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Effect of water stress during flowering of ('*Narve Viking*' and '*Ben Gairn*' two pot grown blackcurrant (*Ribes nigrum* L.)

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The Interreg IVB North Sea Region Programme

Introduction/background

- During the last 5 growing seasons in Denmark extreme weather conditions (periods of drought, heavy rain during the production season, lack of winter chill) have had a negative impact on productivity and sustainability in blackcurrant.

- Water stress during critical developmental phases such as flower induction and flowering may influence growth and yield.

- This study investigated effects of decreasing water availability during flowering in two blackcurrant cultivars.

- Shoot and root growth, as well, as physiological responses were determined during the stress period and after a recovery phase.

Greenhouse experiment

Material and methods

Plant material and location: **1 year old plants** of **'Ben Gairn' and 'Narve Viking'**

- The **experiment was started** in **March 2011** in an **experimental greenhouse**, growing plants in plastic **pots** with a loamy sand soil (USDA).

- Two weeks after potting **treatments were started** (**begining of flowering**).

Treatments: Full irrigation (FI) daily according to weight loss
No irrigation (NI) for 0, 2, 5, 7, 9 and 12 days followed by recovery at full irrigation

Measurements: every day – evapotranspiration
on 0, 2, 5, 7, 9, 12 days of NI– stomatal conductance, water and osmotic potential, samples for gene expression

at the end of treatment , day 12– fresh and dry weight, root window observation, ^{15}N analyses, Whino RHIZO root elongation

at the end of recovery period , 14 days– fresh and dry weight

Results

Accumulated evapotranspiration

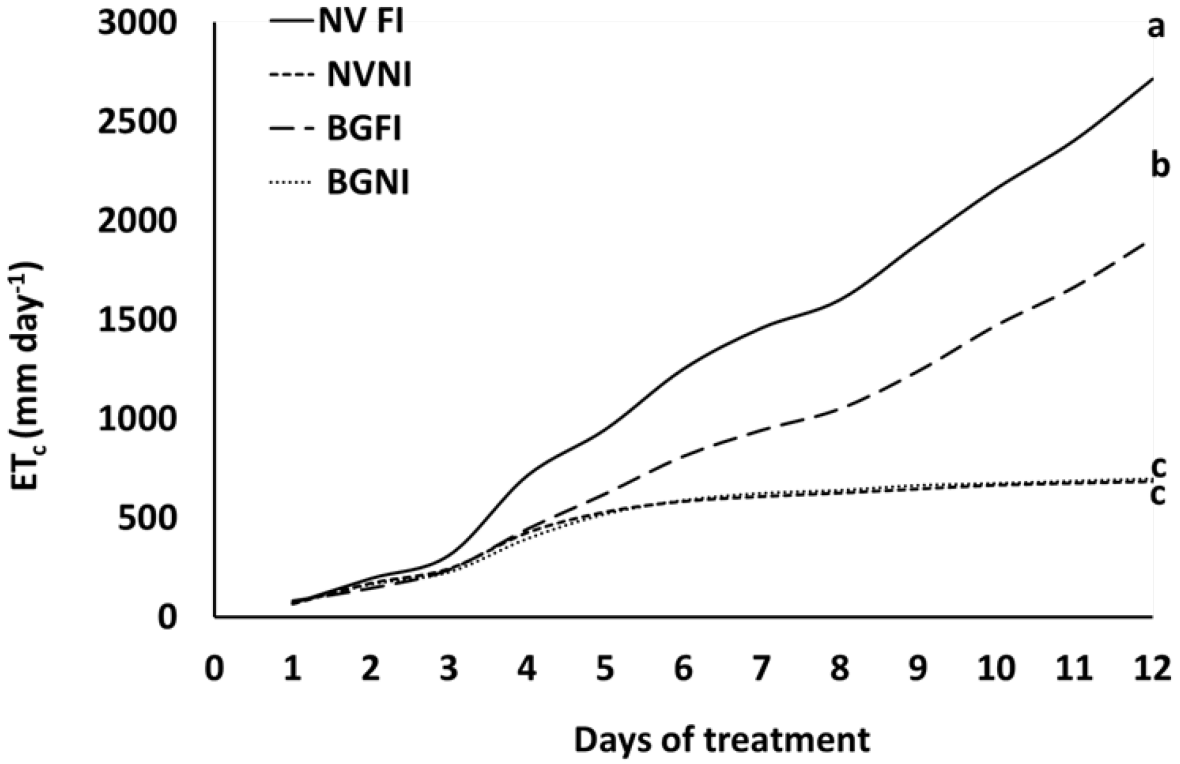


Figure 1. Accumulated evapotranspiration (ET_c) of fully irrigated (FI) and none irrigated (NI) plants, of 'Narve Viking' (NV) and 'Ben Gairn' (BG) over a 12 day period where the small letters indicate significant differences ($P < 0.05$) at day 12 according to Tukey's test (n=4).

Leaf area, leaf water content, specific leaf area, and water use efficiency

Table 2. Effects of FI or NI on total leaf area, leaf water content, specific leaf area and water use efficiency (WUE) in two blackcurrant cultivars 'Ben Gairn' (BG) and 'Narve Viking' (NV) after 12 days of treatment. Values with the same letters within a column are not significantly different at P <0.05 according to Tukey's test (n=4).

Cultivar	Treatment	Total leaf area (cm^2)	Leaf water content (g g^{-1} DW)	Specific leaf area (cm^2 g^{-1}DW)	Water use efficiency (g g^{-1} DW)
Ben Gairn	12FI	1385.02^{a}	3.06^{a}	225.18^{ab}	0.77^{b}
Ben Gairn	12NI	623.87^{b}	2.41^{b}	217.20^{ab}	1.31^{b}
Narve Viking	12FI	1733.81^{a}	3.45^{a}	256.90^{a}	0.94^{b}
Narve Viking	12NI	576.43^{b}	2.04^{b}	195.62^{b}	2.33^{a}

Stomatal conductance

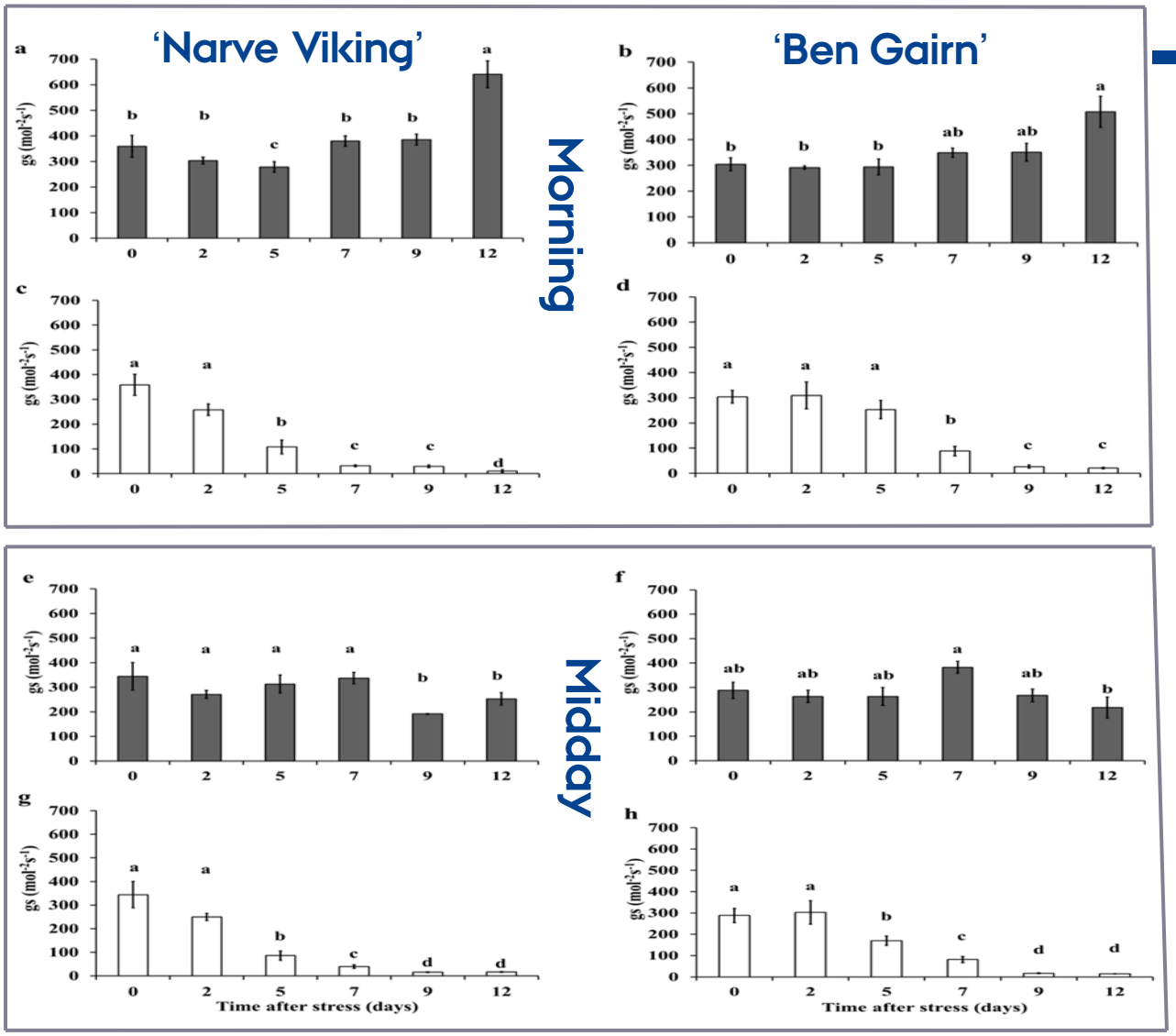


Figure 2. Stomatal conductance measured between 9-10 am (a,b,c,d) and between 12:30-13:30 pm (e,f,g,h) for blackcurrant cultivars 'Narve Viking' (left) and 'Ben Gairn' (right) grown at FI (black) or NI (white) for 0,2,5,7,9 and 12 days. Letters indicate significant differences between days of treatment, within a cultivar, irrigation treatment and time of measurement at P <0.05 according to Tukey's test. Bars indicate standard error of mean (n=4).

Non irrigated

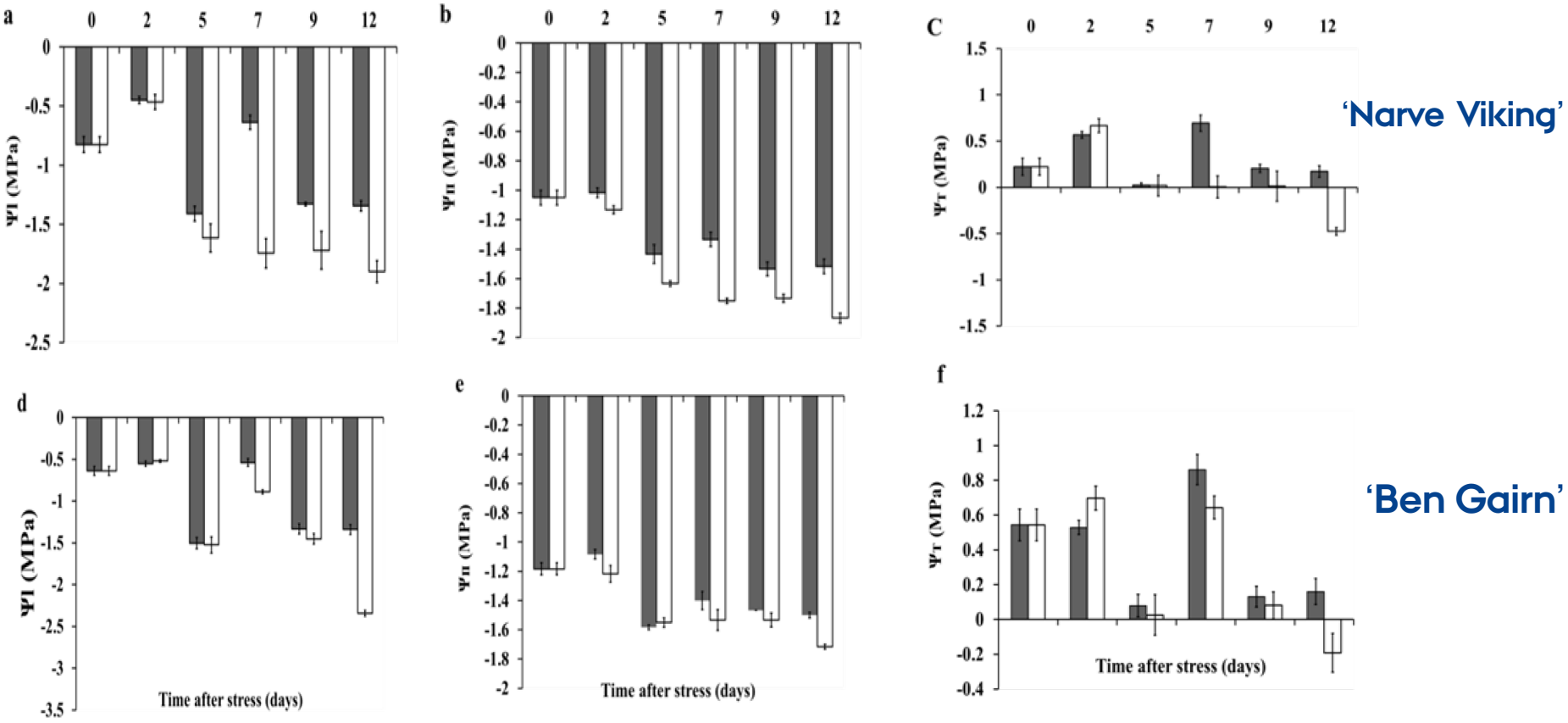
Full irrigated

Plant water status

Water potential

Osmotic potential

Turgor



'Narve Viking'

'Ben Gairn'

Figure 3. Water potential, osmotic potential and turgor of FI and NI plants, of 'Narve Viking' (a,b,c) and 'Ben Gairn' (d,e,f) over a 12 day period. Bars indicate standard error of the mean (n=4).

Dry mass distribution in recovery phases (dry matter g plant $^{-1}$)

Table 3. Dry matter distribution between different organs of blackcurrant cultivars Ben Gairn (BG) and Narve Viking (NV) after 12 days of NI or FI and after 17 days of recovery at FI

Cultivar	Treatment	Flowers	Leaves	Stems	Root	Shoot / Root ratio
Ben Gairn	12FI+ 17FI	1.35 ^{a}	9.93 ^{ab}	11.03 ^{b}	11.94 ^{b}	1.89 ns
Ben Gairn	12NI+ 17FI	0.10 ^{b}	6.85 ^{bc}	9.78 ^{b}	9.64 ^{b}	1.79 ns
Narve Viking	12FI+ 17FI	2.23 ^{a}	14.46 ^{a}	21.96 ^{a}	19.33 ^{a}	2.06 ns
Narve Viking	12NI+ 17FI	0.03 ^{b}	3.63 ^{c}	12.13 ^{b}	10.53 ^{b}	1.39 ns

Root recovery

Table 4. Effects of full irrigation (FI) and no irrigation (NI) after a 17 day recovery phase on root length and root diameter classes in two blackcurrant cultivars grown in greenhouse. Data are means of 4 plants. Values with the same letters within a column are not significantly different at P <0.05 according to Tukey's test.

Cultivar	Treatment	Root length (m)	Diameter classes of root length (mm)				
			0.00-0.20	0.20-0.50	0.50-1.00	1.00-3.00	>3.00
Ben Gairn	12FI+17FI	7.14 [b]	1040.17 [a]	3812.34 [b]	1601.41 [b]	607.70 [b]	80.12 [b]
Ben Gairn	12NI+17FI	5.74 [b]	907.98 [b]	2858.28 [b]	1429.81 [b]	473.00 [b]	79.965 [b]
Narve Viking	12FI+17FI	12.68 [a]	1496.73 [a]	6837.48 [a]	3031.80 [a]	1187.48 [a]	132.42 [a]
Narve Viking	12NI+17FI	6.26 [b]	953.26 [b]	3451.97 [b]	1292.67 [b]	465.54 [b]	100.66 [b]

Root recovery

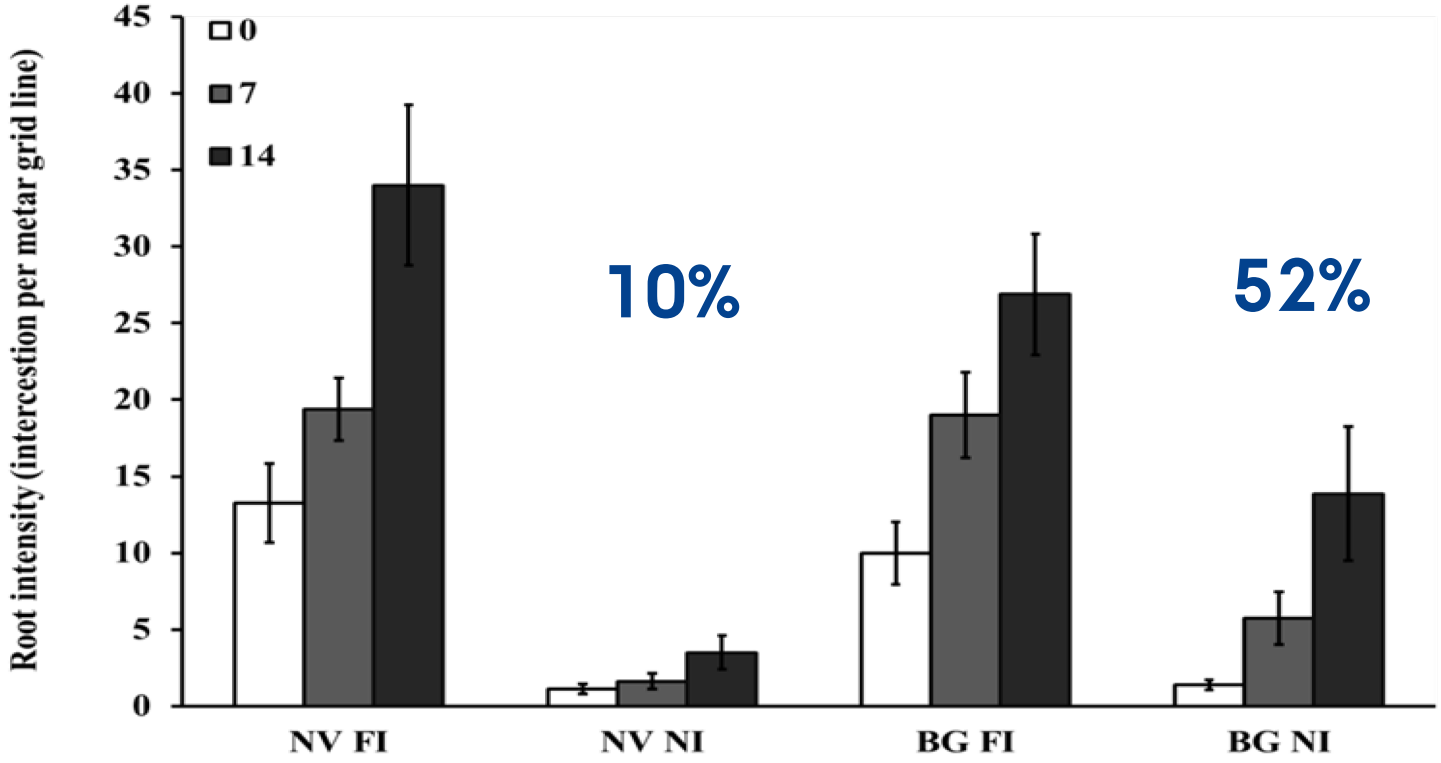


Figure 4. Root intensity, determined as the number of roots in a given area, after 12 days of no irrigation (NI) or full irrigation (FI) followed by 0, 7 and 14 days of recovery in blackcurrant cultivars 'Narve Viking' (NV) and 'Ben Gairn' (BG). Bars indicate standard error of the mean (n=4).

Conclusions: Responses to drought during flowering

- Reduced evapotranspiration
- Decreased stomatal conductance
- Decreased leaf water potential
- Decreased osmotic potential
- Decreased turgor
- Reduced leaf water content
- Decreased leaf area and length of fine roots
- Decreased dry matter in flowers, leaves , stems and roots

- 'Ben Gairn' was less affected by drought stress than 'Narve Viking' and had a faster root recovery and less reduction in growth of aerial parts during the drought treatment.

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