Stojanova B., Münzbergová Z. & Pánková H. (2021) Inbreeding depression and heterosis vary in space and time in the serpentinophyte perennial *Minuartia smejkalii*. – Preslia 93: 149–168.

Electronic appendices

Electronic Appendix 1. – Analyses of late cycle traits for the complete dataset (full model, without effects of sire). Significant values are in bold and significant values after correction for multiple comparisons in a model (31 in total) are underlined. Sample sizes are given in brackets next to the variable name. Flower production was analyzed with a logistic regression, all other traits were long-transformed and analyzed with a linear regression. Flower number is a data subset of plants that produced at least one flower. Dam – pollen recipient (nested in population).

		Width (1679)		N° stems (1672)		Flower set (1653)		Flower number (1450)		Flower production (1672)	
Variable	DF	Dev	p-value	Dev	p-value	Dev	p-value	Dev	p-value	Dev	p-value
Treatment	2	52.8	**<0.001**	189.0	**<0.001**	155.9	**<0.001**	190.6	**<0.001**	29.4	**<0.001**
Soil	1	350.7	**<0.001**	446.9	**<0.001**	415.7	**<0.001**	258.4	**<0.001**	187.4	**<0.001**
Pop	2	14.5	**<0.001**	9.6	**0.0083**	65.4	**<0.001**	17.7	**<0.001**	52.8	**<0.001**
Cross type	4	133.6	**<0.001**	106.4	**<0.001**	44.7	**<0.001**	76.7	**<0.001**	12.9	**0.0117**
Year	1	4.8	**0.0285**	879.9	**<0.001**	446.8	**<0.001**	226.0	**<0.001**	258.4	**<0.001**
Dam_{Pop}	21	59.8	**<0.001**	61.7	**<0.001**	70.3	**<0.001**	52.5	**<0.001**	5.3	**<0.001**
Treatment x Soil	2	43.9	**<0.001**	26.0	**<0.001**	44.2	**<0.001**	40.2	**<0.001**	5.0	0.0698
Treatment x Pop	4	8.2	0.0837	0.7	0.9490	9.4	0.0527	5.2	0.2641	4.8	0.2869
Treatment x Cross type	8	15.7	**0.0461**	12.0	0.1490	4.8	0.7739	7.6	0.4750	6.1	0.7834
Treatment x Year	2	23.6	**<0.001**	19.7	**<0.001**	15.9	**<0.001**	25.3	**<0.001**	0.7	**0.0467**
Soil x Pop	2	6.1	**0.0478**	0.8	0.6756	0.1	0.9377	1.3	0.5182	9.3	0.7091
Soil x Cross type	4	13.3	**0.0099**	10.2	**0.0368**	11.7	**0.0195**	1.4	0.8428	35.6	0.0536
Soil x Year	1	480.5	**<0.001**	445.1	**<0.001**	633.6	**<0.001**	454.9	**<0.001**	26.6	**<0.001**
Pop x Cross type	5	26.6	**<0.001**	20.6	**0.0010**	29.7	**<0.001**	8.1	0.1534	13.8	**<0.001**
Pop x Year	2	135.4	**<0.001**	77.6	**<0.001**	105.1	**<0.001**	60.1	**<0.001**	9.1	**0.0010**
Cross type x Year	4	21.0	**<0.001**	6.1	0.1897	20.6	**<0.001**	19.7	**<0.001**	52.3	0.0590
Treatment x Soil x Pop	4	2.6	0.6233	6.2	0.1871	4.6	0.3289	8.2	0.0838	-	-
Treatment x Soil x Cross type	8	12.5	0.1284	9.6	0.2919	7.6	0.4751	12.3	0.1375	-	-
Treatment x Soil x Year	2	3.8	0.1513	2.5	0.2923	3.9	0.1424	7.3	**0.0257**	-	-
Treatment x Pop x Cross type	9	9.7	0.3772	17.8	**0.0381**	12.7	0.1763	12.7	0.1746	-	-
Treatment x Pop x Year	4	12.7	**0.0128**	8.0	0.0926	11.2	**0.0247**	28.9	**<0.001**	-	-
Treatment x Cross type x Year	8	6.5	0.5937	11.0	0.1990	20.3	**0.0093**	27.1	**<0.001**	-	-
Soil x Pop x Cross type	5	3.9	0.5611	5.0	0.4146	6.2	0.2890	6.2	0.2901	-	-
Soil x Pop x Year	2	23.8	**<0.001**	8.1	**0.0178**	3.3	0.1911	5.8	0.0547	-	-
Soil x Cross type x Year	4	10.2	**0.0367**	7.7	0.1026	12.7	**0.0129**	1.2	0.8788	-	-
Pop x Cross type x Year	5	34.6	**<0.001**	28.5	**<0.001**	35.9	**<0.001**	14.9	**0.0108**	-	-
Treatment x Soil x Pop x Cross type	7	7.4	0.3918	11.3	0.1256	7.5	0.3791	18.3	**0.0109**	-	-
Treatment x Soil x Pop x Year	4	4.5	0.3480	8.5	0.0736	23.5	**<0.001**	11.2	**0.0247**	-	-
Treatment x Soil x Cross type x Year	8	13.4	0.0974	5.1	0.7471	10.0	0.2677	17.5	**0.0252**	-	-
Treatment x Pop x Cross type x Year	9	7.9	0.5406	9.6	0.3807	12.7	0.1754	16.5	**0.0359**	-	-
Soil x Pop x Cross type x Year	5	8.4	0.1371	4.3	0.5134	19.1	**0.0018**	21.3	**<0.001**	-	-
Treatment x Soil x Pop x Cross type x Year	7	4.0	0.7768	5.2	0.6316	5.8	0.5628	11.7	**0.0194**	-	-

Electronic Appendix 2. – Analyses of late cycle traits for the full-sib data subset (full model, with sire). Significant values are in bold and significant values after correction for multiple comparisons in a model (32 in total) are underlined. Sample sizes are given in brackets next to the variable name. All traits were long-transformed and analyzed with a linear regression. Flower number is a data subset of plants that produced at least one flower. Dam – pollen recipient (nested in population), Sire – pollen donor (nested in population).

		Width (1264)		N° stems (1259)		Flower set (1242)		Flower number (1080)	
Variable	DF	Dev	p-value	Dev	p-value	Dev	p-value	Dev	p-value
Treatment	2	41.5	**<0.001**	144.3	**<0.001**	121.4	**<0.001**	135.0	**<0.001**
Soil	1	252.9	**<0.001**	319.6	**<0.001**	308.2	**<0.001**	206.3	**<0.001**
Pop	2	17.5	**<0.001**	5.9	0.0518	51.8	**<0.001**	10.9	**0.0042**
Cross type	4	113.8	**<0.001**	91.9	**<0.001**	41.9	**<0.001**	66.3	**<0.001**
Year	1	3.9	**0.0494**	652.4	**<0.001**	332.6	**<0.001**	177.1	**<0.001**
Dam_{Pop}	18	20.0	0.3330	29.3	**0.0454**	28.2	0.0590	50.3	**<0.001**
$Sire_{Pop}$	83	133.8	**<0.001**	136.5	**<0.001**	115.4	**0.0109**	99.7	0.1860
Treatment x Soil	2	37.0	**<0.001**	24.3	**<0.001**	35.4	**<0.001**	21.6	**<0.001**
Treatment x Pop	4	6.4	0.1688	1.3	0.8571	7.8	0.0989	1.1	0.8988
Treatment x Cross type	8	16.6	**0.0342**	11.8	0.1620	4.2	0.8352	7.8	0.4558
Treatment x Year	2	21.1	**<0.001**	16.4	**<0.001**	10.6	**0.0049**	14.8	**<0.001**
Soil x Pop	2	2.5	0.2816	0.5	0.7969	0.8	0.6657	1.0	0.6014
Soil x Cross type	4	9.5	**0.0492**	12.9	**0.0120**	10.7	**0.0296**	0.3	0.9883
Soil x Year	1	404.7	**<0.001**	390.2	**<0.001**	516.2	**<0.001**	408.8	**<0.001**
Pop x Cross type	5	1.2	0.2674	0.2	0.6885	0.0	0.9923	0.7	0.3902
Pop x Year	2	113.1	**<0.001**	58.3	**<0.001**	83.6	**<0.001**	46.6	**<0.001**
Cross type x Year	4	19.1	**<0.001**	6.1	0.1886	22.8	**<0.001**	17.4	**0.0016**
Treatment x Soil x Pop	4	3.3	0.5085	6.3	0.1750	3.8	0.4267	5.1	0.2782
Treatment x Soil x Cross type	8	8.8	0.3619	5.0	0.7575	6.1	0.6380	8.5	0.3834
Treatment x Soil x Year	2	5.0	0.0804	1.8	0.4114	3.3	0.1967	8.2	**0.0162**
Treatment x Pop x Cross type	9	6.1	0.7291	15.1	0.0881	13.7	0.1317	15.5	0.0783
Treatment x Pop x Year	4	9.9	**0.0415**	8.7	0.0691	7.2	0.1274	15.2	**0.0043**
Treatment x Cross type x Year	8	7.9	0.4403	11.8	0.1610	17.8	**0.0226**	28.9	**<0.001**
Soil x Pop x Cross type	5	2.3	0.8134	4.8	0.4442	3.2	0.6638	3.1	0.6836
Soil x Pop x Year	2	15.9	**<0.001**	6.3	**0.0429**	3.2	0.1996	1.6	0.4428
Soil x Cross type x Year	4	14.2	**0.0066**	11.2	**0.0243**	13.8	**0.0079**	3.3	0.5020
Pop x Cross type x Year	5	35.3	**<0.001**	30.9	**<0.001**	31.6	**<0.001**	8.7	0.1195
Treatment x Soil x Pop x Cross type	7	6.6	0.4685	5.9	0.5559	3.6	0.8251	11.6	0.0728
Treatment x Soil x Pop x Year	4	1.3	0.8674	5.5	0.2404	15.6	**0.0035**	12.9	**0.0117**
Treatment x Soil x Cross type x Year	8	12.6	0.1260	4.3	0.8271	7.3	0.5026	14.9	**0.0374**
Treatment x Pop x Cross type x Year	9	6.5	0.6875	6.6	0.6738	9.8	0.3695	16.9	**0.0183**
Soil x Pop x Cross type x Year	5	7.0	0.2242	5.9	0.3148	11.6	**0.0415**	21.3	**<0.001**
Treatment x Soil x Pop x Cross type x Year	6	6.2	0.4051	7.9	0.2482	10.1	0.0735	15.5	**0.0015**

Electronic Appendix 3. – Inbreeding/outbreeding depression (A) and change in log fitness ± standard error (B) for early and mid-cycle traits. For germination, estimates per soil type (garden or serpentine) are only reported when a significant interaction cross type x soil was detected. The results of significance testing made for the inbreeding and outbreeding load are reported: grey – non significant, black – significant effect of cross type or an interaction in the linear regression according to χ^2 testing of log-likelihood ratios, bold and underlined – significant according to a t-test comparison to the within population outcrossed offspring.

A)

		Z1				Z2				Z6		
		Seed production	Seed number	Germination	Pollen donor	Seed production	Seed number	Germination	Pollen donor	Seed production	Seed number	Germination
	Inbreeding											
		-0.125	-0.337	-		0.104	0.151	0.142		0.009	0.407	0.319
Soil type	Garden			-0.017								
	Serpentine			**0.469**								
	Outbreeding											
Pollen donor	Z6	0.089	0.245	0.084	Z6	-0.026	0.005	0.080	Z1	0.067	-0.304	-0.056
	Z2	0.073	0.083	0.076	Z1	-0.028	-0.075	0.008	Z2	0.157	0.205	0.042

B)

	Z1				Z2				Z6		
	Seed production	Seed number	Germination		Seed production	Seed number	Germination		Seed production	Seed number	Germination
Inbreeding											
	0.050 ± 0.120	0.329 ± 0.420			-0.203 ± 0.161	-0.290 ± 0.475	-0.047 ± 0.055		0.002 ± 0.136	-0.482 ± 0.506	-0.236 ± 0.128
Ctrl			0.065 ± 0.055								
Serp			**-0.118 ± 0.058**								
Between pop breeding											
Z6	0.027 ± 0.519	0.184 ± 0.769	0.032 ± 0.056	Z6	0.169 ± 0.514	0.580 ± 0.901	-0.008 ± 0.058	Z1	-0.326 ± 0.415	1.558 ± 0.974	0.006 ± 0.115
Z2	0.612 ± 0.591	0.919 ± 0.895	0.071 ± 0.051	Z1	0.147 ± 0.601	-0.245 ± 1.282	-0.044 ± 0.053	Z2	-0.381 ± 0.540	0.067 ± 0.732	0.070 ± 0.108

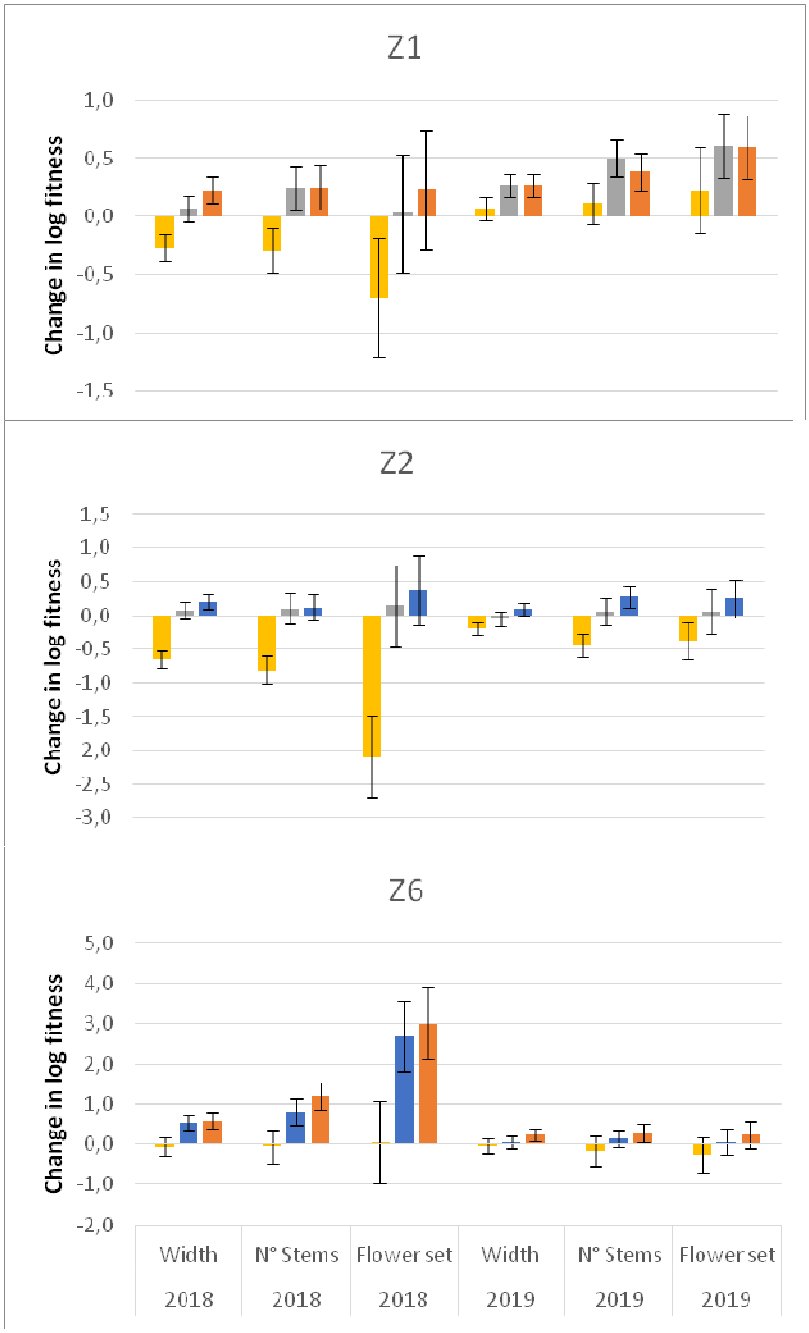
Electronic Appendix 4. – (A) Inbreeding/outbreeding depression estimates and (B) change in log fitness in late-acting traits (± standard error). A negative value signifies a decrease of performance in between population relative to within population outbred offspring. Estimates per soil type (garden or serpentine), treatment (control, competition, shade) or soil x treatment, are only reported when a significant interaction with cross type was detected. The results of significance testing made for the inbreeding and outbreeding load are reported: grey – non significant (without further testing per soil or treatment), black – significant effect of cross type or an interaction with cross type in the linear regression according to χ^2 testing of log-likelihood ratios, bold – significant according to a t-test comparison to the within population outcrossed offspring.

A)

				Z1				Z2				Z6		
		Treatment + cross	Width	Stem number	Flower set	Treatment + cross	Width	Stem number	Flower set	Treatment + cross	Width	Stem number	Flower set
Inbreeding	2018	Global	**0.066**	0.126	0.114		**0.451**	-	**0.556**		-0.007	-0.165	-0.524
		Control						**0.523**					
		Competition						**0.311**					
		Shade						**0.666**					
	2019	Global	0.084	-	-			0.125	0.131		0.203	0.252	0.271
		Control		0.021	-0.009		**0.192**	-	-				
		Competition		**0.358**	0.363		0.068						
		Shade		-0.390	-0.82		0.118						
Outbreeding	2018	Global	Z6 -	-0.081	-	Global Z6	-	-	-	Global Z1	**-0.368**	**-0.388**	**-0.647**
			Z2 -	-0.114	-	Z1	-	-	-	Z2	**-0.331**	**-0.28**	**-0.692**
		Control	Z6 -0.013		0.014	Garden Z6	-0.059	-0.142	-0.039	Control Z6			
			Z2 -0.252		-0.199	Z1	**-0.144**	-0.042	-0.112	Z2			
		Competition	Z6 -0.166		-0.038	Serpentine Z6	**0.355**	0.170	**0.601**	Competition Z6			
			Z2 -0.104		-0.004	Z1	**0.262**	**0.048**	0.210	Z2			
		Shade	Z6 0.199		**0.408**					Shade Z6			
			Z2 -0.025		0.231					Z2			
	2019	Global	Z6 -0.247	-0.311	**-**	Global Z6	-0.099	-0.199	-0.212	Global Z1	-0.081	0.055	-
			Z2 -0.205	-0.215	**-**	Z1	-0.076	-0.16	-0.107	Z2	-0.055	0.069	-
		Control	Z6		**-0.351**					Control - Garden Z1			-0.167
			Z2		**-0.383**					Z2			0.033
		Competition	Z6		**-0.282**					Competition - Garden Z1			0.163
			Z2		**-0.167**					Z2			0.139
		Shade	Z6		**-0.851**					Shade - Garden			-
		Control - Serpentine	Z2		-0.802					Control - Serpentine Z1			-0.68
										Z2			-0.088
										Competition - Serpentine Z1			-0.29
										Z2			-0.161
										Shade - Serpentine Z1			-0.751
										Z2			-0.186

B)

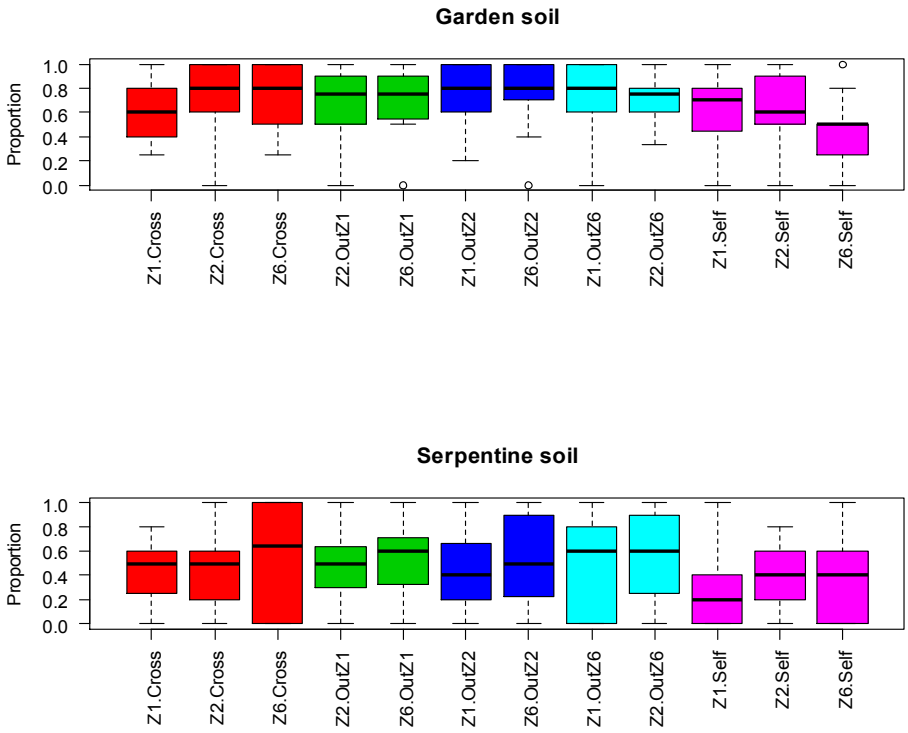
		Treatment + cross		Z1 Width	Z1 N° Stems	Z1 Flower set	Treatment + cross		Z2 Width	Z2 N° Stems	Z2 Flower set	Treatment + cross		Z6 Width	Z6 N° Stems	Z6 Flower set
Inbreeding	2018	Global		-0.292 ± 0.216	-0.698 ± 0.524	**-0.65 ± 0.124**	Global		**-0.65 ± 0.124**	-	**-2.093 ± 0.606**	Global		-0.061 ± 0.244	-0.052 ± 0.41	0.045 ± 1.028
		Control								**-2.004 ± 0.665**						
		Competition								**-1.65 ± 0.603**						
		Shade								**-3.12 ± 1.248**						
	2019	Global		-	-	-	Global			**-0.438 ± 0.177**	-0.378 ± 0.271	Global		-0.047 ± 0.198	-0.168 ± 0.364	-0.257 ± 0.44
		Control		0.076 ± 0.146	0.182 ± 0.192	**-0.187 ± 0.068**			**-0.187 ± 0.068**							
		Competition		**-0.532 ± 0.198**	-0.566 ± 0.4	0.04 ± 0.108			0.04 ± 0.108							
		Shade		0.552 ± 0.313	1.927 ± 1.011	0.589 ± 0.455			0.589 ± 0.455	-	-					
Outbreeding	2018	Global	Z6	-	0.238 ± 0.188	-	Global	Z6	-	-	-	Global		**0.59 ± 0.202**	**1.203 ± 0.338**	**3.009 ± 0.888**
			Z2	-	0.244 ± 0.188	-		Z1	-	-	-			**0.539 ± 0.193**	**0.799 ± 0.323**	**2.686 ± 0.863**
		Control	Z6	0.055 ± 0.122		-0.067 ± 0.53	Control	Z6	0.092 ± 0.097	0.159 ± 0.178	0.319 ± 0.411					
			Z2	0.201 ± 0.119		0.124 ± 0.513		Z1	**0.219 ± 0.086**	0.141 ± 0.158	0.471 ± 0.363					
		Competition	Z6	0.194 ± 0.119		0.239 ± 0.546	Serpentine	Z6	**-0.476 ± 0.173**	-0.566 ± 0.299	**-2.353 ± 0.884**					
			Z2	0.116 ± 0.119		0.248 ± 0.546		Z1	**-0.323 ± 0.157**	**-0.591 ± 0.272**	-1.562 ± 0.803					
		Shade	Z6	-0.138 ± 0.158		**-1.385 ± 0.677**		Z6								
			Z2	0.027 ± 0.152		0.12 ± 0.651		Z1								
	2019	Global	Z6	**0.262 ± 0.097**	**0.501 ± 0.157**	-	Global	Z6	-0.057 ± 0.105	0.065 ± 0.199	0.062 ± 0.33	Global	Z1	0.238 ± 0.151	0.275 ± 0.228	-
			Z2	**0.264 ± 0.097**	**0.382 ± 0.156**	-		Z1	0.088 ± 0.088	0.273 ± 0.167	0.248 ± 0.277		Z2	0.049 ± 0.145	0.143 ± 0.219	-
		Control	Z6			**0.592 ± 0.163**						Control - Control	Z1			0.289 ± 0.218
			Z2			**0.624 ± 0.158**							Z2			0.104 ± 0.21
		Competition	Z6			**0.709 ± 0.278**						Competition - Control	Z1			-0.056 ± 0.239
			Z2			**0.602 ± 0.278**							Z2			-0.187 ± 0.23
		Shade	Z6			**2.311 ± 0.745**						Shade - Control	Z2			
			Z2			0.797 ± 0.723							Z1			
												Ctrl. - Serp.	Z2			0.051 ± 0.258
												Competition - Serpentine	Z1			0.389 ± 0.292
													Z2			0.291 ± 0.279
												Shade - Serpentine	Z1			0.394 ± 1.846
													Z2			-0.926 ± 1.692



Electronic Appendix 5. – Change in log fitness for late life cycle traits. The bars correspond to the performance of inbred or between population outbred offspring relative to that of the within population outbred offspring (set at 0). Yellow – inbred, blue – outbred with Z1 as pollen donor, orange – outbred with Z2, grey – outbred with Z6. Note the inversion of the y-axis, so that values below the axis indicate inbreeding/outbreeding depression, and values above inbreeding benefit or heterosis. Error bars correspond to standard errors. Note the difference in scales on the y-axes.

Electronic Appendix 6. – Analyses of early and mid-cycle traits. Significant values are in bold. Dam – pollen recipient (nested in population), Sire – pollen donor (nested in population).

	Pollination success (1077)			Seed number (605)			Germination (511)		
	Df	Deviance	p-value	Df	Deviance	p-value	Df	Deviance	p-value
Soil	-	-	-	-	-	-	1	3.636	**< 0.001**
Cross type	4	0.449	0.752	4	1.501	0.546	4	0.843	**< 0.001**
Pop	2	0.021	0.957	2	0.532	0.580	2	0.105	0.253
Soil x cross type	-	-	-	-	-	-	4	0.177	0.325
Soil x pop	-	-	-	-	-	-	2	0.111	0.233
Cross type x Pop	5	1.541	0.255	5	6.244	**0.026**	5	0.042	0.953
Soil x Cross type x Pop	-	-	-	-	-	-	5	0.195	0.401
Dam_{Pop}	26	9.938	**0.023**	26	20.91	**0.020**	27	1.709	**0.017**
$Sire_{Pop}$	238	50.963	0.831	185	75.913	0.945	-	-	-



Electronic Appendix 7. – Germination by cross type and population in garden and serpentine soil. Colour code corresponds to the pollination type – red – outcrossing within population, green –outcrossing with population Z1, blue – outcrossing with population Z2, teal – outcrossing with population Z6, magenta – selfing.

Electronic Appendix 8. – Analyses of inbreeding and outbreeding depression for early and mid-cycle traits. Inbreeding depression analyses were done on a data subset that only included within-population inbred and outbred offspring, with the latter set as the intercept of the regression. Outbreeding depression analyses were done on a data subset that only included within- and between-population outbred offspring, with the former set as the intercept of the regression. Significant are in bold. Dam – pollen recipient (nested in population), Sire – pollen donor (nested in population). Sample sizes for each regression are given in backets on the top of the Df column.

		Z6			Z1			Z2		
		Df	Deviance	p-value	Df	Deviance	p-value	Df	Deviance	p-value
Inbreeding	Pollination success	(119)			(381)			(288)		
	Cross type	1	0.031	0.709	1	0.561	0.115	1	0.631	0.106
	Dam_{Pop}	4	1.554	0.143	9	0.945	0.900	11	2.764	0.405
	$Sire_{Pop}$	7	2.378	0.161	40	6.991	0.850	52	11.78	0.597
	Seed production	(63)			(210)			(168)		
	Cross type	1	3.415	**0.028**	1	1.211	0.264	1	1.535	0.162
	Dam_{Pop}	4	6.812	**0.048**	9	5.623	0.761	11	13.68	0.095
	$Sire_{Pop}$	6	0.854	0.977	32	22.20	0.883	37	22.65	0.826
	Germination	(63)			(175)			(143)		
	Soil	1	0.061	0.287	1	1.304	**< 0.001**	1	0.979	**< 0.001**
	Cross type	1	0.115	0.144	1	0.181	**0.012**	1	0.081	0.133
	Soil x Cross type	1	0.004	0.791	1	0.198	**0.009**	1	0.005	0.706
	Dam(Pop)	4	0.401	0.115	11	0.612	**0.031**	11	0.367	0.512
Outbreeding	Pollination success	(71)			(275)			(239)		
	Cross type	2	0.538	0.347	2	0.331	0.480	2	0.033	0.932
	Dam(Pop)	4	1.210	0.313	11	5.561	**0.010**	11	3.667	0.157
	Sire(Pop)	54	15.127	0.281	94	16.828	0.931	86	19.401	0.585
	Seed production	(39)			(146)			(125)		
	Cross type	2	2.456	0.148	2	1.783	0.314	2	1.665	0.386
	Dam_{Pop}	4	4.695	0.121	11	13.502	0.093	11	15.877	0.078
	$Sire_{Pop}$	38	17.328	0.909	70	66.824	0.085	65	47.488	0.824
	Germination	(29)			(109)			(101)		
	Soil	1	0.235	**0.027**	1	1.243	**< 0.001**	1	0.773	**< 0.001**
	Cross type	2	0.020	0.816	2	0.013	0.828	2	0.028	0.668
	Soil x Cross type	2	0.002	0.978	2	0.052	0.479	2	0.096	0.257
	Dam_{Pop}	4	0.326	0.147	12	1.055	**0.003**	11	0.507	0.214

Electronic Appendix 9. – Analyses of late cycle traits in each year separately. Significant values are in bold, significant values after correction for multiple comparisons in a model (16 in total) are underlined. Dam – pollen recipient (nested in population). Sample sizes are given in brackets next to the trait.

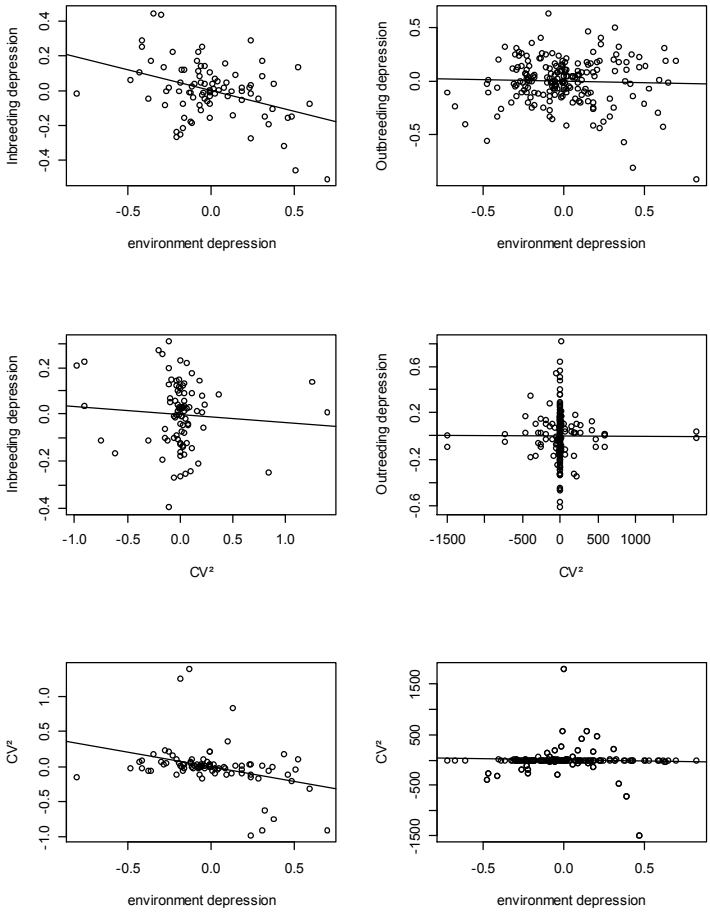
		2018										2019					
		Width (869)		N° stems (869)		Flower set (856)		Flower number (646)		Flower production (869)		Width (809)		N° stems (802)		Flower set (796)	
Variable	DF	Dev	p-value	Dev	p-value	Dev	p-value	Dev	p-value	Dev	p-value	Dev	p-value	Dev	p-value	Dev	p-value
Treatment	2	71.0	**<u>≤0.001</u>**	16.9	**<u>≤0.001</u>**	90.7	**<u>≤0.001</u>**	73.7	**<u>≤0.001</u>**	21.1	**<u>≤0.001</u>**	216.9	**<u>≤0.001</u>**	77.6	**<u>≤0.001</u>**	321.8	**<u>≤0.001</u>**
Soil	1	598.0	**<u>≤0.001</u>**	0.1	0.7790	637.5	**<u>≤0.001</u>**	594.4	**<u>≤0.001</u>**	227.0	**<u>≤0.001</u>**	9.3	**0.0023**	617.1	**<u>≤0.001</u>**	0.4	0.5377
Pop	2	93.5	**<u>≤0.001</u>**	35.4	**<u>≤0.001</u>**	56.5	**<u>≤0.001</u>**	96.1	**<u>≤0.001</u>**	68.8	**<u>≤0.001</u>**	21.7	**<u>≤0.001</u>**	123.1	**<u>≤0.001</u>**	3.4	0.1790
Cross type	4	112.1	**<u>≤0.001</u>**	85.6	**<u>≤0.001</u>**	63.0	**<u>≤0.001</u>**	94.9	**<u>≤0.001</u>**	15.2	**<u>≤0.001</u>**	95.3	**<u>≤0.001</u>**	41.6	**<u>≤0.001</u>**	54.4	**<u>≤0.001</u>**
Dam_{Pop}	21	52.3	**<u>≤0.001</u>**	42.1	**0.0041**	44.1	**0.0023**	52.8	**<u>≤0.001</u>**	55.0	**<u>≤0.001</u>**	48.8	**<u>≤0.001</u>**	65.7	**<u>≤0.001</u>**	31.0	0.0736
Treatment x Soil	2	12.0	**<u>≤0.001</u>**	45.3	**<u>≤0.001</u>**	5.7	0.0590	5.7	0.0589	5.9	0.0514	29.9	**<u>≤0.001</u>**	12.1	**0.0024**	77.9	**<u>≤0.001</u>**
Treatment x Pop	4	3.0	0.5639	24.2	**<u>≤0.001</u>**	2.3	0.6810	2.0	0.7333	3.0	0.5529	7.5	0.1121	12.9	**0.0116**	10.7	**0.0305**
Treatment x Cross type	8	11.5	0.1731	12.8	0.1173	9.8	0.2790	9.2	0.3268	4.9	0.7694	14.9	0.0611	12.9	0.1165	22.4	**0.0043**
Soil x Pop	2	3.1	0.2105	34.8	**<u>≤0.001</u>**	1.7	0.4346	2.4	0.3034	2.0	0.3726	9.6	**0.0081**	0.9	0.6233	4.9	0.0871
Soil x Cross type	4	17.1	**<u>0.0019</u>**	3.1	0.5491	13.5	**0.0093**	18.8	**<u>≤0.001</u>**	7.3	0.1213	2.4	0.6549	15.7	**0.0035**	3.6	0.4630
Pop x Cross type	5	44.4	**<u>≤0.001</u>**	6.5	0.2637	31.6	**<u>≤0.001</u>**	42.8	**<u>≤0.001</u>**	28.9	**<u>≤0.001</u>**	7.2	0.2079	40.8	**<u>≤0.001</u>**	7.6	0.1770
Treatment x Soil x Pop	4	1.7	0.7928	7.6	0.1065	2.3	0.6812	1.5	0.8319	4.6	0.3300	17.3	**0.0017**	12.0	**0.0172**	23.6	**<u>≤0.001</u>**
Treatment x Soil x Cross type	8	8.9	0.3518	16.9	**0.0310**	8.6	0.3789	4.3	0.8252	8.3	0.4051	4.0	0.8608	9.0	0.3445	4.6	0.7975
Treatment x Pop x Cross type	9	9.4	0.3987	10.7	0.2962	15.2	0.0844	7.9	0.5474	14.6	0.1010	10.7	0.2969	12.2	0.2015	10.1	0.3389
Soil x Pop x Cross type	5	6.3	0.2750	4.7	0.4576	4.3	0.5031	6.9	0.2277	6.4	0.2670	4.4	0.4974	12.9	**0.0239**	7.4	0.1956
Treatment x Soil x Pop x Cross type	7	4.4	0.7298	8.7	0.2726	5.6	0.5878	3.8	0.8030	-	-	12.1	0.0986	3.9	0.7925	16.5	**0.0211**

Electronic Appendix 10. – Analyses of inbreeding and outbreeding depression for late cycle traits. Inbreeding depression analyses were done on a data subset that only included within-population inbred and outbred offspring, with the latter set as the intercept of the regression. Outbreeding depression analyses were done on a data subset that only included within- and between-population outbred offspring, with the former set as the intercept of the regression. Significant values are in bold, significant values after correction for multiple comparisons (30 in total) are underlined. Dam – pollen recipient (nested in population). Sample sizes for each regression are given in backets on the top of the p-value column.

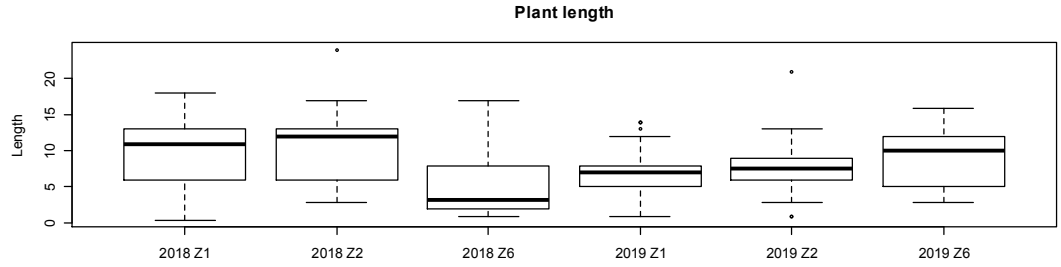
			Z6						Z1						Z2					
		INBREEDING	DF	Width		N° stems		Flower set		DF	Width		N° stems		Flower set		DF	Width		N° stems		Flower set	
				Dev	p-value	Dev	p-value	Dev	p-value		Dev	p-value	Dev	p-value	Dev	p-value		Dev	p-value	Dev	p-value	Dev	p-value
Inbreeding	2018	(Sample size)			(67)		(67)		(66)			(183)		(183)		(180)			(143)		(143)		(142)
		Treatment	2	0.2	0.905	0.9	0.628	0.4	0.826	2	23.7	**<0.001**	25.5	**<0.001**	31.7	**<0.001**	2	1.4	0.488	4.5	0.104	4.3	0.118
		Soil	1	35.1	**<0.001**	38.2	**<0.001**	32.2	**<0.001**	1	133.0	**<0.001**	120.5	**<0.001**	136.8	**<0.001**	1	68.2	**<0.001**	93.3	**<0.001**	78.7	**<0.001**
		Cross type	1	0.3	0.603	2.2	0.135	1.0	0.320	1	6.8	**0.009**	7.4	**0.007**	1.2	0.265	1	56.9	**<0.001**	30.2	**<0.001**	35.6	**<0.001**
		Treatment x Soil	1	0.1	0.816	2.0	0.160	0.1	0.715	2	1.0	0.613	0.7	0.705	1.6	0.439	2	0.6	0.755	0.6	0.724	1.7	0.422
		Treatment x Cross type	1	0.5	0.471	0.7	0.397	2.0	0.159	2	1.2	0.537	0.2	0.924	1.9	0.394	2	3.6	0.166	6.7	**0.034**	3.9	0.139
		Soil x Cross type	1	0.1	0.807	0.3	0.600	1.2	0.279	1	0.0	0.868	0.6	0.440	3.2	0.073	1	0.0	0.866	0.0	0.844	0.0	0.944
		Treatment x Soil x Cross type	1	0.0	0.864	0.5	0.502	0.4	0.536	2	0.8	0.684	0.1	0.970	0.7	0.691	1	0.2	0.651	0.0	0.967	0.1	0.732
		Dam_{Pop}	4	12.5	**0.014**	12.0	**0.017**	13.9	**0.008**	8	11.8	0.158	12.9	0.117	9.0	0.338	8	12.0	0.151	7.2	0.517	20.5	**0.009**
	2019	(Sample size)			(58)		(58)		(58)			(165)		(161)		(160)			(139)		(137)		(137)
		Treatment	2	6.2	**0.045**	1.0	0.610	3.9	0.145	2	8.7	**0.013**	48.8	**<0.001**	76.2	**<0.001**	2	7.6	**0.023**	10.4	**0.006**	14.5	**<0.001**
		Soil	1	9.4	**<0.001**	5.6	**0.018**	2.2	0.142	1	15.8	**<0.001**	1.0	0.306	1.2	0.265	1	4.0	**0.046**	2.5	0.117	0.0	0.933
		Cross type	1	2.6	0.109	2.1	0.147	3.9	**0.048**	1	0.2	0.678	1.0	0.320	0.3	0.610	1	5.3	**0.021**	5.5	**0.019**	2.2	0.138
		Treatment x Soil	1	0.0	0.901	0.9	0.337	0.1	0.706	2	7.6	**0.022**	4.9	0.085	13.0	**<0.001**	2	33.3	**<0.001**	6.5	**0.038**	5.3	0.070
		Treatment x Cross type	1	0.9	0.339	0.3	0.570	0.1	0.818	2	1.0	0.616	10.9	**0.004**	11.5	**0.003**	2	8.6	**0.014**	4.7	0.096	1.7	0.429
		Soil x Cross type	1	0.3	0.593	0.6	0.452	0.2	0.670	1	1.1	0.288	0.3	0.590	0.7	0.417	1	0.8	0.386	1.1	0.302	1.3	0.249
		Treatment x Soil x Cross type	1	0.7	0.407	0.6	0.450	1.2	0.277	2	5.6	0.062	5.5	0.066	4.0	0.132	1	0.9	0.347	3.3	0.069	3.1	0.077
		Dam_{Pop}	4	1.7	0.784	1.5	0.820	4.5	0.343	8	19.7	**0.012**	25.0	**0.002**	19.3	**0.013**	8	21.2	**0.007**	16.5	**0.036**	10.1	0.260
Outbreeding	2018	(Sample size)			(157)		(157)		(152)			(297)		(297)		(294)			(219)		(219)		(217)
		Treatment	2	16.2	**<0.001**	22.6	**<0.001**	30.3	**<0.001**	2	41.5	**<0.001**	49.9	**<0.001**	31.1	**<0.001**	2	2.4	0.300	4.9	0.085	2.2	0.329
		Soil	1	89.8	**<0.001**	89.6	**<0.001**	84.8	**<0.001**	1	242.3	**<0.001**	277.6	**<0.001**	262.0	**<0.001**	1	203.0	**<0.001**	215.0	**<0.001**	213.5	**<0.001**
		Cross type	2	23.7	**<0.001**	18.0	**<0.001**	19.1	**<0.001**	2	12.7	**0.002**	4.4	0.109	8.4	**0.015**	2	2.8	0.241	2.9	0.231	9.6	**0.008**
		Treatment x Soil	2	2.2	0.325	3.3	0.190	16.9	**<0.001**	2	11.1	**0.004**	1.4	0.487	5.2	0.074	2	4.8	0.090	2.0	0.364	1.9	0.395
		Treatment x Cross type	4	2.9	0.576	4.4	0.358	0.6	0.964	4	9.5	**0.050**	7.9	0.096	12.9	**0.012**	4	4.5	0.339	4.9	0.299	4.4	0.350
		Soil x Cross type	2	0.2	0.926	1.6	0.451	5.4	0.067	2	1.5	0.467	0.2	0.903	1.8	0.399	2	15.4	**<0.001**	8.1	**0.017**	12.7	**0.002**
		Treatment x Soil x Cross type	3	1.9	0.599	2.3	0.521	0.4	0.947	4	2.1	0.724	5.9	0.210	7.0	0.135	4	5.1	0.274	3.6	0.466	4.9	0.299
		Dam_{Pop}	4	4.9	0.300	4.0	0.405	7.1	0.128	8	33.6	**<0.001**	22.7	**0.004**	33.6	**<0.001**	9	16.7	0.054	11.7	0.228	15.1	0.089
	2019	(Sample size)			(137)		(137)		(134)			(284)		(279)		(278)			(213)		(212)		(211)
		Treatment	2	13.5	**0.001**	20.3	**<0.001**	35.3	**<0.001**	2	18.1	**<0.001**	134.2	**<0.001**	180.7	**<0.001**	2	9.0	**0.011**	44.4	**<0.001**	36.5	**<0.001**
		Soil	1	15.9	**<0.001**	20.5	**<0.001**	4.0	**0.047**	1	19.5	**<0.001**	0.0	0.842	1.0	0.313	1	2.5	0.115	0.9	0.333	4.5	**0.033**
		Cross type	2	0.7	0.697	0.8	0.675	1.7	0.419	2	30.8	**<0.001**	36.4	**<0.001**	26.5	**<0.001**	2	3.5	0.174	4.1	0.128	2.3	0.322
		Treatment x Soil	2	1.0	0.604	0.7	0.705	3.3	0.189	2	19.4	**<0.001**	9.5	**0.009**	60.4	**<0.001**	2	38.9	**<0.001**	38.0	**<0.001**	24.2	**<0.001**
		Treatment x Cross type	4	4.5	0.337	2.6	0.631	1.8	0.771	4	5.8	0.216	3.2	0.525	11.4	**0.022**	4	8.8	0.065	2.8	0.591	0.5	0.977
		Soil x Cross type	2	2.0	0.366	2.3	0.311	2.0	0.376	2	3.3	0.189	1.8	0.415	4.2	0.121	2	2.2	0.338	2.1	0.345	1.7	0.431
		Treatment x Soil x Cross type	3	3.4	0.331	4.3	0.231	11.2	**0.011**	4	1.4	0.844	0.9	0.924	3.2	0.518	4	14.7	**0.005**	1.8	0.771	1.2	0.881
		Dam_{Pop}	4	0.7	0.948	1.7	0.796	2.7	0.606	8	5.0	0.754	10.3	0.246	11.7	0.166	9	19.1	**0.024**	17.6	**0.040**	5.3	0.803

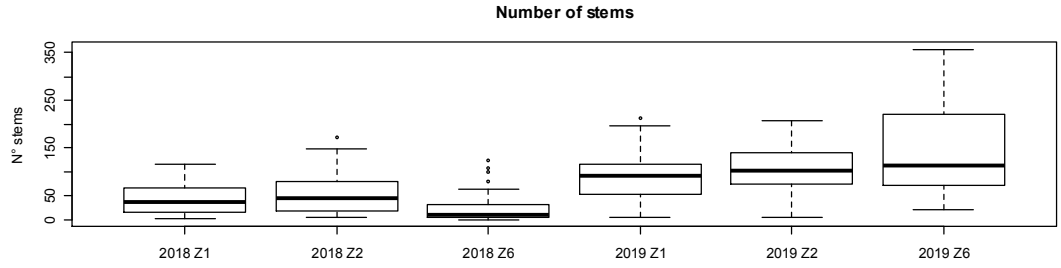
Electronic Appendix 11. – Analysis of plant survival between 2018 and 2019. Significant values are in bold.

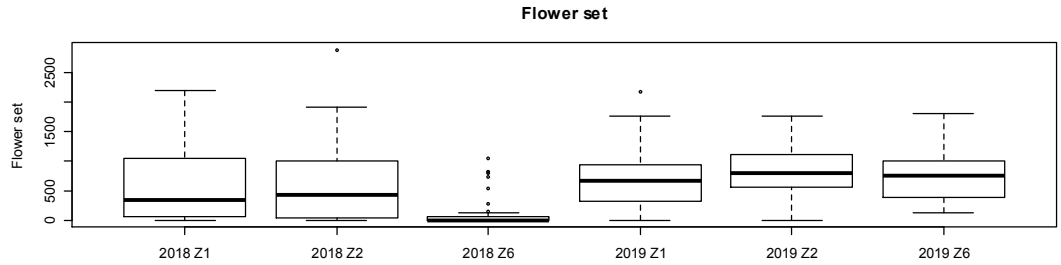
	Df	Deviance	p-value
Treatment	2	370.56	**<0.001**
Soil	1	327.83	0.108
Pop	2	339.62	**0.001**
Cross type	4	336.71	**0.022**
Treatment x Soil	2	288.84	0.526
Treatment x Pop	4	289.98	0.657
Treatment x Cross type	8	304.25	**0.033**
Soil x Pop	2	289.15	0.450
Soil x Cross type	4	291.63	0.396
Pop x Cross type	5	299.45	**0.036**



Electronic Appendix 12. – Partial regression plots of inbreeding (left panels) and outbreeding (right panels) depression as a function of environmental stress (top), coefficient of variation (middle), and the relationship between the coefficient of variation and environment stress (bottom).







Electronic Appendix 13. – Late cycle trait means per population and per year. To avoid the effects of the cross type, only data from within population outbred offspring is used.

Electronic appendix 14. Cumulative estimates of inbreeding depression and heterosis. Estimates were made by combining one early cycle trait (pollination success or seed number), germination as mid cycle trait, and one late cycle trait (plant width, number of stems or flower set). Cell colours correspond to the effect of cross type on the offspring fitness. Red – fitness decrease (inbreeding or outbreeding depression), blue – fitness increase (inbreeding benefit or heterosis) relative to the within-population outcrossed offspring.

		Z1				Z2				Z6		
		Width	N° stems	Flower set		Width	N° stems	Flower set		Width	N° stems	Flower set
Inbreeding												
Seed production		0.388	0.486	0.467		0.634	0.622	0.704		0.458	0.396	0.766
Seed number		0.536	0.610	0.596		0.653	0.642	0.719		0.676	0.639	0.860
Outbreeding												
Seed production	Z6	-0.150	-0.318	-0.141	Z6	0.102	-0.156	-0.022	Z1	-0.516	-0.360	-1.868
	Z2	-0.277	-0.232	-0.276	Z1	-0.054	-0.063	-0.078	Z2	-0.276	0.015	-1.576
Seed number	Z6	0.047	-0.092	0.055	Z6	0.083	-0.181	-0.044	Z1	-1.119	-0.900	-3.008
	Z2	-0.264	-0.219	-0.263	Z1	-0.004	-0.012	-0.026	Z2	-0.204	0.071	-1.430