

Table S1 Response of leaf gas exchange parameters to elevated CO₂ and heat stress: Summary of leaf gas exchange parameters measured at different time points for wheat cultivar Scout grown at ambient CO₂ (aCO₂) or elevated CO₂ (eCO₂) and exposed (H) or not exposed (control) to 5-day heat stress (HS) at the anthesis stage. Values are means \pm SE (n= 9-10).

Parameter	Growth	Measurement		T1 (13WAP)	HS Cycle (15WAP)			T2 (17WAP)	
		Temp	CO ₂	Control	Before (Control)	During (HS)	After (HS)	Recovery (HS)	Control
A ($\mu\text{mol m}^{-2}\text{s}^{-1}$)	aCO ₂	25	400	31 \pm 0.3	28.3 \pm 0.8	23.7 \pm 0.8	14.2 \pm 1.2	13.4 \pm 2.6	23.1 \pm 1.2
		25	650	44.2 \pm 0.7	38.1 \pm 1.1	30 \pm 1.1	20.2 \pm 1.4	19.1 \pm 3.3	31.8 \pm 1.9
		35	400	26.4 \pm 0.4	25.4 \pm 0.7	21.7 \pm 0.8	15.6 \pm 1.1	11.2 \pm 2	18.6 \pm 1.9
		35	650	42.3 \pm 0.8	39.8 \pm 0.8	33.1 \pm 1.1	25.9 \pm 1.8	19.8 \pm 2.9	28.7 \pm 2.6
	eCO ₂	25	400	27.4 \pm 0.7	27.1 \pm 0.8	28 \pm 1.1	18.7 \pm 1	22.9 \pm 1	22 \pm 0.9
		25	650	38.6 \pm 1.3	40.5 \pm 1.1	35.4 \pm 1.2	27.1 \pm 1.4	34.6 \pm 1.8	31.6 \pm 1
		35	400	23.3 \pm 0.8	24 \pm 0.7	24.9 \pm 1.2	19.2 \pm 1.1	17.4 \pm 2.1	13.6 \pm 1.9
		35	650	36.8 \pm 0.9	38.9 \pm 1	38.5 \pm 1.8	30 \pm 2.2	29.8 \pm 3.2	22.7 \pm 4
Rd ($\mu\text{mol m}^{-2}\text{s}^{-1}$)	aCO ₂	25	400	-2.4 \pm 0.2	-1.8 \pm 0.1	-2.5 \pm 0.1	-2.4 \pm 0.1	-1.9 \pm 0.3	-1.8 \pm 0.1
		35	400	-4.0 \pm 0.2	-2.9 \pm 0.2	-3.7 \pm 0.1	-3 \pm 0.2	-2.6 \pm 0.2	-2.8 \pm 0.2
	eCO ₂	25	400	-1.9 \pm 0.2	-2.6 \pm 0.2	-2.3 \pm 0.1	-2.9 \pm 0.1	-2.3 \pm 0.2	-2.1 \pm 0.1
		35	400	-3.1 \pm 0.3	-3.7 \pm 0.1	-3.9 \pm 0.2	-4.5 \pm 0.2		-3.3 \pm 0.2
g _s ($\text{mol m}^{-2}\text{s}^{-1}$)	aCO ₂	25	400	0.42 \pm 0.02	0.41 \pm 0.03	0.54 \pm 0.02	0.22 \pm 0.02	0.26 \pm 0.03	0.38 \pm 0.01
		25	650	0.42 \pm 0.02	0.4 \pm 0.03	0.54 \pm 0.02	0.23 \pm 0.02	0.25 \pm 0.02	0.41 \pm 0.02
		35	400	0.29 \pm 0.01	0.4 \pm 0.03	0.49 \pm 0.03	0.41 \pm 0.03	0.26 \pm 0.03	0.23 \pm 0.03
		35	650	0.29 \pm 0.01	0.39 \pm 0.02	0.47 \pm 0.03	0.44 \pm 0.04	0.25 \pm 0.02	0.23 \pm 0.03
	eCO ₂	25	400	0.4 \pm 0.02	0.47 \pm 0.03	0.66 \pm 0.04	0.31 \pm 0.02	0.39 \pm 0.04	0.41 \pm 0.04
		25	650	0.38 \pm 0.02	0.49 \pm 0.02	0.63 \pm 0.03	0.3 \pm 0.02	0.41 \pm 0.02	0.43 \pm 0.03
		35	400	0.26 \pm 0.02	0.43 \pm 0.02	0.54 \pm 0.03	0.36 \pm 0.02	0.24 \pm 0.04	0.19 \pm 0.04
		35	650	0.27 \pm 0.02	0.43 \pm 0.02	0.53 \pm 0.03	0.35 \pm 0.04	0.24 \pm 0.04	0.19 \pm 0.05
PWUE (A _{sat} /g _s) ($\mu\text{mol mol}^{-1}$)	aCO ₂	25	400	74 \pm 3	72 \pm 4	44 \pm 2	66 \pm 3	51 \pm 5	61 \pm 2
		25	650	107 \pm 6	98 \pm 6	56 \pm 3	89 \pm 3	74 \pm 7	77 \pm 4
		35	400	92 \pm 4	65 \pm 3	46 \pm 3	39 \pm 3	43 \pm 6	83 \pm 10
		35	650	146 \pm 6	105 \pm 5	72 \pm 5	61 \pm 4	78 \pm 9	127 \pm 7
	eCO ₂	25	400	69 \pm 2	58 \pm 2	43 \pm 2	62 \pm 4	61 \pm 6	55 \pm 4
		25	650	101 \pm 3	84 \pm 3	57 \pm 3	95 \pm 7	85 \pm 3	75 \pm 5
		35	400	91 \pm 6	57 \pm 2	48 \pm 3	54 \pm 4	75 \pm 6	75 \pm 11
		35	650	139 \pm 10	93 \pm 4	75 \pm 5	99 \pm 15	132 \pm 14	134 \pm 25
Fv'/Fm'	aCO ₂	25	400	0.48 \pm 0.02	0.5 \pm 0.01	0.47 \pm 0.01	0.41 \pm 0.01	0.33 \pm 0.04	0.46 \pm 0.02
		35	400	0.42 \pm 0.01	0.45 \pm 0.01	0.42 \pm 0.02	0.35 \pm 0.01	0.31 \pm 0.04	0.4 \pm 0.01
	eCO ₂	25	400	0.48 \pm 0.03	0.52 \pm 0.01	0.47 \pm 0.01	0.45 \pm 0.01	0.46 \pm 0.01	0.47 \pm 0.01
		35	400	0.41 \pm 0.01	0.47 \pm 0.01	0.41 \pm 0.01	0.41 \pm 0.01	0.42 \pm 0.01	0.37 \pm 0.04
Fv/Fm	aCO ₂	25	400	0.82 \pm 0.01	0.8 \pm 0.01	0.75 \pm 0.01	0.75 \pm 0.01	0.73 \pm 0.02	0.76 \pm 0.01
		35	400	0.79 \pm 0.01	0.8 \pm 0	0.73 \pm 0.02	0.72 \pm 0.01	0.72 \pm 0.04	0.78 \pm 0.01
	eCO ₂	25	400	0.8 \pm 0.02	0.82 \pm 0	0.79 \pm 0.01	0.76 \pm 0.01	0.78 \pm 0.01	0.78 \pm 0.01
		35	400	0.79 \pm 0.01	0.81 \pm 0	0.75 \pm 0.01	0.76 \pm 0.01		0.74 \pm 0.04

Table S2 Response of plant dry mass (DM) and morphological parameters to elevated CO₂ and heat stress: Summary of plant biomass and morphological parameters measured at different time points for what cultivar Scout grown at ambient CO₂ (aCO₂) or elevated CO₂ (eCO₂), with some plants exposed to heat stress (HS) at the anthesis stage. Values are means \pm SE (n= 9-10).

Parameter (Mean plant ⁻¹)	Time	T1(13WAP)	T2 (Anthesis, 17 WAP)		T3 (Maturity, 25	
	Heat Stress	Control	Control	HS	Control	HS
	Growth CO ₂					
Tiller Number	aCO ₂	9.2 \pm 0.6	10.9 \pm 0.5	16.3 \pm 0.7		
	eCO ₂	12.9 \pm 0.7	12.3 \pm 0.8	28.3 \pm 1.6		
Leaf Area (cm ²)	aCO ₂	338 \pm 27	338 \pm 40	296 \pm 47		
	eCO ₂	680 \pm 59	441 \pm 58	650 \pm 55		
Leaf Number (n)	aCO ₂	33.8 \pm 2.6	26.9 \pm 0.8	37 \pm 3.1		
	eCO ₂	49.5 \pm 2.8	27.6 \pm 2.2	66.7 \pm 4.4		
Leaf Size (cm ²)	aCO ₂	27 \pm 7	32 \pm 5	38 \pm 5		
	eCO ₂	24 \pm 2	24 \pm 3	42 \pm 5		
Leaf Mass Area	aCO ₂	58 \pm 1	56 \pm 2	68 \pm 1		
	eCO ₂	52 \pm 2	48 \pm 3	60 \pm 1		
Leaf DM (g)	aCO ₂	1.9 \pm 0.1	1.8 \pm 0.1	2.0 \pm 0.3		
	eCO ₂	3.5 \pm 0.2	1.8 \pm 0.1	3.9 \pm 0.3		
Stem DM (g)	aCO ₂	3.9 \pm 0.1	9.6 \pm 0.3	9.3 \pm 0.7		
	eCO ₂	8.5 \pm 0.6	11.4 \pm 0.8	17.1 \pm 0.7		
Root DM (g)	aCO ₂	1.4 \pm 0.2	1.6 \pm 0.1	1.9 \pm 0.2	0.6 \pm 0.1	2 \pm 0.3
	eCO ₂	2.0 \pm 0.2	2.4 \pm 0.4	3.8 \pm 0.8	0.6 \pm 0.1	1.2 \pm
Shoot DM (g)	aCO ₂	8.1 \pm 0.3	32.9 \pm 1.3	22.1 \pm 0.8	9.3 \pm 0.4	10.3 \pm
	eCO ₂	16.8 \pm 1.1	41.2 \pm 1.9	35.5 \pm 0.8	12.7 \pm 0.7	18.9 \pm
Total DM (g)	aCO ₂	9.5 \pm 0.4	34.5 \pm 1.5	24.1 \pm 1.0	33.7 \pm 1.5	31.4 \pm
	eCO ₂	18.8 \pm 1.3	43.6 \pm 2.2	39.3 \pm 0.9	45.5 \pm 2.2	48.8 \pm
Ear Number	aCO ₂				10.2 \pm 0.3	16.7 \pm
	eCO ₂				12.5 \pm 0.4	22.6 \pm
Grains Per Ear	aCO ₂				41 \pm 1	21 \pm 1
	eCO ₂				41 \pm 1	17 \pm 1
Total Grain Number	aCO ₂				415 \pm 21	352 \pm
	eCO ₂				511 \pm 20	384 \pm
Single Grain Weight	aCO ₂				44 \pm 1	32 \pm 1
	eCO ₂				46 \pm 1	35 \pm 1
Grain yield (g)	aCO ₂				18.1 \pm 0.9	11.2 \pm
	eCO ₂				23.5 \pm 1.1	13.7 \pm
Harvest Index	aCO ₂				0.536 \pm	0.357 \pm
	eCO ₂				0.518 \pm	0.281 \pm

Table S3 Temperature response of mesophyll conductance (g_m) in Scout: Summary of mesophyll conductance measured at five leaf temperatures using concurrent gas exchange and stable carbon isotope measurements. Values are means \pm SE (n=4)

Leaf Temperature (°C)	Mesophyll Conductance (g_m, mol m⁻²s⁻¹)
15	0.232 \pm 0.005
20	0.286 \pm 0.01
25	0.309 \pm 0.008
30	0.279 \pm 0.007
35	0.292 \pm 0.01

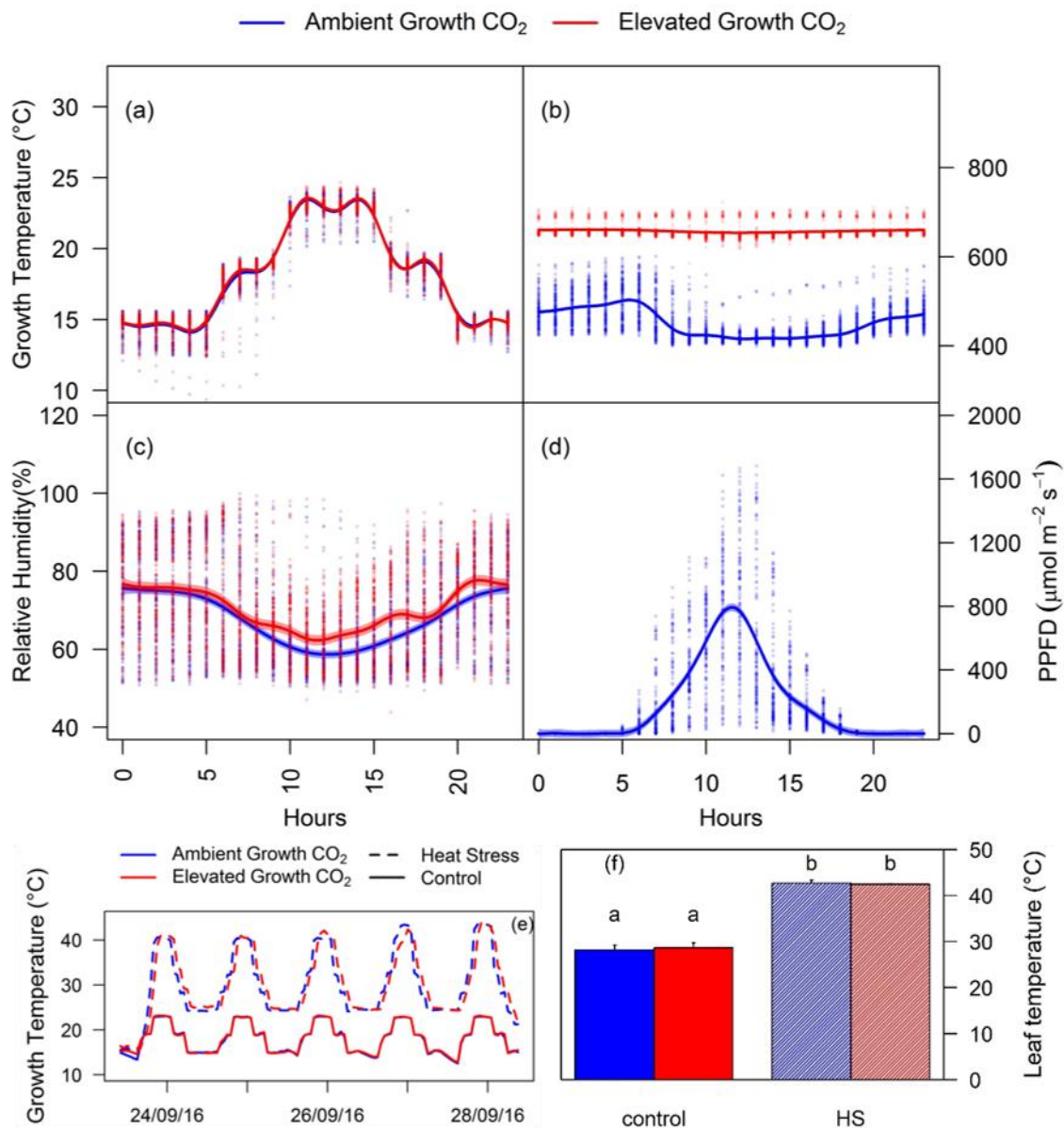


Figure S1 Glasshouse growth conditions and heat stress cycle

Daily averages of growth temperature (a), CO₂ (b), relative humidity (c) and PPFD (d). In panels, a, b, c and d solid lines represent the growth averages, while the faint data points show recorded observations. Lower panel (e) illustrates the 5-day heat stress cycle at the anthesis stage. Growth air temperatures recorded in control and heat stress chambers during heat stress are depicted using solid and dotted lines, respectively. Bar plot of means for leaf temperature (f) of 2-way analysis of variance (anova). Values represent means \pm standard error (n=5). Bars sharing the same letter in the individual panel are not significantly different according to Tukey's HSD test at the 5% level. Ambient and elevated CO₂ treatments are depicted in blue and red, respectively.

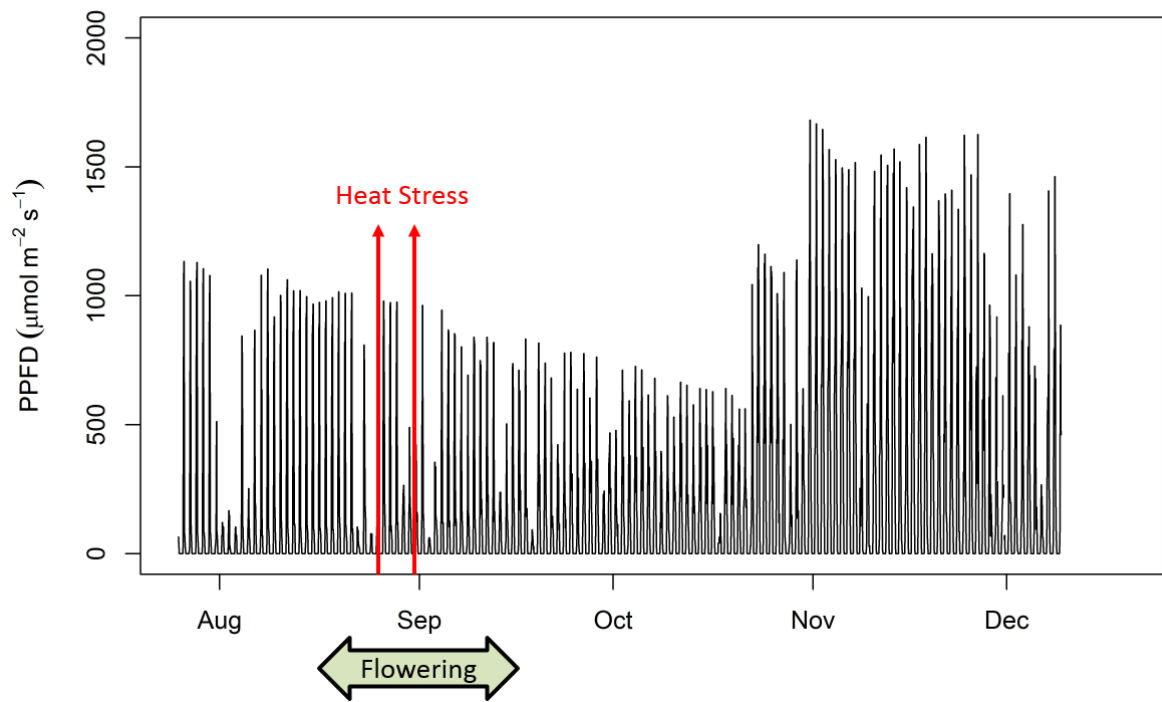


Figure S2 Radiation over time

Radiation over time depicting the radiation load during the experiment highlighted for anthesis and heat stress.

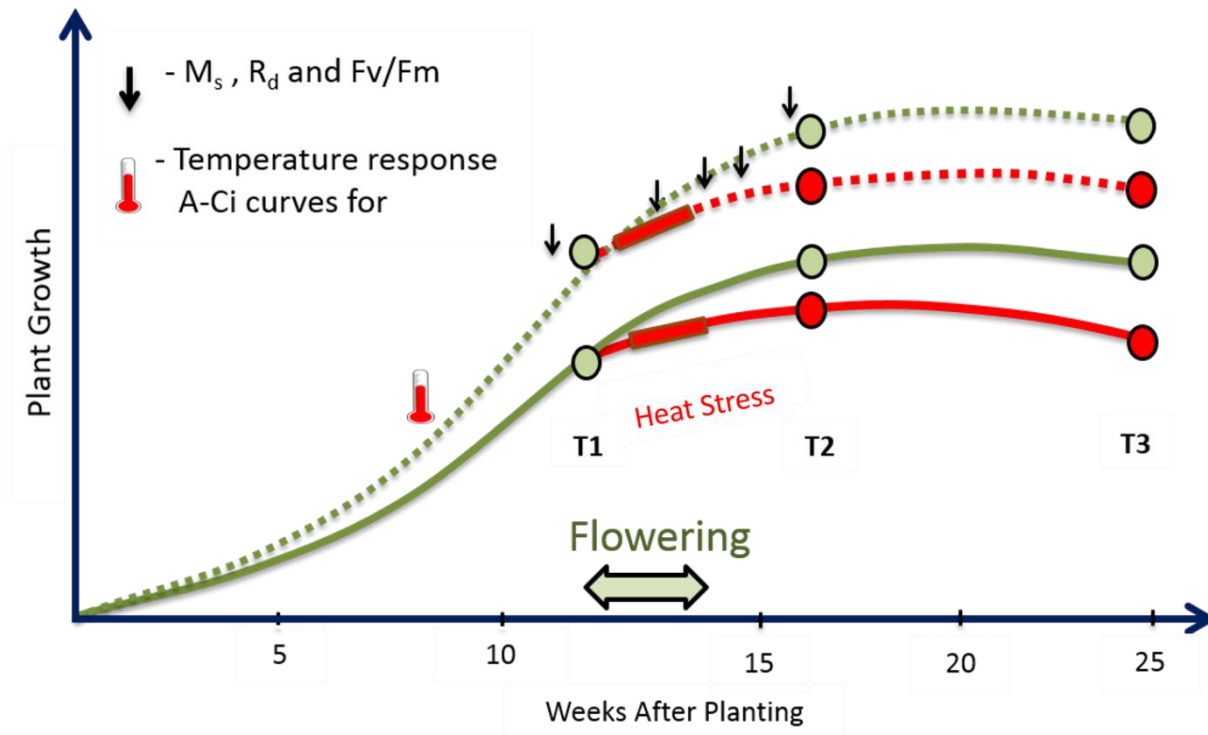


Figure S3 Experimental design depicting plant growth plotted over time showing harvesting at 3-time points (T1, T2 and T3) across the wheat life cycle till maturity, timing of heat stress and measurements

The circles represent harvest of 10 plants at corresponding time point. Green circles on the green solid and dotted lines represent control plants grown at ambient and elevated CO₂ respectively. Red rectangles point to timing and duration of the heat stress (HS) at anthesis stage. The red circles on red solid and dotted lines represent plants subjected to heat stress and grown at ambient and elevated CO₂ respectively. Thermometer symbol represents timing of temperature response measurements.

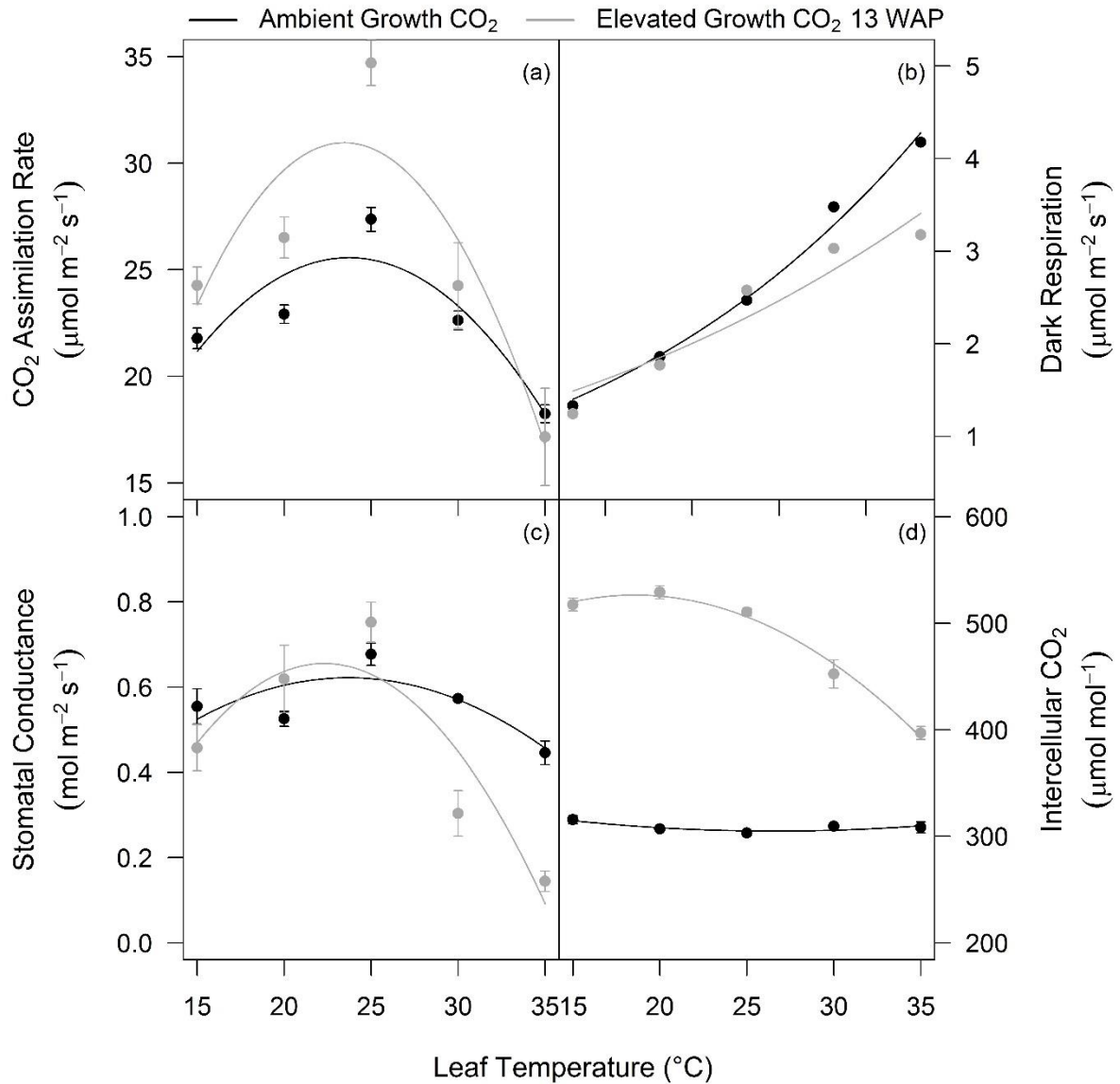


Figure S4 Temperature response of spot gas exchange parameters measured thirteen weeks after planting (WAP)

CO₂ assimilation rate (a), dark respiration (b), stomatal conductance (c) and intercellular CO₂ (d) measured at growth CO₂ and five leaf temperatures (15, 20, 25, 30 and 35 °C) in wheat cultivar Scout. Values are mean ± SE (n=6). Ambient and elevated CO₂ grown plants are depicted in black and grey, respectively.







Heat Stress →	Control	HS	
CO ₂ ↓		Old tillers	New tillers
Ambient	(a) 	(b) 	(c) 
Elevated	(d) 	(e) 	(f) 

Figure S5 Response of grain size and morphology to heat stress at the final harvest

Heat stress effect on grain size and morphology from old tillers and additional late tillers developed after HS under ambient (a, b, c) and elevated CO₂ (d, e, f).