forests

Supplementary Material

MDPI

Article

Counter-intuitive response to water limitation in a Southern European provenance of *Frangula alnus* Mill. in a common garden experiment

Kristine Vander Mijnsbrugge [1,*], Lise De Clerck[2], Nele Van der Schueren [3], Stefaan Moreels [1], Amy Lauwers [4], Kathy Steppe [5], Liselotte De Ligne [6], Matteo Campioli [7] and Jan Van den Bulcke [6]

[1] Department of Forest Ecology and Management, Research Institute for Nature and Forest, 9500 Geraardsbergen, Belgium; kristine.vandermijnsbrugge@inbo.be; stefaan.moreels@inbo.be
[2] present address: Galgenberg 5, 9000 Ghent, Belgium; LiseDeClerck@hotmail.com
[3] present address: Spaarstraat 56, 3000 Leuven, Belgium; vdsnele@hotmail.be
[4] present address: Tacituslaan 31, 5600 Eindhoven, The Netherlands; amy.lauwers@hotmail.com
[5] Laboratory of Plant Ecology, Faculty of Bioscience Engineering, Ghent University, 9000 Ghent, Belgium; kathy.steppe@ugent.be
[6] UGent-Woodlab, Faculty of Bioscience Engineering, Ghent University, 9000 Ghent, Belgium; Liselotte.DeLigne@ugent.be; Jan.Vandenbulcke@ugent.be
[7] Research Group PLECO (Plants and Ecosystems), Department of Biology, University of Antwerp, 2160 Wilrijk, Belgium
* Correspondence: Kristine.vandermijnsbrugge@inbo.be (first name: Kristine, last name: Vander Mijnsbrugge); Tel.: +3247 828 2137

1. Supplementary Figures

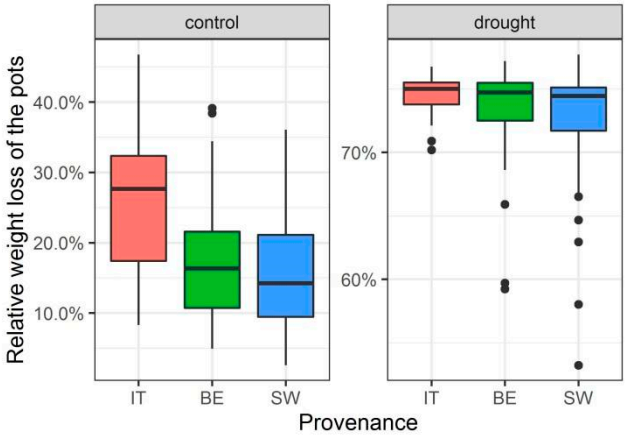

Figure S1. Relative weight loss of the pots for each provenance and according to the treatment of the plants. IT: Italian provenance, BE: Belgian provenance, SW: Swedish provenance.

2. Supplementary Tables

Table S1. Model statistics for leaf lamina length and lamina widest width in the control group. P is the provenance, with the Belgian provenance as the standard level to which the Italian (P_I) and Swedish (P_S) provenance are compared with. H_2 is the length of the central shoot at the end of the drought treatment.

Response variable	Co-variable	Estimate	Std. error	df	t-value	p-value
Lamina length	intercept	7.68	0.405	115	18.96	< 0.001***
	H_2	0.03	0.004	115	8.34	< 0.001***
	P_I	1.02	0.462	36	2.20	0.034*
	P_S	0.66	0.389	36	1.69	0.099
Lamine width	intercept	4.51	0.262	115	17.18	< 0.001***
	H_2	0.01	0.003	115	3.97	< 0.001***
	P_I	1.06	0.265	36	3.99	< 0.001***
	P_S	0.61	0.223	36	2.73	0.009**

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Table S2. Model statistics for stomatal density and stomatal length. P is the provenance, with the Belgian provenance as the standard level to which the Italian (P_I) and Swedish (P_S) provenance are compared with. H_2 is the length of the central shoot at the end of the treatment. L is the length of the leaf lamina.

Response variable	Co-variable	Estimate	Std. error	df	t-value	p-value
Stomatal density	intercept	41.49	15.21	144	2.73	0.007**
	P_I	8.34	3.20	19	2.61	0.017*
	P_S	-3.20	2.83	19	-1.13	0.273
	H_2	0.09	0.14	19	0.69	0.499
	L	-1.53	0.84	19	-1.85	0.080
Stomatal length	intercept	0.012462	0.002901	1008	4.30	< 0.001***
	P_I	0.000673	0.000610	19	1.10	0.283
	P_S	0.001155	0.000542	19	2.13	0.046*
	H_2	-0.000141	0.000158	19	-0.89	0.384
	L	-0.000001	0.000026	19	-0.05	0.962

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Table S3. Model statistics for the length and diameter measurements of the central shoot at the start of the treatment. P is the provenance, with the Belgian provenance as the standard level to which the Italian (P_I) and Swedish (P_S) provenance are compared with.

Response variable	Co-variable	Estimate	Std. error	df	t-value	p-value
Central shoot length	intercept	64.37	2.62	270	24.57	< 0.001***
	P_I	5.91	4.62	36	1.28	0.210
	P_S	-0.32	3.90	36	-0.08	0.935
Central shoot diameter	intercept	3.34	0.09	270	37.49	< 0.001***
	P_I	0.36	0.16	36	2.29	0.028*
	P_S	0.50	0.13	36	3.78	< 0.001***

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Table S4. Model statistics for the growth increments of the length and the diameter of the central shoot during and after the water withholding period in 2018. P is the provenance, with the Belgian provenance as the standard level to which the Italian (P_I) and Swedish (P_S) provenance are compared with. W is the weight loss of the pots during the water withholding treatment. H_1 and H_2 are the lengths of the central shoots at the start and at the end of the treatment respectively.

Time frame	Response variable	Co-variable	Estimate	Std. error	df	t-value	p-value
During drought treatment	Length increment	intercept	4.52	1.85	266	2.45	0.015*
		W	-12.72	1.90	266	-6.68	< 0.001***
		P_I	14.37	2.24	36	6.40	< 0.001***
		P_S	-8.68	1.68	36	-5.15	< 0.001***
		H_1	0.20	0.02	266	8.61	< 0.001***
		W:P_I	-19.33	3.68	266	-5.25	< 0.001***
		W:P_S	6.70	2.81	266	2.38	0.018*
	Diameter increment	intercept	0.685	0.13	266	5.21	< 0.001***
		W	0.036	0.03	266	1.10	0.274
		P_I	-0.63	0.13	266	-5.00	< 0.001***
		P_S	0.48	0.14	36	3.41	0.002**
		H_1	0.041	0.10	36	0.40	0.689
		W:P_I	-0.96	0.25	266	-3.90	< 0.001***
		W:P_S	-0.07	0.19	266	-0.35	0.724
After drought treatment	Length increment	intercept	1.755	0.318	266	5.51	< 0.001***
		W	-1.279	0.034	266	-3.52	0.001**
		P_I	1.003	0.396	36	2.53	0.016*
		P_S	-0.945	0.289	36	-3.27	0.002**
		H_2	0.004	0.003	266	1.32	0.189
		W:P_I	-1.242	0.706	266	-1.76	0.080
		W:P_S	1.114	0.540	266	2.06	0.040*
	Diameter increment	intercept	0.15	0.13	266	1.15	0.253
		W	0.07	0.03	266	2.40	0.017*
		P_I	-0.27	0.12	266	-2.23	0.026*
		P_S	0.68	0.14	36	4.99	< 0.001***
		H_2	-0.27	0.099	36	-2.68	0.011*
		W:P_I	-1.19	0.24	266	-5.01	< 0.001***
		W:P_S	-0.08	0.18	266	-0.44	0.659

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Table S5. Model statistics for the timing of the wilting of the leaves during the drought treatment of the plants. P is the provenance, with the Belgian provenance as the standard level to which the Italian (P_I) and Swedish (P_S) provenance are compared with. W is the weight loss of the pots during the water withholding treatment. H_1 is the length of the central shoot at the start of the treatment.

Co-variable	Estimate	Std. error	z-value	p-value
D	1.05	0.08	12.74	< 0.001***
H_1	6.46	0.50	12.90	< 0.001***

W	6.87	0.53	12.95	< 0.001***
P_I	5.51	1.19	4.62	< 0.001***
P_S	-0.87	0.99	-0.88	0.38
H_1:W	-0.08	0.01	-12.37	< 0.001***

*** $p < 0.001$.

Table S6. Model statistics for the binary response variable presence/absence of new emerging shoots after post-drought re-watering. P is the provenance, with the Belgian provenance as the standard level to which the Italian (P_I) and Swedish (P_S) provenance are compared with. H_2 is the length of the central shoot at the end of the treatment. W is the weight loss of the pots during the water withholding treatment.

Co-variable	Estimate	Std. error	z-value	p-value
intercept	-10.53	9.25	-1.14	0.255
P_I	-20.19	43.12	-0.47	0.640
P_S	-17.24	18.72	-0.92	0.357
W	7.36	13.59	0.54	0.588
H_2	0.07	0.02	2.80	0.005**
P_I:W	27.94	58.43	0.48	0.632
P_S:W	22.39	25.36	0.88	0.377

** $p < 0.01$.

Table S7. Model statistics for the post-drought phenophases leaf senescence and bud burst. P is the provenance, with the Belgian provenance as the standard level to which the Italian (P_I) and Swedish (P_S) provenance are compared with. H_3 and H_4 are the length of the central shoot at the end of 2018 and the length of the largest shoot at the end of 2019 respectively. W is the weight loss of the pots during the water withholding treatment.

Response variable	Co-variable	Estimate	Std. error	z-value	p-value
Leaf senescence 2018, top	W	-0.24	0.94	-0.25	0.800
	P_I	3.88	1.07	3.64	< 0.001***
	P_S	1.58	0.72	2.20	0.028*
	H_3	-0.02	0.72	-2.20	0.028*
	W:P_I	-5.76	2.77	-2.08	0.037*
	W:P_S	2.15	1.26	1.71	0.087
Leaf senescence 2018, base stem	W	-3.24	0.69	-4.71	< 0.001***
	P_I	0.23	0.72	0.32	0.746
	P_S	1.78	0.51	3.50	< 0.001***
	H_3	0.04	0.01	5.21	< 0.001***
	W:P_I	-0.15	1.69	-0.09	0.929
	W:P_S	3.45	1.02	3.37	< 0.001***
Bud burst 2019, top	D	-0.57	0.03	-17.12	< 0.001***
	P_I	-0.73	1.13	-0.64	0.520
	P_S	1.95	0.87	2.25	0.025 *
	W	-1.59	0.76	-2.10	0.036 *
	H_3	0.04	0.01	5.46	< 0.001***

	W:P_I	-0.86	1.94	-0.44	0.657
	W:P_S	-2.56	1.14	-2.24	0.025 *
Bud burst 2019, base stem	D	-0.47	0.03	-16.02	< 0.001***
	W	-0.44	0.76	-0.58	0.520
	P_I	-0.21	1.00	-0.21	0.836
	P_S	1.37	0.75	1.83	0.067
	H_3	0.025	0.01	3.07	0.002 **
	W:P_I	-3.93	2.08	-1.89	0.059
	W:P_S	-1.15	1.25	-0.93	0.354
Leaf senescence 2019	D	0.180	0.01	20.45	< 0.001***
	P_I	0.38	0.46	0.83	0.406
	P_S	2.50	0.36	7.03	< 0.001***
	W	1.96	0.42	4.70	< 0.001***
	H_4	0.02	0.01	3.78	< 0.001***
	W:P_I	-1.45	0.96	-1.51	0.131
	W:P_S	-0.73	0.61	-1.20	0.230
Bud burst 2020	D	-0.54	0.036	-15.09	< 0.001***
	P_I	-2.88	1.78	-1.62	0.105
	P_S	-2.12	1.45	-1.46	0.144
	W	0.012	0.85	0.01	0.989
	H_4	0.076	0.01	6.04	< 0.001***
	W:P_I	-0.18	1.86	-0.10	0.921
	W:P_S	-1.12	1.15	-0.93	0.329

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Table S8. Model statistics for the largest shoot size measurements at the end of 2019. P is the provenance, with the Belgian provenance as the standard level to which the Italian (P_I) and Swedish (P_S) provenance are compared with. W is the weight loss of the pots during the water withholding treatment.

Response variable	Co-variable	Estimate	Std. error	df	t-value	p-value
Length	intercept	55.21	2.81	202	19.65	< 0.001***
	W	-29.85	4.54	202	-6.57	< 0.001***
	P_I	11.22	5.69	36	1.971	0.057
	P_S	-5.77	4.16	36	-1.39	0.174
	W:P_I	-11.28	11.27	202	-1.00	0.318
	W:P_S	-4.75	6.78	202	-0.70	0.485
Diameter	intercept	5.15	0.22	202	23.07	< 0.001***
	W	-1.34	0.39	202	-3.47	0.001**
	P_I	0.68	0.46	36	1.48	0.148
	P_S	0.45	0.33	36	1.37	0.181
	W:P_I	-0.14	0.96	202	-0.14	0.888
	W:P_S	-0.88	0.58	202	-1.53	0.128

*** $p < 0.001$; ** $p < 0.01$.

Table S9. Model statistics for the number of reshoots per plant at the end of 2019. P is the provenance, with the Belgian provenance as the standard level to which the Italian (P_I) and Swedish (P_S) provenance are compared with. W is the weight loss of the pots during the water withholding treatment. H_4 is the length of the largest shoot at the end of 2019.

Co-variable	Estimate	Std. error	z-value	p-value
intercept	2.48	0.13	18.527	< 0.001***
W	-0.36	0.14	-2.563	0.010 *
P_I	-0.12	0.17	-0.676	0.499
P_S	-0.64	0.13	-4.866	< 0.001***
H_4	-0.00	0.00	-2.050	0.040 *
W:P_I	-0.53	0.36	-1.485	0.137
W:P_S	0.01	0.23	0.039	0.969

*** $p < 0.001$; * $p < 0.05$.