

Supplementary Materials



Figure S1. Germinated seedlings of *Abies marocana* after the growth experiment (twelve weeks) in the greenhouse of the Ecology Area at the University Pablo de Olavide (Seville, Spain).

Table S1. Microclimatic conditions measured at the Talassemtane study site. Mean (T), maximum (TM), and minimum (Tm) monthly air temperature (°C). Mean monthly relative air humidity, (RH, %). Mean monthly soil water content, (SWC, vol%). Mean monthly vapor pressure deficit (VPD, kPa).

Month	SWC (% vol.)	RH (%)	T (°C)	TM (°C)	Tm (°C)	VPD (kPa)
January	39.08	0.78	3.50	14.45	-4.27	0.21
February	40.99	0.73	2.23	13.65	-6.19	0.24
March	40.56	0.83	3.63	18.33	-3.99	0.17
April	37.45	0.69	10.02	22.45	1.29	0.46
May	38.78	0.79	11.48	21.25	2.57	0.32
June	36.66	0.58	16.37	29.65	5.37	0.90
July	28.71	0.40	22.27	31.05	16.29	1.56
August	26.00	0.43	21.72	33.89	9.81	1.53
September	25.16	0.58	16.58	28.69	4.89	0.85
October	35.28	0.71	10.28	24.29	3.29	0.39
November	38.98	0.79	6.10	15.53	-1.07	0.22
December	40.37	0.78	5.34	17.73	-2.79	0.23

Table S2. Calculation of the variables used to characterize cone scales morphology.

Variable	Computation	Units
Area	Area of the object in square pixels or in the square calibrated unit.	cm ²
Perimeter	Length of the outer boundary of the selected object.	cm
Circularity	Calculate the circularity of an object using the formula: $circularity = 4\pi (Area / (perimeter)^2)$. A circularity value of 1.0 indicates a perfect circle. As the value approaches 0.0, it indicates an increasingly elongated polygon.	Dimensionless
FERET Diameter	Longest distance between two points along the selection boundary.	cm
FERET Diameter	Min. Minimum diameter between two points along the selection boundary.	cm
AR	Aspect ratio, AR=main axe/minor axe	Dimensionless
Round	ROUND = 1/AR	Dimensionless
Solidity	Solidity=area/convex area	Dimensionless
Fractal Dimension	A measure of the complexity of the pattern presented by the object. Fractal Dimension counts the number of cells of increasing size needed to cover a one-pixel binary object boundary.	

Table S3. Correlation matrix for cone scales dimensions seed weight and early seedling development (germination, cotyledons emergence and growth). See variable units and abbreviations in Table 1. Significant values, $p < 0.05$, are highlighted in red.

	Sw	Ger_rat	Ger_tim	Cot_tim	Sling_siz	G_rat	Scal_are	Scal_per	Scal_dmax	Scal_dmin	Scal_areCV	Scal_perCV	Scal_dmax CV	Scal_dminCV
Sw	-	0.21	0.12	0.15	-0.41	-0.41	-0.27	-0.12	-0.02	-0.17	-0.22	-0.44	-0.22	-0.30
Ger_rat	0.21	-	-0.24	0.06	-0.08	-0.08	-0.15	-0.14	-0.17	-0.11	0.21	0.14	0.07	0.05
Ger_tim	0.12	-0.24	-	-0.11	-0.35	-0.35	-0.21	-0.19	-0.22	-0.18	-0.05	0.12	-0.02	-0.10
Cot_tim	0.15	0.06	-0.11	-	-0.08	-0.08	-0.16	-0.14	-0.11	-0.13	0.04	-0.08	0.06	-0.01
Sling_siz	-0.41	-0.08	-0.35	-0.08	-	1.00	0.66	0.61	0.57	0.60	0.02	-0.04	-0.06	0.32
G_rat	-0.41	-0.08	-0.35	-0.08	1.00	-	0.66	0.61	0.57	0.60	0.02	-0.04	-0.06	0.32
Scal_are	-0.27	-0.15	-0.21	-0.16	0.66	0.66	-	0.98	0.93	0.98	-0.24	-0.24	-0.19	0.16
Scal_per	-0.12	-0.14	-0.19	-0.14	0.61	0.61	0.98	-	0.95	0.98	-0.29	-0.35	-0.28	0.12
Scal_dmax	-0.02	-0.17	-0.22	-0.11	0.57	0.57	0.93	0.95	-	0.91	-0.30	-0.43	-0.30	0.14
Scal_dmin	-0.17	-0.11	-0.18	-0.13	0.60	0.60	0.98	0.98	0.91	-	-0.24	-0.27	-0.18	0.11
Scal_areCV	-0.22	0.21	-0.05	0.04	0.02	0.02	-0.24	-0.29	-0.30	-0.24	-	0.78	0.81	0.76
Scal_perCV	-0.44	0.14	0.12	-0.08	-0.04	-0.04	-0.24	-0.35	-0.43	-0.27	0.78	-	0.70	0.54
Scal_dmax CV	-0.22	0.07	-0.02	0.06	-0.06	-0.06	-0.19	-0.28	-0.30	-0.18	0.81	0.70	-	0.42
Scal_dminCV	-0.30	0.05	-0.10	-0.01	0.32	0.32	0.16	0.12	0.14	0.11	0.76	0.54	0.42	-

Table S4. Main effects ANOVA for cone scales dimensions. See variable units and abbreviations in the main text Table 1.

	mean	SE	Species			Population			Tree			Cone		
			DF	F	P	DF	F	P	DF	F	P	DF	F	P
Scal_are	6.49	0.07	1	8036.37	0.00	2	201.97	0.00	16	71.84	0.00	85	2.23	0.00
Scal_per	12.31	0.06	1	2378.37	0.00	2	99.15	0.00	16	47.97	0.00	85	2.32	0.00
Scal_dmax	3.75	0.02	1	2048.57	0.00	2	127.45	0.00	16	48.05	0.00	85	1.74	0.00
Scal_dmin	2.83	0.02	1	2918.09	0.00	2	65.71	0.00	16	48.09	0.00	85	1.72	0.00

Table S5. Main effects ANOVA for seed weight and early seedling development (germination, cotyledons emergence and growth). See variable units and abbreviations in main text, Table 1.

	mean	SE	Species			Population			Tree		
			DF	F	P	DF	F	P	DF	F	P
Sw	104.61	2.00	1	613.91	0.00	2	38.80	0.00	16	180.21	0.00
Ger_rat	73.10	1.41	1	3236.17	0.00	2	924.98	0.00	16	3529.07	0.00
Ger_tim	29.46	0.57	1	3.71	0.06	2	4.02	0.02	15	2.99	0.00
Cot_tim	5.51	0.17	1	17.18	0.00	2	1.97	0.14	15	1.12	0.34
Sling_siz	6.35	0.20	1	221.22	0.00	2	1.15	0.32	14	2.31	0.01
G_rat	0.79	0.02	1	221.22	0.00	2	1.15	0.32	14	2.31	0.01