BAY KLIMAFIT 2
Projektverbund · Starke Pflanzen im Klimawandel

Identification of physiological responses to combined boron and water limitation in *Brassica napus*

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Boron deficiency and drought stress

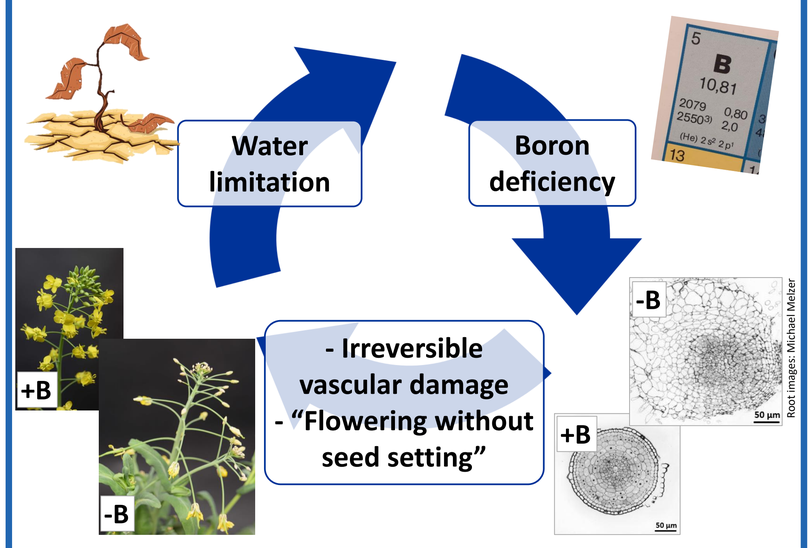


Fig. 1: Drought increases the severity of boron (B) deficiency symptoms in *B. napus*, a B deficiency sensitive crop[1,2].

Project aim

Identification of physiological responses and mechanisms in two *Brassica napus* accessions, contrasting in their B efficiency, grown under boron and water limitation.

Materials and Methods

- B-efficient (*CR2267*) and B-inefficient (*CR3153*) *B. napus* accessions were grown on a peat-based B-free substrate (Fruhstorfer Nullerde)[3].
- Boric acid was 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.
- At flower bud formation, plants were either well-watered (WW, 30-50% volumetric water content, VWC) or water-limited (WL, 5-30% VWC) and phenotyped during flowering.

B deficiency and drought stress reduces shoot length and increases number of side racemes

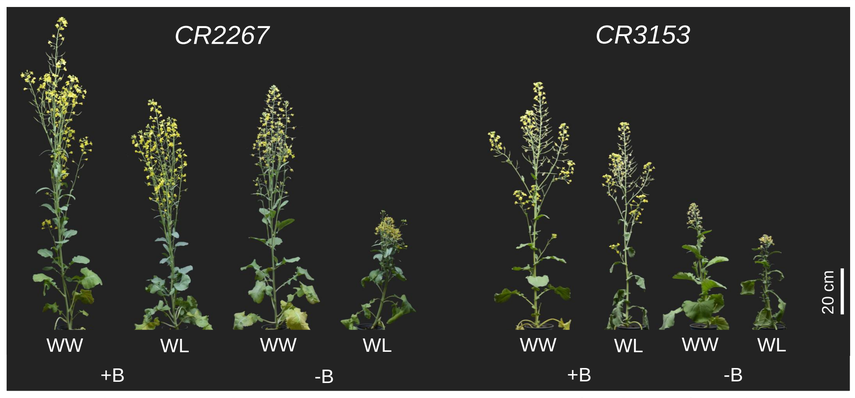


Fig. 3: Phenotype of *B. napus* accessions *CR2267* (B-efficient) and *CR3153* (B-inefficient), 7 days after first flowers opened.

B-efficient *CR2267* grows more side racemes with open flowers than B-inefficient *CR3153* in -B conditions regardless of water supply

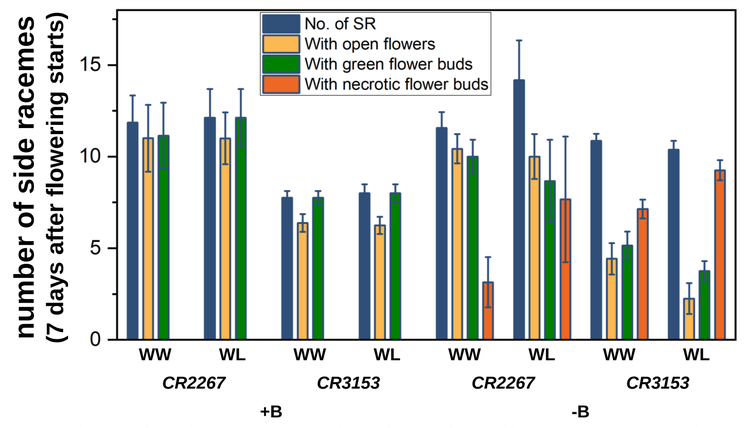


Fig. 4: Number of side racemes (SR) and number of side racemes with a specific inflorescence stage at 7 days after the first flowers opened of *B. napus* accessions *CR2267* and *CR3153* grown in different B concentrations (+B, -B) and well-watered (WW) and water-limited (WL) treatments. Error bars = SE, n = 4.

Inflorescence: *CR2267* is B-efficient but still suffers under drought stress in -B conditions

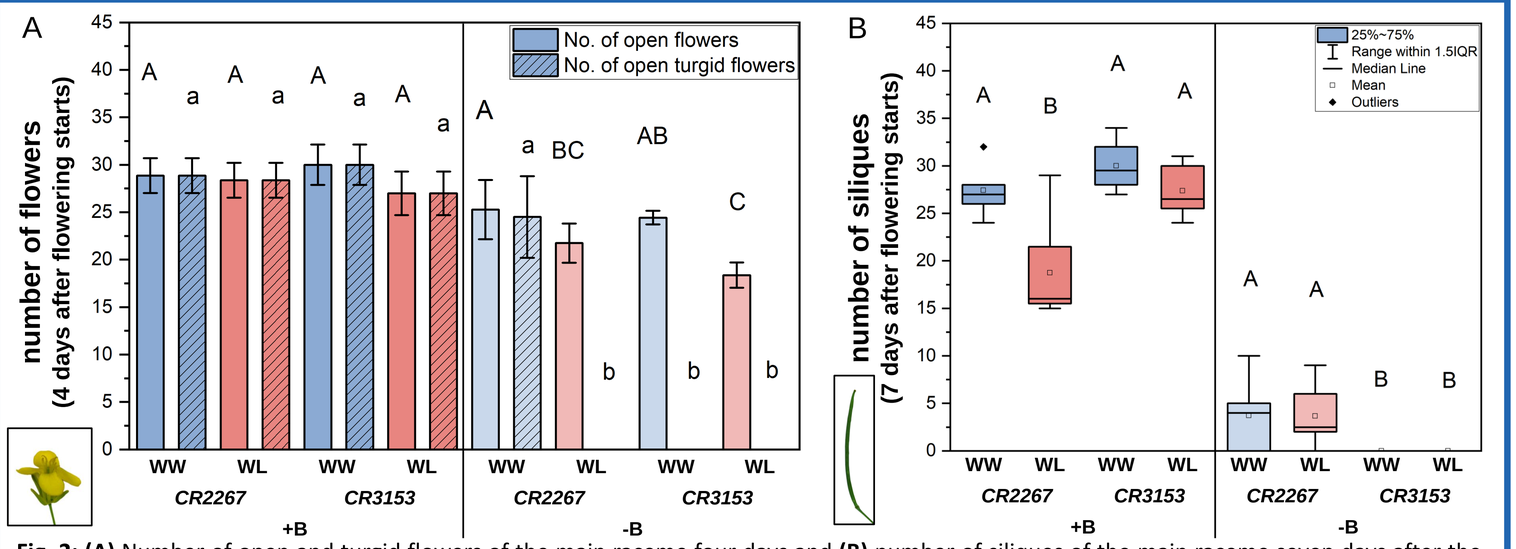


Fig. 2: (A) Number of open and turgid flowers of the main raceme four days and **(B)** number of siliques of the main raceme seven days after the first flowers opened of *B. napus* accessions *CR2267* (B-efficient) and *CR3153* (B-inefficient) grown in different B concentrations (+B, -B) and well-watered (WW) and water-limited (WL) treatments. Different letters indicate significant differences between genotypes and water treatments within a B concentration (for (A) upper case letters for number of open flowers, lower case letters for number of open turgid flowers) ($p < 0.05$, 2-way ANOVA, post hoc Tukey test); for (A): error bars = SE, (n = 6-8).

Reduction of shoot biomass due to drought stress, due to B deficiency only for B-efficient *CR2267*

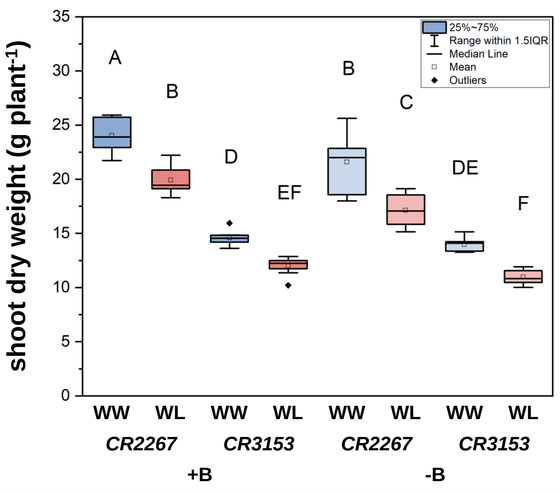


Fig. 7: Shoot dry weight of *B. napus* accessions *CR2267* and *CR3153* grown in different B concentrations and well-watered and water-limited treatments. Different letters indicate significant differences between genotypes, water treatments and B conc. ($p < 0.05$, 3-way ANOVA, post hoc Tukey test) (n = 6-8).

Note: *CR3153* is severely limited in development despite maintaining shoot dry weight.

B-inefficient *CR3153* seems to be more water-use efficient than B-efficient *CR2267*

Δ ^{13}C discrimination and water use efficiency (WUE) are negatively correlated[4].

CR3153 discriminates ^{13}C less and, therefore, seems to be more water-use efficient than *CR2267* on WW and esp. in WW and -B conditions. However, WUE increases more for *CR2267* than *CR3153* comparing WL to WW treatment on each B concentration.

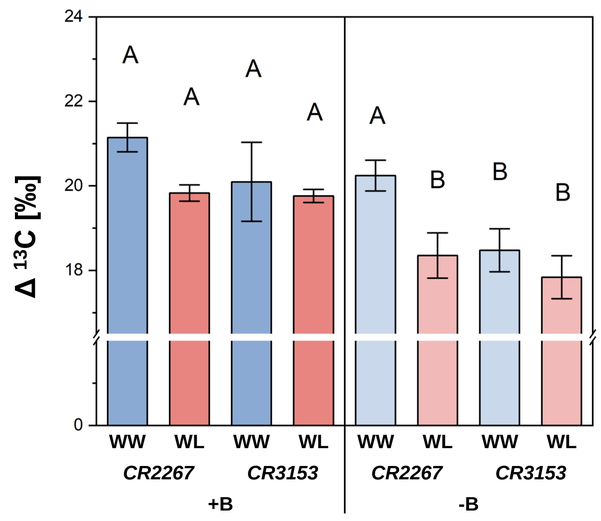
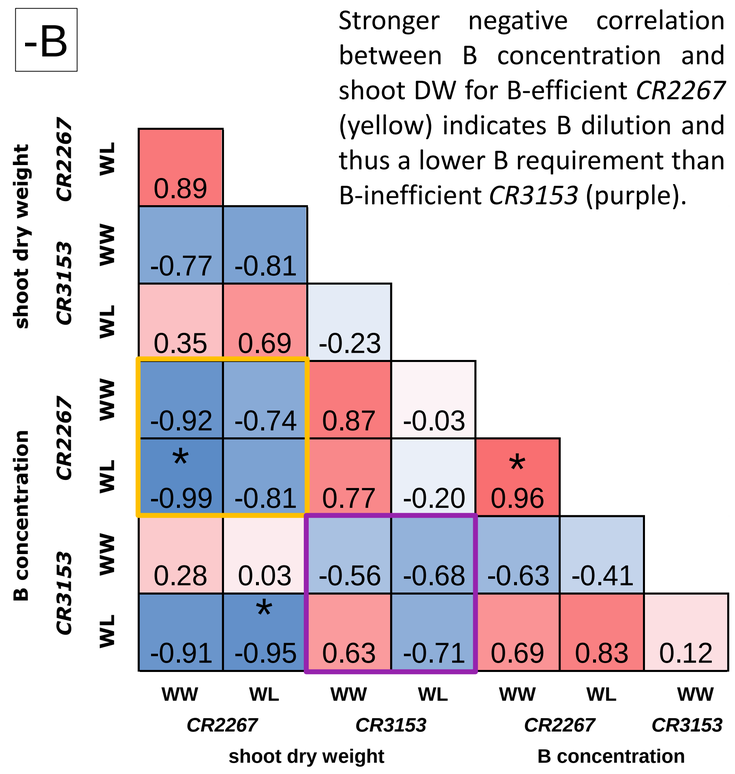


Fig. 5: Δ ^{13}C discrimination of *B. napus* accessions *CR2267* and *CR3153* 7 days after the first flowers opened, being two weeks after drought stress induction at the stage of flower bud development. Plants were grown in different B concentrations (+B, -B) and well-watered (WW) and water-limited (WL) treatments. Different letters indicate significant differences between accessions and water treatments within a B concentration ($p < 0.05$, 2-way ANOVA, post hoc Tukey test); error bars = SE; n = 4.

B-efficient *CR2267* continues to develop biomass in -B conditions with less B than *CR3153*



Stronger negative correlation between B concentration and shoot DW for B-efficient *CR2267* (yellow) indicates B dilution and thus a lower B requirement than B-inefficient *CR3153* (purple).

Fig. 6: Pearson correlation table between shoot dry weight and leaf B concentration of *B. napus* accessions *CR2267* and *CR3153* grown in B deficient concentration and well-watered (WW) and water-limited (WL) treatments. Different colours represent positive (red) or negative correlations (blue), and colour intensity represents Pearson correlation coefficient (* $p < 0.05$; n = 4-8).

B concentration is the same in leaves of B-inefficient *CR3153* and B-efficient *CR2267* within B treatment

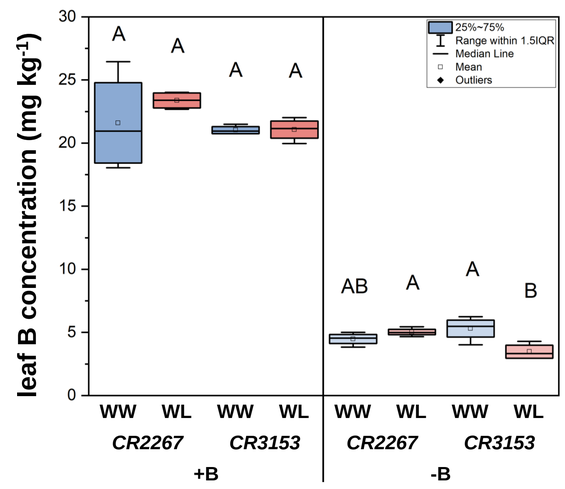


Fig. 8: B concentrations in leaves of the main raceme of *B. napus* accessions *CR2267* and *CR3153* grown in different B concentrations (+B, -B) and well-watered (WW) and water-limited (WL) treatments. Different letters indicate significant differences between genotypes and water treatments within a B concentration ($p < 0.05$, 2-way ANOVA, post hoc Tukey test) (n = 4).

Conclusion

B-efficient *CR2267* is more fertile in -B conditions and can continue development in a lower B environment, even with a significantly lower leaf B concentration. Meanwhile, B-inefficient *CR3153* discriminates ^{13}C less than *CR2267* indicating a higher water-use efficiency and potentially different adaptive strategies between the two genotypes.

Next steps

Identification of underlying genes controlling water usage- and B efficiency by quantitative trait locus (QTL) mapping. This will make use of a doubled-haploid population derived from a F_1 cross of *CR2267* and *CR3153* and segregating for B efficiency, data for which is currently being analysed.

References

1: Brdar-Jokanovic (2020), Int. J. Mol. Sci., 21, 1424.
2: Wimmer & Eichert (2013), Plant Sci., 203-204, 25 – 32.
3: Pommerrenig et al. (2018), Front. Plant Sci., 9, 1142.
4: Hubick & Farquhar (1989), Plant, Cell and Environ., 12, 795-804.

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