. 2: *B. napus* inflorescence phenotype on +B and -B.

Little is known about the availability of various other B species for plants under water-limited growth conditions.

Materials and Methods

- A B-inefficient spring type *B. napus* cultivar (*CR3153*) was grown on a peat-based B-free soil substrate (< 0.08 mg B kg substrate^{-1}; Fruhstorfer Nullerde)[3] in glasshouse conditions.
- Five different B species (Tab. 1) were supplied sufficiently (2.5 mg B kg substrate^{-1}, +B) or deficiently (0.25 mg B kg substrate^{-1}, -B); other essential nutrients were sufficiently supplied.

Tab. 1: B species being used in this study.

B species	Chemical formula	Dissolution in water	Particle size (content %)		
			<200µm	200 - 630µm	>630µm
Boric acid	H_3BO_3	high	39.8	50.8	8.5
Borax	$Na_2B_4O_7*10H_2O$	high	27.2	54.8	17.7
Colemanite (Colem)	$2CaO.3B_2O_3*5H_2O$	low	100	-	-
Ulexite (Ulex)	$Na_2O.2CaO.5B_2O_3*5H_2O$	low	100	-	-
Zinc borate (ZnB)	$2ZnO.3B_2O_3*5H_2O$	low	100	-	-

- At flower bud formation, plants were either exposed to well-watered (WW, 30-50% volumetric water content, VWC) or water-limited (WL, 5-30% VWC) treatments and phenotyped during flowering.

Supplying Borax led to the most open turgid flowers, green flower buds and least necrotic flower buds in -B conditions but only with sufficient water

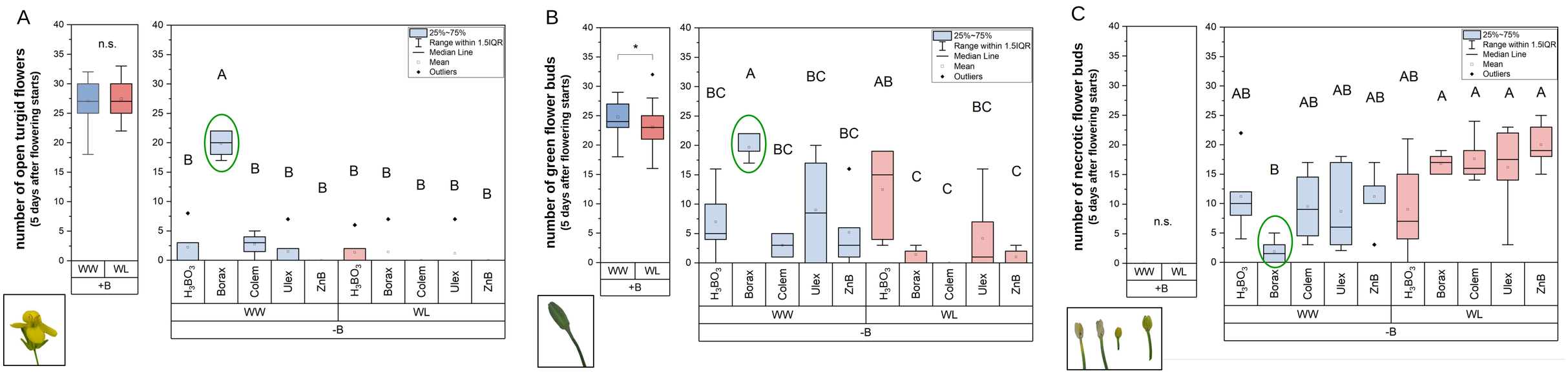
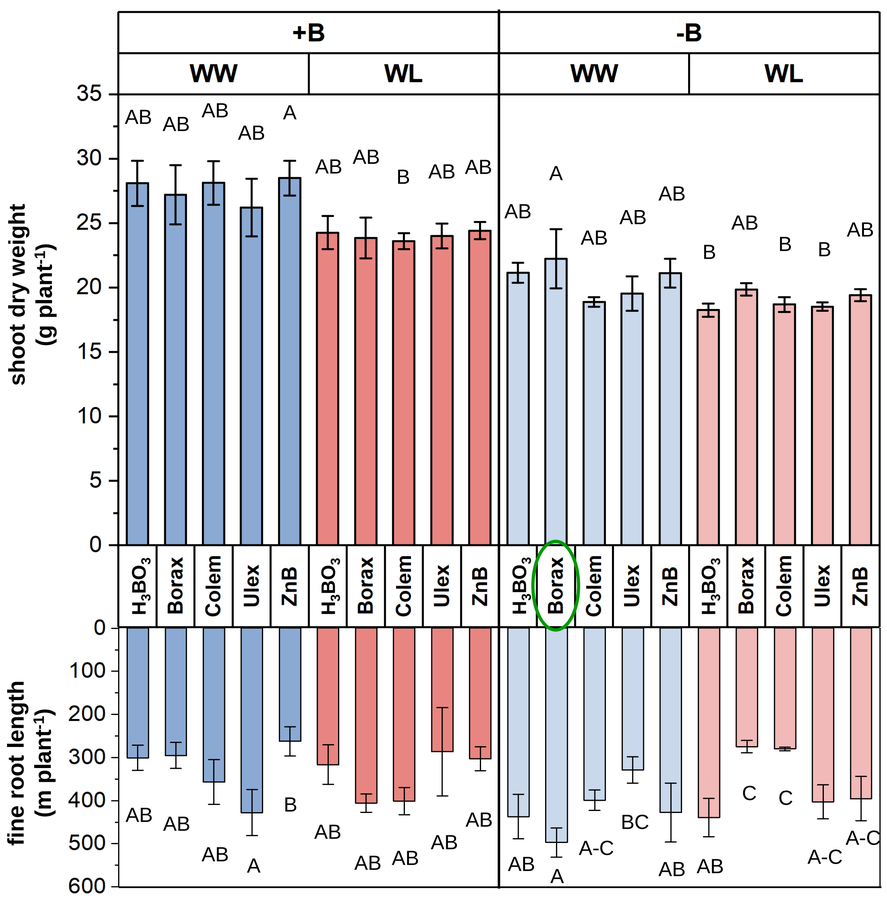


Fig. 3: (A) Number of open turgid flowers, **(B)** green and **(C)** necrotic flower buds of the main raceme 5 days after the first flowers opened of *B. napus* plants grown under sufficient (+B) and deficient (-B) B concentrations supplied as five different B species, comparing well-watered (WW) and water-limited (WL) treatments. Plants on +B: showing no significant difference between B species for a parameter and were summed up within the water treatment (t-Test between water treatments: not significant (n.s.), *: $p < 0.05$; n = 29-30) . Plants on -B: upper case letters indicate significance between B species and water treatments ($p < 0.05$, 2-way ANOVA, post hoc Tukey test; n = 4-6).

Plants supplied with Borax had the highest shoot dry weight in -B conditions, but the longest roots when well-watered



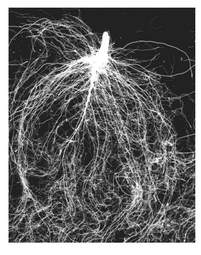


Fig. 4: Shoot dry weight and fine root length (< 0.3 mm diameter) at 77 days after sowing of *B. napus* plants grown under sufficient (+B) and deficient (-B) B concentrations supplied as five different B species, comparing well-watered (WW) and water-limited (WL) treatments. Upper case letters indicate significance between B species and water treatments within one B concentration ($p < 0.05$, 2-way ANOVA, post hoc Tukey test); error bars = SE (shoot: n = 4-6, root: n = 3).

Plants supplied with Borax were the tallest in -B conditions independent of water supply

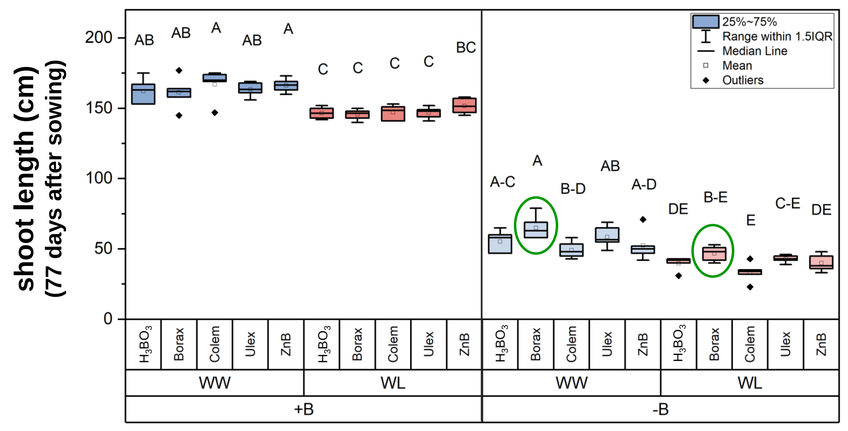


Fig. 5: Main shoot length at 77 days after sowing of *B. napus* plants grown under sufficient (+B) and deficient (-B) B concentrations supplied as five different B species, comparing well-watered (WW) and water-limited (WL) treatments. Upper case letters indicate significance between B species and water treatments within one B concentration ($p < 0.05$, 2-way ANOVA, post hoc Tukey test, n = 4-6).

Conclusion: In -B and well-watered conditions the supply of Borax resulted in the highest vigour and fertility of plants

The supply of Borax is most advantageous amongst all tested B species for the majority of the developmental parameters in -B and well-watered conditions, while Colemanite and Zinc borate did not significantly boost these parameters (Tab. 2)

	+B		-B	
	WW	WL	WW	WL
H_3BO_3	19	17	12	18
Borax	10	9	22	13
Colem	19	22	7	5
Ulex	10	11	9	16
ZnB	21	16	6	3

Tab. 2: Number of times a certain B species performed best or second for one of 32 phenotypic parameters, comparing the B species within a water treatment and B concentration (23 inflorescence parameters at 5 days and 15 days after flowering starts and 9 biomass parameters).

Next steps: leaf elemental composition via ICP-MS analysis to understand which of the supplied B species resulted in the highest B uptake

References
1: Brdar-Jokanovic (2020), Int. J. Mol. Sci. 21: 1424.
2: Wimmer & Eichert (2013), Plant Science, 203-204, 25 – 32.
3: Pommerrenig et al. (2018), Front Plant Sci., 9, 1142.

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