

Grünzweig, J. M. and Dumbur, R. 2012. Seed traits, seed-reserve utilization and offspring performance across pre-industrial to future CO<sub>2</sub> concentrations in a Mediterranean community. – Oikos 121: 579–588.

## Appendix A1

Table A1. Seed traits as affected by CO<sub>2</sub> concentration at the species level. Species were ranked according to their contribution to community biomass at peak-season (Grünzweig and Körner 2001a). Mean ( $\pm$  1 SE), n = 2–3 model ecosystems.

Species	Species ranking	CO <sub>2</sub> conc. (ppm)	Seed size (mg seed <sup>-1</sup> ) <sup>z</sup>	Total protein concentration (%) <sup>y</sup>	Seed protein pool (mg seed <sup>-1</sup> )	Soluble protein concentration (%)	NSC concentration (%) <sup>x</sup>	Seed NSC pool (mg seed <sup>-1</sup> )	Soluble sugar concentration (%)
<b>Grasses</b>									
<i>Aegilops kotschy</i>	4	280	5.84 (0.22)	23.94 (0.15)	0.82 (0.01)	6.50 (0.32)	25.56 (1.23)	0.878 (0.042)	1.78 (0.25)
		440	7.25 (0.62)	22.20 (0.17)	0.80 (0.01)	6.27 (0.17)	28.53 (2.37)	1.031 (0.086)	2.73 (0.39)
		600	7.28 (0.73)	20.07 (0.25)	0.68 (0.01)	5.51 (0.33)	31.51 (0.42)	1.073 (0.014)	2.15 (0.12)
<i>Aegilops peregrina</i>	1	280	8.53 (0.40)	20.07 (0.65)	1.20 (0.04)	5.41 (0.16)	33.37 (1.23)	1.993 (0.073)	1.35 (0.03)
		440	8.39 (0.64)	18.58 (0.55)	1.02 (0.03)	5.82 (0.93)	38.66 (1.78)	2.125 (0.098)	1.42 (0.07)
		600	9.43 (0.16)	17.00 (0.28)	0.90 (0.01)	5.22 (0.07)	33.20 (2.11)	1.755 (0.111)	1.36 (0.13)
<i>Brachypodium distachyon</i>	7	280	3.23 (0.09)	10.15 (0.30)	0.30 (0.01)	1.53 (0.08)	12.57 (0.07)	0.375 (0.002)	1.46 (0.20)
		440	3.07 (0.08)	9.38 (0.57)	0.28 (0.02)	1.35 (0.03)	14.43 (0.43)	0.434 (0.013)	1.20 (0.16)
		600	3.33 (0.07)	9.21 (0.62)	0.28 (0.02)	1.30 (0.02)	16.06 (0.84)	0.486 (0.025)	1.03 (0.17)
<i>Bromus alopecuross</i>	17	280	0.55 (0.01)			2.15 (0.13)			
		440	0.61 (0.01)			1.80 (0.23)			
		600	0.62 (0.03)			1.71 (0.10)			

<i>Bromus fasciculatus</i>	10	280	0.71 (0.03)			1.72 (0.21)	15.62 (0.52)	0.107 (0.004)	4.83 (0.74)
		440	0.67 (0.05)			1.68 (0.09)	14.69 (0.83)	0.102 (0.006)	4.55 (0.65)
		600	0.63 (0.06)			1.32 (0.15)	17.82 (1.63)	0.122 (0.011)	6.73 (0.74)
<i>Bromus lanceolatus</i>	15	280	1.84 (0.13)			3.00 (0.17)	9.94 (1.35)	0.183 (0.025)	4.77 (0.52)
		440	2.16 (0.20)			2.82 (0.32)	12.19 (1.36)	0.264 (0.029)	5.50 (0.83)
		600	2.33 (0.22)			3.00 (0.27)	10.76 (0.75)	0.251 (0.017)	5.33 (0.80)
<i>Crithopsis delileana</i>	3	280	3.10 (0.25)	14.22 (0.55)	0.35 (0.01)	3.65 (0.02)	28.16 (0.49)	0.68 (0.01)	1.52 (0.46)
		440	3.26 (0.18)	11.93 (0.21)	0.29 (0.01)	3.67 (0.15)	26.33 (1.38)	0.64 (0.03)	1.10 (0.03)
		600	3.34 (0.11)	11.68 (0.35)	0.28 (0.01)	3.45 (0.09)	30.63 (2.53)	0.74 (0.06)	1.08 (0.02)
<i>Stipa capensis</i>	9	280	1.66 (0.13)			3.82 (0.25)	22.69 (2.37)	0.401 (0.042)	1.55 (0.27)
		440	1.88 (0.10)			3.76 (0.42)	21.91 (2.45)	0.386 (0.043)	1.42 (0.30)
		600	1.73 (0.15)			3.78 (0.22)	19.24 (2.01)	0.336 (0.035)	1.09 (0.13)
<b>Legumes</b>									
<i>Hippocrepis unisiliquosa</i>	14	280	1.71 (0.05)			14.05 (0.57)			
		440	1.73 (0.06)			13.21 (0.54)			
		600	1.78 (0.01)			14.04 (0.55)			
<i>Hymenocarpus circinnatus</i>	2	280	5.54 (0.07)	40.97 (0.52)	1.88 (0.02)	20.89 (0.62)	9.50 (0.23)	0.436 (0.010)	7.92 (0.20)
		440	4.92 (0.06)	39.12 (0.55)	1.74 (0.02)	18.80 (0.30)	8.60 (0.59)	0.383 (0.026)	7.09 (0.51)
		600	5.01 (0.13)	38.18 (0.72)	1.67 (0.03)	18.09 (0.51)	10.45 (0.22)	0.457 (0.009)	8.46 (0.22)
<i>Medicago minima</i>	8	280	1.71 (0.09)	44.09 (0.62)	0.60 (0.01)	23.65 (0.63)	5.94 (2.26)	0.081 (0.031)	4.82 (2.34)
		440	1.68 (0.04)	43.25 (0.28)	0.59 (0.00)	16.25 (0.58)	4.94 (1.43)	0.068 (0.020)	3.55 (1.32)
		600	1.65 (0.06)	42.33 (1.25)	0.58 (0.02)	13.29 (0.66)	6.19 (1.65)	0.084 (0.022)	4.57 (1.54)
<i>Medicago truncatula</i>	6	280	3.68 (0.06)	38.73 (1.01)	1.42 (0.04)	15.03 (1.10)	6.90 (1.90)	0.253 (0.070)	4.60 (1.33)
		440	3.93 (0.08)	38.48 (1.05)	1.46 (0.04)	21.57 (1.59)	6.72 (1.08)	0.255 (0.041)	4.76 (0.80)
		600	4.10 (0.08)	40.23 (0.94)	1.55 (0.04)	18.90 (0.85)	8.36 (0.75)	0.321 (0.029)	6.60 (0.38)
<i>Onobrychis crista-galli</i>	5	280	10.91 (0.72)	45.29 (0.63)	4.06 (0.06)	19.60 (0.91)	15.43 (0.77)	1.383 (0.069)	6.42 (0.31)
		440	8.94 (0.44)	44.37 (1.00)	3.75 (0.08)	12.12 (0.21)	18.87 (1.97)	1.595 (0.166)	8.20 (0.41)
		600	9.27 (0.22)	43.60 (0.77)	3.71 (0.07)	14.56 (0.51)	18.27 (0.49)	1.556 (0.041)	7.24 (0.47)
<i>Trifolium campestre</i>	12	280	0.39 (0.01)	36.20 (0.55)	0.13 (0.00)	22.76 (0.39)	8.75 (0.36)	0.031 (0.001)	6.86 (0.20)
		440	0.40 (0.02)	34.86 (1.02)	0.12 (0.00)	21.50 (1.48)	9.47 (0.97)	0.033 (0.003)	7.52 (0.82)
		600	0.40 (0.01)	37.82 (0.47)	0.13 (0.00)	24.22 (0.37)	8.25 (0.06)	0.029 (0.000)	6.46 (0.21)
<b>Forbs</b>									
<i>Carrichtera annua</i>	19	280	0.93 (0.04)						
		440	0.79 (0.06)						

		600	0.92 (0.03)					
<i>Daucus durieua</i>	20	280	0.90 (0.03)		4.66 (0.08)			
		440	1.01 (0.11)		5.21 (0.15)			
		600	1.10 (0.03)		5.57 (0.19)			
<i>Hedypnois cretica</i>	13	280	3.53 (0.20)		3.88 (0.15)	7.87 (1.69)	0.175 (0.038)	3.69 (1.21)
		440	3.10 (0.23)		4.14 (0.45)	3.92 (0.49)	0.091 (0.011)	1.51 (0.53)
		600	3.36 (0.08)		3.74 (0.32)	5.12 (0.06)	0.119 (0.001)	2.39 (0.15)
<i>Plantago cretica</i>	11	280	0.90 (0.04)		4.03 (0.38)	8.66 (1.03)	0.077 (0.009)	5.08 (0.40)
		440	0.96 (0.05)		2.87 (0.45)	7.54 (0.58)	0.065 (0.005)	4.88 (0.41)
		600	0.98 (0.03)		2.82 (0.32)	6.44 (0.56)	0.054 (0.005)	4.76 (0.29)

<sup>z</sup> seed size was obtained by weighing individual seeds after adjusting moisture content in a growth chamber; seed protein and carbohydrates were based on seed dry mass.

<sup>y</sup> calculated from total seed N obtained by elemental analysis; N-to-protein conversion factors: 5.45 for grasses, 5.42 for legumes (5.1 for *M. truncatula*); values for *A. kotschyi* from Grünzweig and Körner (2000).

<sup>x</sup> NSC = non-structural carbohydrates = starch + soluble sugars

Table A2. Results of seed-reserve utilization and offspring-development assays as affected by maternal CO<sub>2</sub> at the species level. Seed-reserve utilization was determined as shoot and root elongation under controlled conditions in the dark; emergence success and biomass production were measured in native soil under ambient conditions at peak season. Mean ( $\pm$  1 SE), n = 2–3 model ecosystems for reserve utilization, – = 3 model ecosystems for biomass production. Legume seeds were scarified to break dormancy.

Species	CO <sub>2</sub> conc. (ppm)	Seed-reserve utilization assay			Offspring-development assay			
		Germinability (fraction)	Shoot length (cm)	Root length (cm)	Emerg. success (fraction)	Shoot biomass (mg indiv. <sup>-1</sup> )	Root biomass (mg indiv. <sup>-1</sup> )	Total biomass (mg indiv. <sup>-1</sup> )
<b>Grasses</b>								
<i>Aegilops</i>	280	0.97 (0.03)	9.23 (0.29)	13.26 (0.01)	0.81 (0.06)	129.4 (6.3)	102.1 (5.4)	231.6 (10.7)
<i>kotschyi</i>	440	0.99 (0.01)	10.68 (0.34)	19.91 (0.57)	0.70 (0.04)	106.4 (5.1)	89.3 (2.9)	195.8 (6.9)
	600	0.90 (0.02)	9.89 (0.61)	19.97 (1.64)	0.81 (0.01)	113.1 (3.6)	84.4 (0.7)	197.5 (2.9)
<i>Aegilops</i>	280	0.99 (0.01)	7.19 (0.41)	22.79 (1.35)	0.81 (0.09)	111.3 (3.2)	56.6 (3.5)	167.9 (6.7)
<i>peregrina</i>	440	0.98 (0.02)	6.62 (0.44)	22.50 (1.39)	0.90 (0.01)	109.3 (2.3)	64.9 (2.1)	174.2 (4.0)
	600	0.95 (0.01)	7.23 (0.27)	25.76 (0.87)	0.84 (0.04)	106.0 (4.6)	59.0 (2.4)	165.0 (6.8)
<i>Brachypodium</i>	280	0.82 (0.01)	5.22 (0.24)	9.49 (0.34)	0.79 (0.02)	53.2 (1.1)	26.5 (0.8)	79.7 (1.2)
<i>distachyon</i>	440	0.61 (0.07)	4.78 (0.20)	8.56 (0.85)	0.85 (0.03)	52.2 (1.1)	25.4 (0.6)	77.6 (1.1)
	600	0.90 (0.02)	5.02 (0.19)	9.72 (0.40)	0.86 (0.04)	54.2 (1.6)	27.3 (0.7)	81.5 (1.2)
<i>Bromus</i>	280				0.68 (0.09)	10.6 (0.6)	6.3 (0.3)	16.9 (0.7)
<i>alopecuross</i>	440				0.80 (0.08)	10.1 (1.2)	5.7 (0.3)	15.8 (1.5)
	600				0.59 (0.03)	10.4 (0.5)	6.5 (0.1)	17.0 (0.7)
<i>Bromus</i>	280	0.12 (0.04)	2.56 (0.19)	4.44 (0.84)	0.32 (0.11)	27.5 (6.5)	13.8 (3.4)	41.3 (9.9)
<i>fasciculatus</i>	440	0.54 (0.03)	2.94 (0.14)	4.71 (0.16)	0.36 (0.02)	22.4 (1.4)	10.5 (0.3)	33.0 (1.7)
	600	0.56 (0.00)	2.24 (0.26)	4.37 (0.19)	0.51 (0.12)	20.6 (0.1)	10.6 (0.7)	31.1 (0.8)
<i>Crithopsis</i>	280	0.84 (0.01)	3.42 (0.38)	6.55 (0.70)	0.69 (0.05)	26.6 (0.7)	15.7 (0.8)	42.3 (0.5)
<i>delileana</i>	440	0.91 (0.02)	4.27 (0.14)	8.70 (0.21)	0.78 (0.05)	23.9 (0.6)	14.8 (0.6)	38.8 (0.2)
	600	0.91 (0.02)	4.02 (0.26)	8.64 (0.46)	0.67 (0.09)	27.0 (2.0)	15.5 (1.0)	42.5 (1.4)
<i>Stipa</i>	280	1.00 (0.00)	3.04 (0.17)	4.91 (0.20)	0.93 (0.04)	53.4 (1.7)	24.8 (2.1)	78.2 (0.7)
<i>capensis</i>	440	1.00 (0.00)	3.36 (0.55)	6.34 (0.24)	0.95 (0.02)	60.4 (7.8)	23.7 (2.0)	84.1 (9.7)
	600	0.99 (0.01)	3.10 (0.38)	5.66 (0.48)	0.94 (0.04)	58.6 (5.5)	24.9 (0.6)	83.5 (6.0)
<b>Legumes</b>								
<i>Hippocrepis</i>	280	1.00 (0.00)			0.87 (0.08)	35.2 (3.2)	11.0 (0.2)	46.2 (3.3)
<i>unisiliquosa</i>	440	1.00 (0.00)			0.89 (0.01)	36.7 (0.8)	11.2 (1.3)	47.8 (2.0)
	600	1.00 (0.00)			0.89 (0.02)	38.1 (2.3)	12.1 (0.8)	50.2 (2.9)

<i>Hymenocarpus circinnatus</i>	280	1.00 (0.00)	4.02 (0.13)	4.74 (0.05)	0.99 (0.01)	105.8 (14.7)	40.3 (5.1)	146.1 (19.7)
	440	1.00 (0.00)	4.24 (0.30)	4.43 (0.15)	0.98 (0.02)	84.3 (1.2)	30.0 (0.6)	114.3 (1.4)
	600	1.00 (0.00)	4.12 (0.08)	4.94 (0.22)	0.98 (0.02)	85.6 (6.8)	34.1 (0.9)	119.7 (7.2)
<i>Medicago minima</i>	280	1.00 (0.00)	2.80 (0.06)	4.32 (0.45)	0.93 (0.03)	46.9 (1.8)		
	440	1.00 (0.00)	2.79 (0.08)	4.26 (0.04)	0.96 (0.04)	47.6 (2.9)		
	600	0.99 (0.01)	2.60 (0.28)	3.69 (0.41)	0.91 (0.02)	43.5 (1.3)		
<i>Medicago truncatula</i>	280	0.99 (0.01)	4.02 (0.06)	7.22 (0.25)	1.00 (0.00)	128.7 (5.7)	28.8 (1.1)	157.5 (6.1)
	440	1.00 (0.00)	4.07 (0.18)	8.23 (0.23)	1.00 (0.00)	122.6 (8.6)	26.1 (1.1)	148.7 (9.7)
	600	0.96 (0.01)	4.17 (0.19)	7.97 (0.52)	0.98 (0.02)	118.2 (8.6)	24.0 (1.3)	142.3 (9.8)
<i>Onobrychis crista-galli</i>	280	1.00 (0.00)	2.12 (0.28)	10.08 (0.46)	0.95 (0.03)			
	440	1.00 (0.00)	1.75 (0.04)	8.04 (0.77)	0.95 (0.01)			
	600	1.00 (0.00)	1.64 (0.10)	9.01 (0.62)	0.96 (0.02)			
<i>Trifolium campestre</i>	280				0.95 (0.02)	16.9 (0.4)	4.8 (0.5)	21.6 (0.6)
	440				0.92 (0.00)	19.3 (2.0)	5.0 (0.1)	24.3 (2.0)
	600				0.91 (0.03)	17.4 (1.7)	4.7 (0.2)	22.1 (1.8)
<b>Forbs</b>								
<i>Carrichtera annua</i>	280				0.68 (0.11)	23.9 (1.6)	63.4 (13.3)	87.2 (13.8)
	440				0.35 (0.01)	24.1 (8.2)	57.6 (9.6)	81.7 (17.4)
	600				0.50 (0.06)	29.6 (7.8)	52.2 (10.6)	81.7 (18.4)
<i>Hedypnois cretica</i>	280	0.39 (0.01)	3.51 (0.97)	3.44 (0.59)	0.49 (0.01)	74.4 (7.3)	39.1 (2.4)	113.6 (7.7)
	440	0.62 (0.02)	4.69 (0.16)	4.22 (0.31)	0.45 (0.02)	62.9 (5.2)	36.1 (4.2)	99.0 (8.2)
	600	0.77 (0.00)	3.91 (0.12)	4.42 (0.49)	0.41 (0.08)	74.6 (4.9)	46.4 (7.1)	121.0 (11.9)
<i>Plantago cretica</i>	280	0.99 (0.01)	1.71 (0.08)	3.58 (0.14)	0.69 (0.02)	38.6 (2.5)	16.0 (0.8)	54.5 (3.1)
	440	0.96 (0.01)	1.72 (0.08)	3.90 (0.31)	0.73 (0.09)	34.1 (3.9)	13.5 (2.0)	47.5 (5.6)
	600	0.94 (0.01)	1.66 (0.02)	3.85 (0.28)	0.59 (0.05)	36.3 (0.3)	15.8 (0.4)	52.0 (0.7)
<i>Rhagadiolus stellatus</i>	280				0.90 (0.03)	9.0 (0.5)	9.9 (0.9)	18.9 (1.0)
	440				0.81 (0.02)	10.7 (0.6)	10.9 (0.7)	21.6 (1.0)
	600				0.74 (0.02)	8.4 (0.2)	10.8 (1.1)	19.2 (1.2)