Interactive effect of relative humidity and elevated CO_2 on C and N metabolism of two barley genotypes

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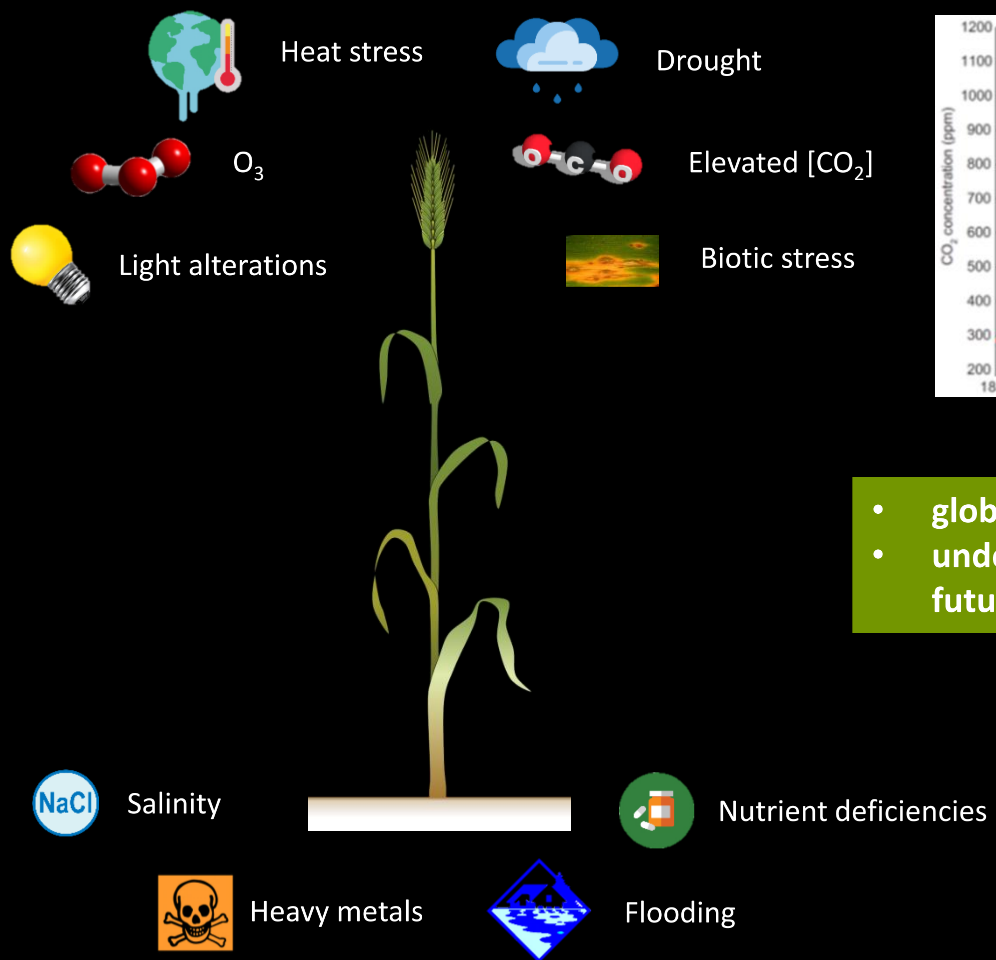
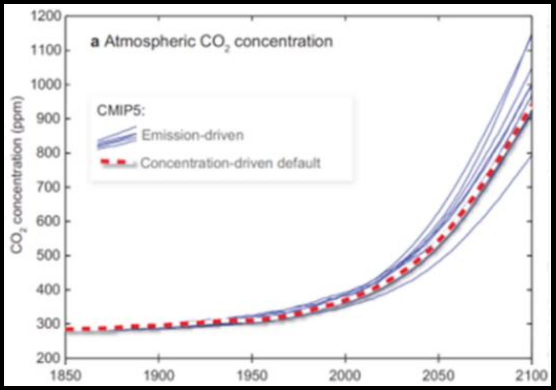
Climate change and crop production

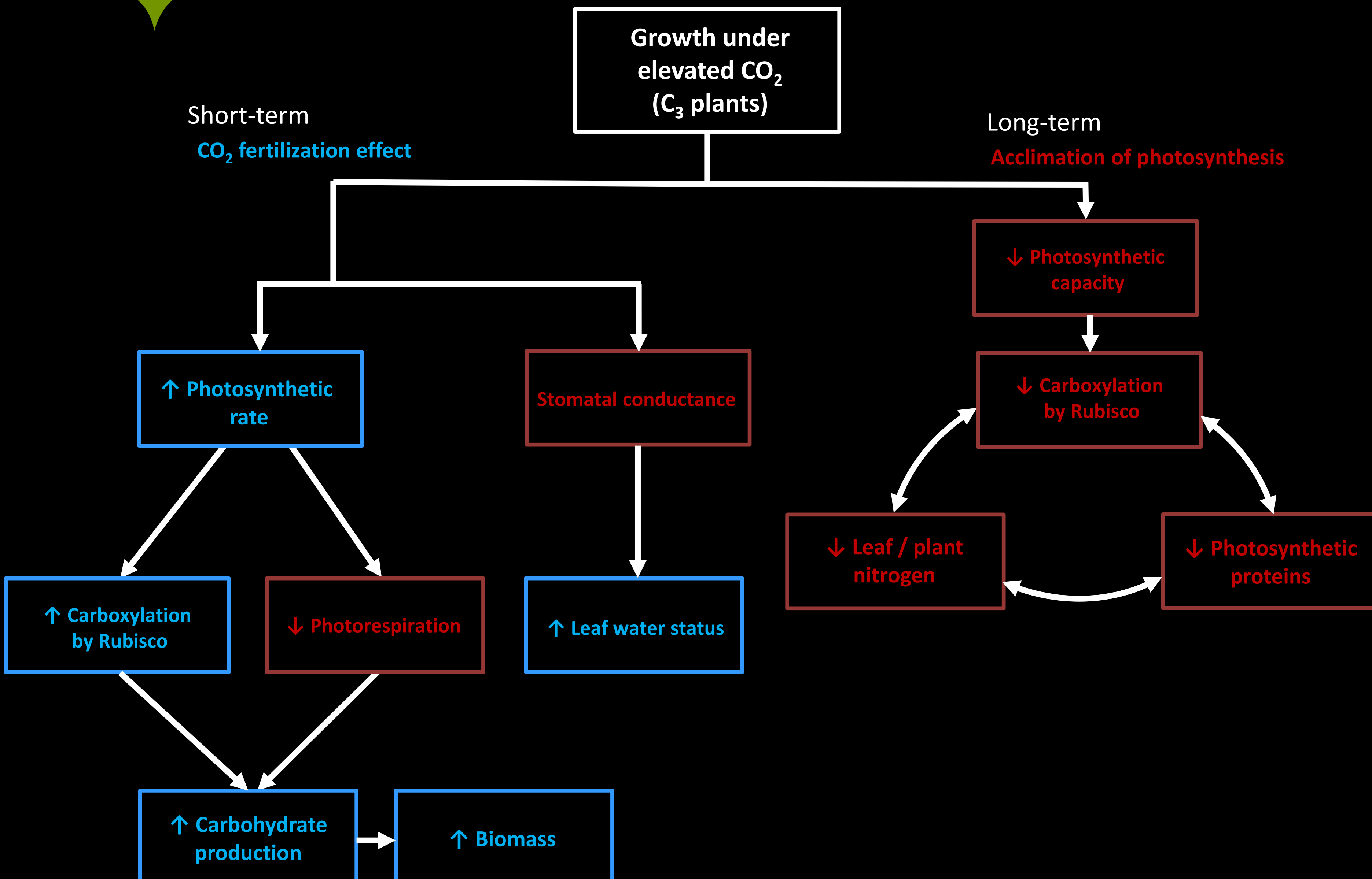
climate change → **biotic & abiotic stresses** ⊣ **crop improvement**



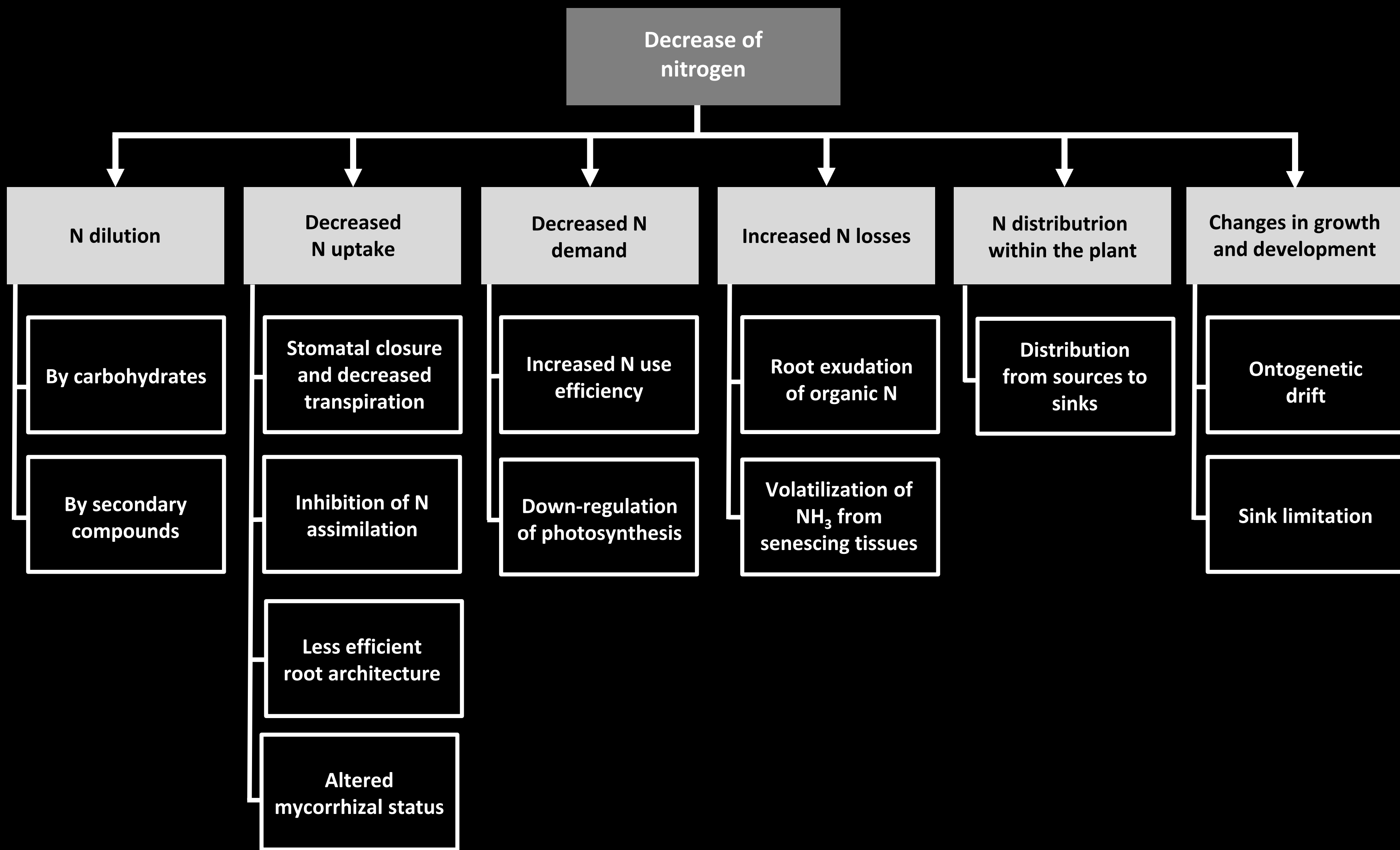


- **global food insecurity**
- **understanding plant growth under future climate change scenario**

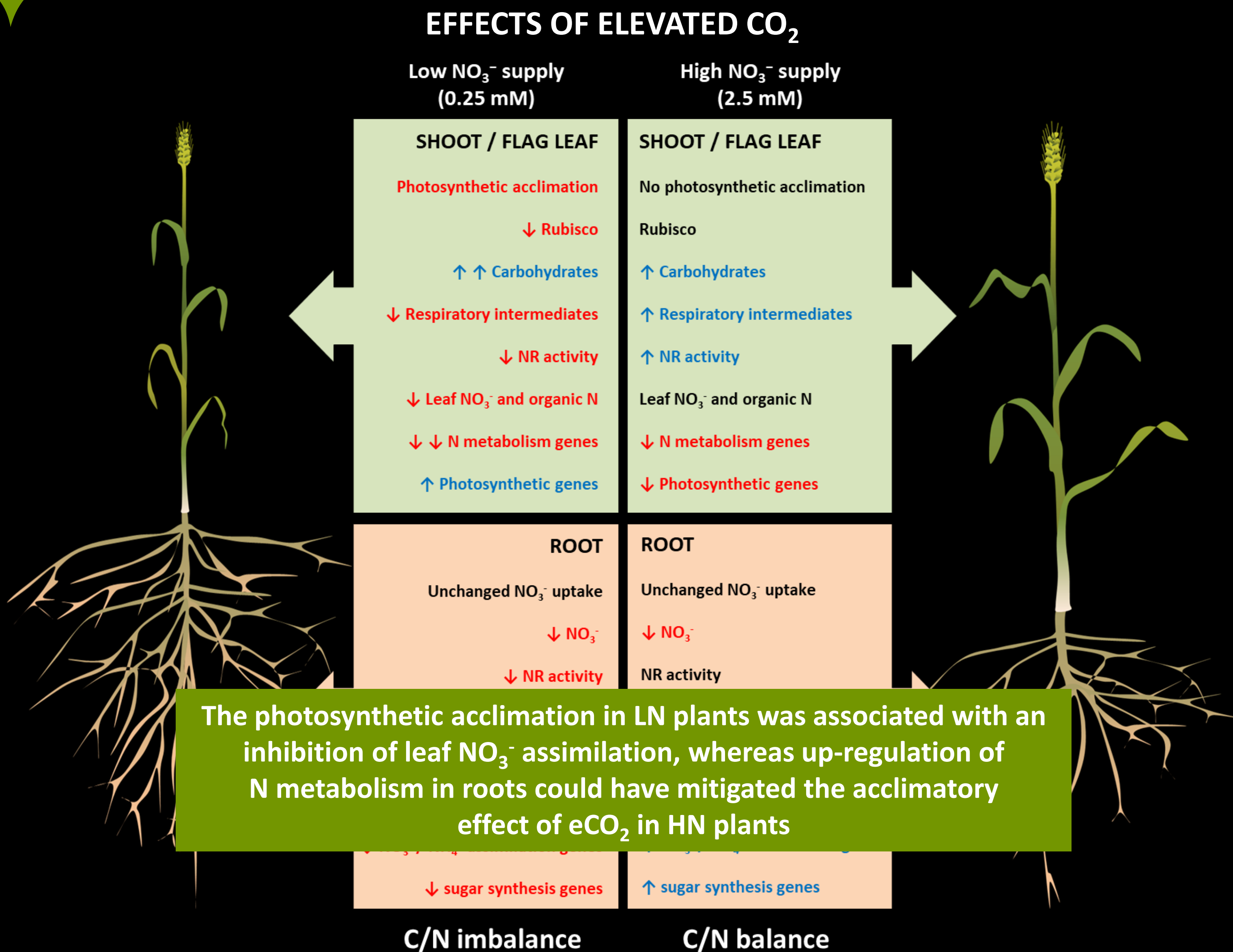
C_3 plant responses to elevated [CO_2]



Why are leaf nitrogen concentrations lower under elevated CO_2?



Coordination of C and N metabolism under elevated [CO_2]

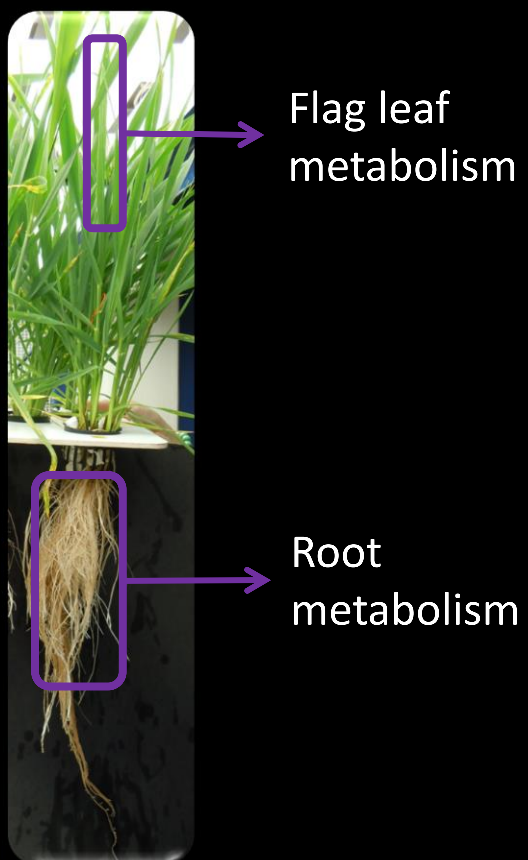


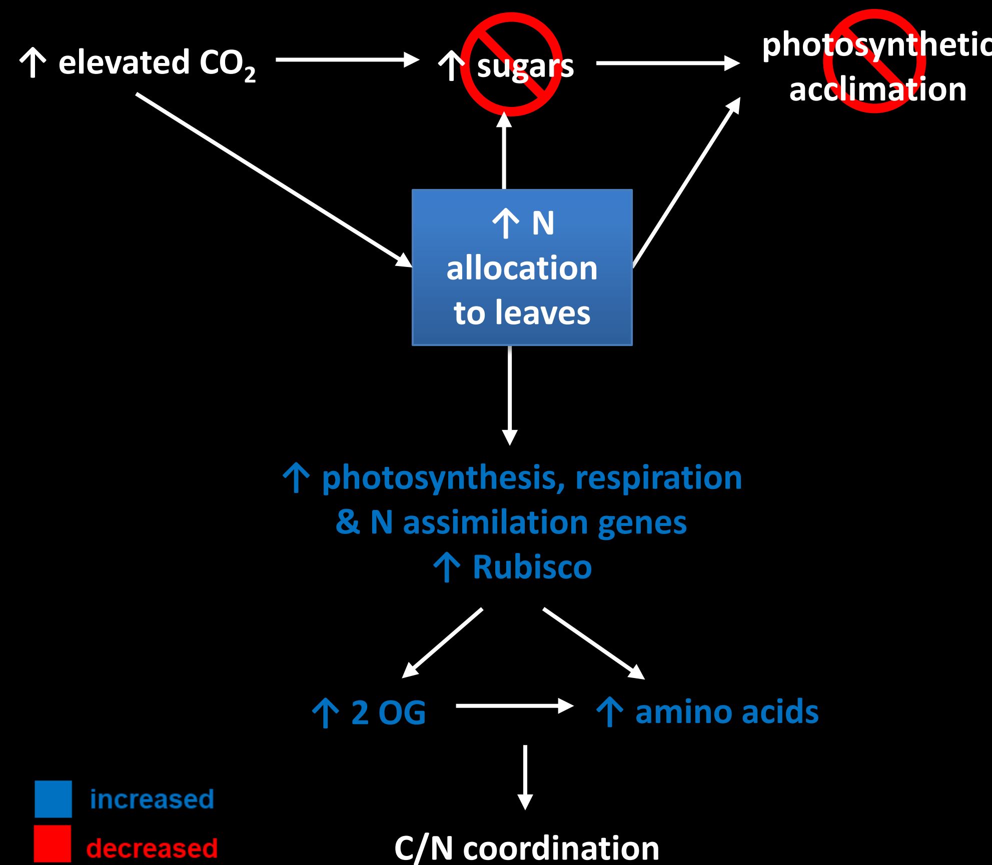
The photosynthetic acclimation in LN plants was associated with an inhibition of leaf NO_3^- assimilation, whereas up-regulation of N metabolism in roots could have mitigated the acclimatory effect of eCO_2 in HN plants

Vicente *et al.* (2016) *Plant Cell Physiol*

Coordination of C and N metabolism under elevated [CO_2]

Elevated [CO_2] × nitrogen





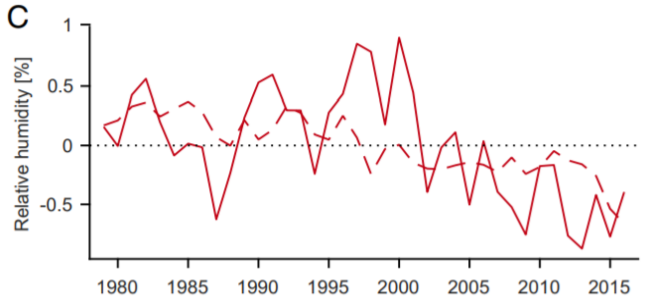
Increased N allocation to young leaves at low N supply (with a good renewal frequency) alleviated photosynthetic acclimation to elevated CO_2

Vicente *et al.* (2015) *Acta Physiol Plant*
Vicente *et al.* (2017) *Plant Sci*

Hypothesis

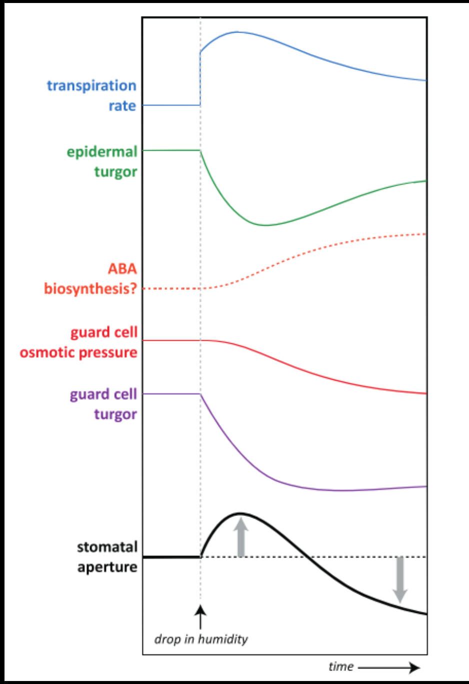
The manipulation of transpiration through changes in relative humidity can alter nutrient assimilation and the response to elevated CO_2 in barley

- In recent decades, RH has fallen over the land



Byrne & O'Gorman (2018) PNAS

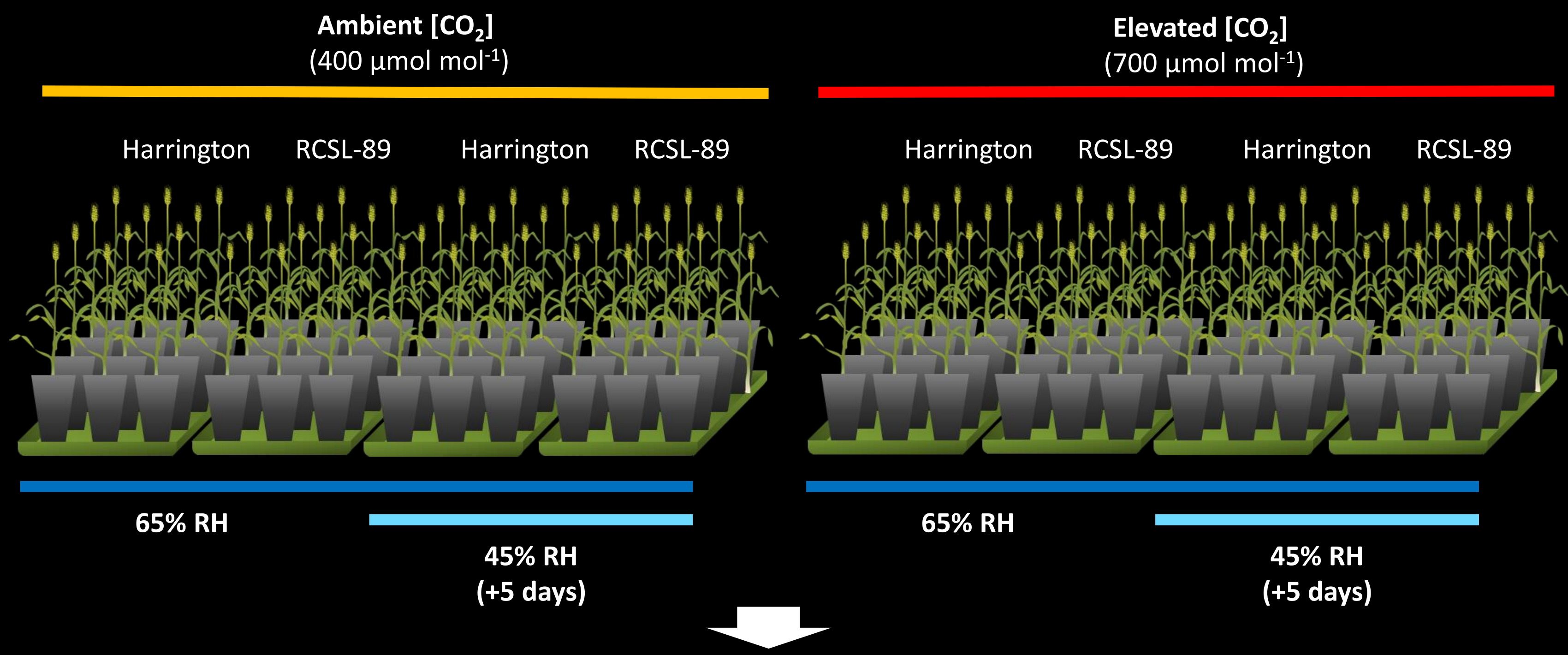
- Mechanism of stomatal responses to humidity



Buckley (2016) Plant Cell Environ

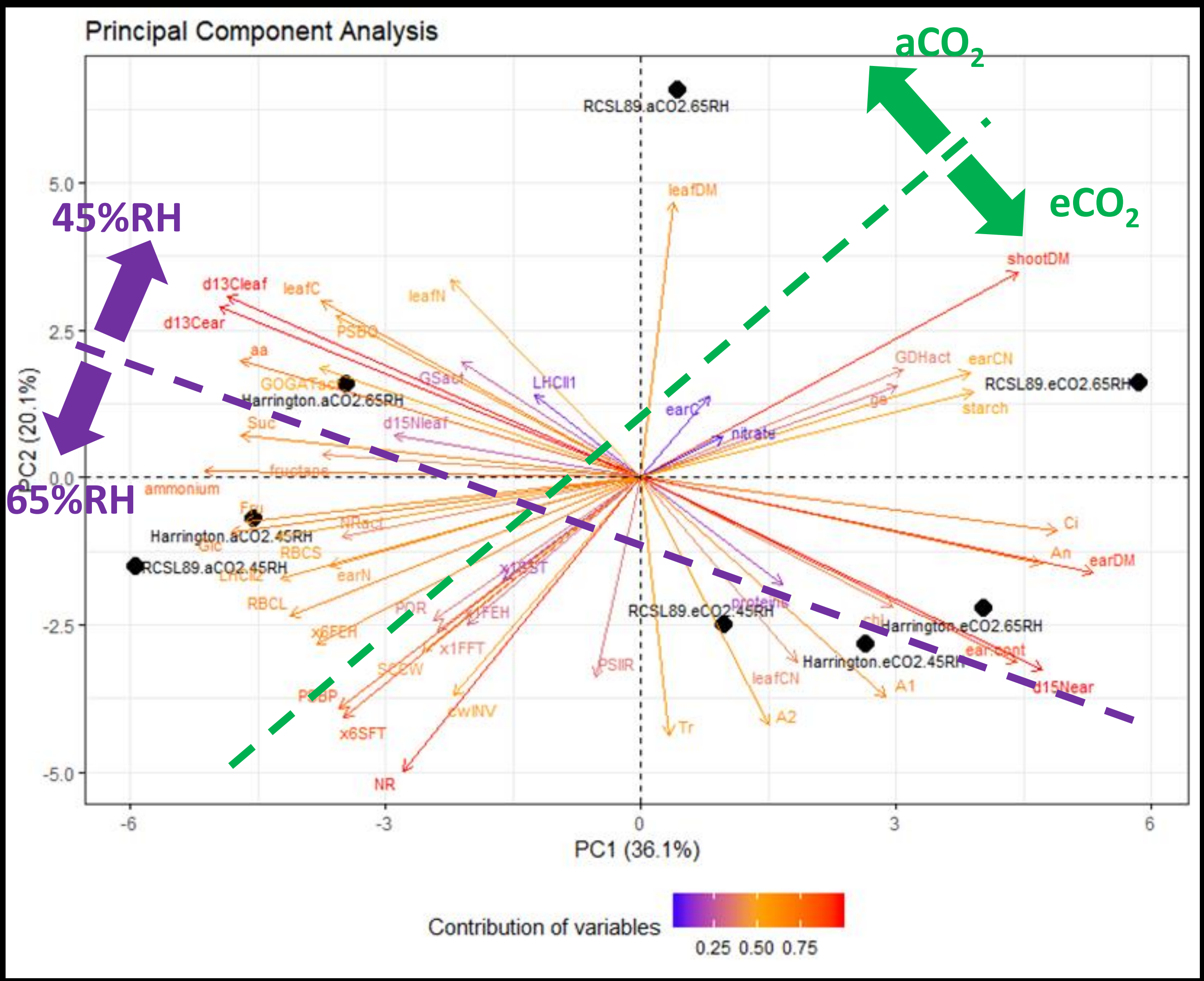
Approach

Investigate the interactive effects of eCO_2 and RH on plant physiology and C/N coordination in source/sink organs of two barley genotypes (Harrington and RCSL-89)

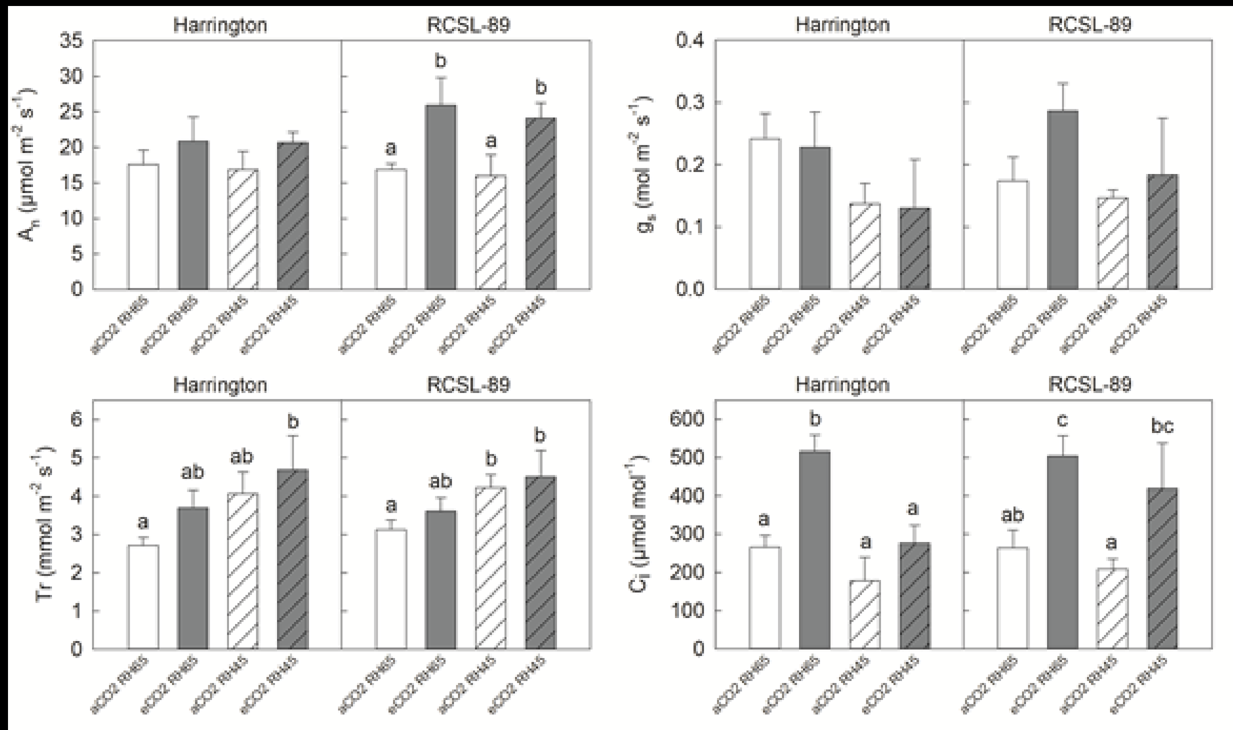


Physiological, biochemical and molecular analyses

Principal Component Analysis

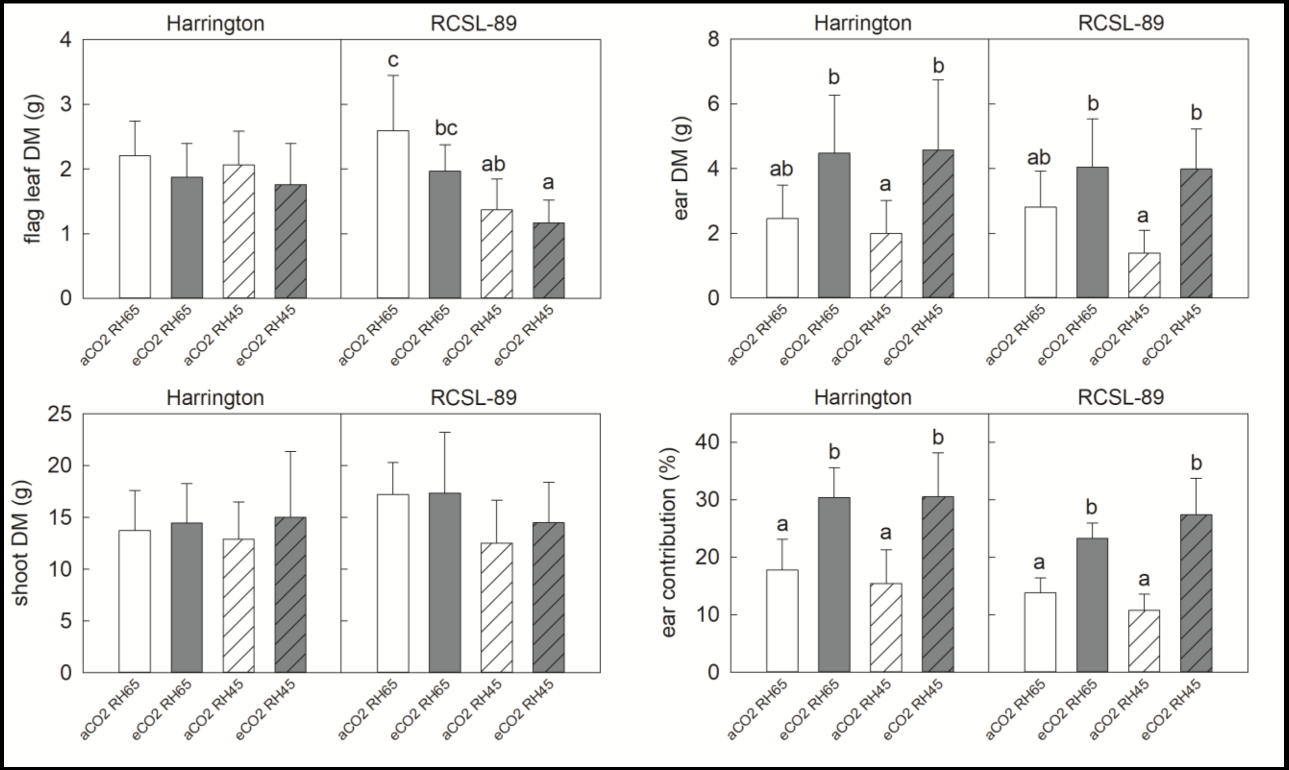


Gas exchange measurements in flag leaves



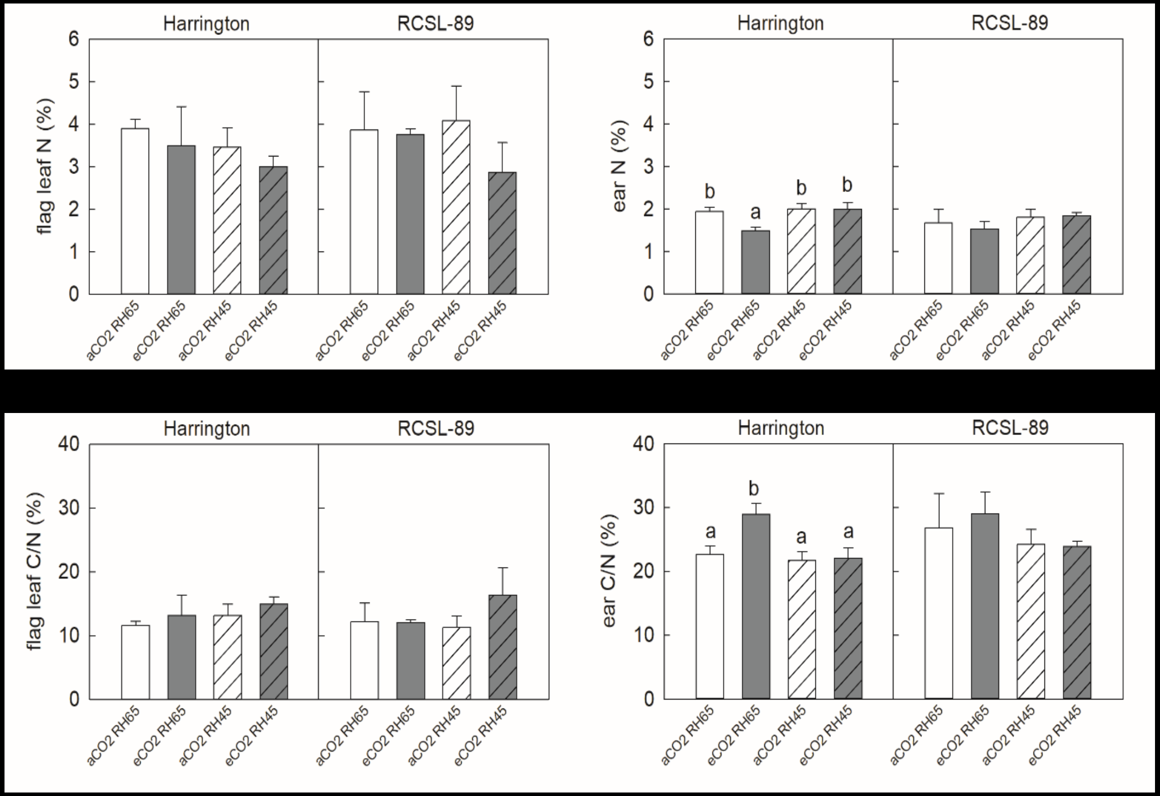
eCO_2 increased photosynthesis while the fall of RH decreased increased transpiration rate

Dry matter of different plant fractions and contribution of ear biomass



eCO_2 decreased flag leaf dry matter, but increased ear biomass and ear biomass contribution with no significant changes in shoot biomass or due to RH

C-N content in flag leaves and ears



eCO_2 tended to decrease ear N content under 65%RH, leading to a high C:N ratio (effect not shown with 45% RH)

C-/N-rich compounds and enzyme activities

	Harrington				RCSL-89			
	65% RH		45% RH		65% RH		45% RH	
	aCO_2	eCO_2	aCO_2	eCO_2	aCO_2	eCO_2	aCO_2	eCO_2
Glucose (µmol g FW^{-1})	35.0 b	10.5 a	28.3 b	12.1 a	9.7 a	11.4 a	26.9 b	21.7 b
Fructose (µmol g FW^{-1})	27.1 b	14.3 a	23.2 b	10.6 a	10.9 a	12.1 a	21.2 b	16.5 ab
Sucrose (µmol g FW^{-1})	113.7 b	63.2 a	96.0 b	68.8 a	78.9	73.6	95.2	89.9
Fructans (µmol g FW^{-1})	20.7	14.9	19	19.1	24.4 ab	18.0 a	36.9 b	22.2 ab
Starch (µmol g FW^{-1})	5.2 a	22.0 b	18.4 b	14.6 ab	20.0 b	54.6 c	9.0 a	9.9 a
NO_3^- (µmol g FW^{-1})	12.0	12.3	10.5	11.6	12.4	14.3	14.4	12.3
NH_4^+ (nmol g FW^{-1})	0.3 a	0.2 a	0.6 b	0.1 a	0.3 b	0.1 a	0.5 c	0.2 b
Chlorophylls (mg g FW^{-1})	2.3	2.4	2.2	2.6	2.3 a	2.5 a	2.3 a	2.9 b
Amino acids (µmol g FW^{-1})	28.2 c	16.1 a	27.2 c	19.8 b	29.7 b	18.8 a	30.8 b	28.0 b
Soluble protein (mg g FW^{-1})	19.8 a	21.4 ab	22.7 ab	26.6 b	20.3	23.6	21.8	19.0
NR (µmol NO_2^- g FW^{-1} h^{-1})	2.6 ab	1.8 a	3.9 ab	3.3 b	2.8 ab	1.5 a	2.7 ab	3.1 b
GS (µmol GHM g FW^{-1} h^{-1})	62.8 b	60.9 b	62.1 b	34.3 a	63.4	62.7	68.5	63.2
GOGAT (µmol NADH g FW^{-1} h^{-1})	3.3 b	2.0 a	4.0 b	3.7 b	4.3	2.7	4.1	3.4
GDH (µmol NADH g FW^{-1} h^{-1})	36.2	39.5	37.9	31.1	34.3 a	45.5 b	24.2 a	27.4 a

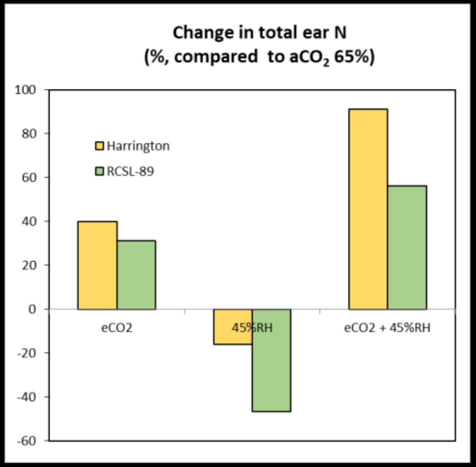
scale

min max

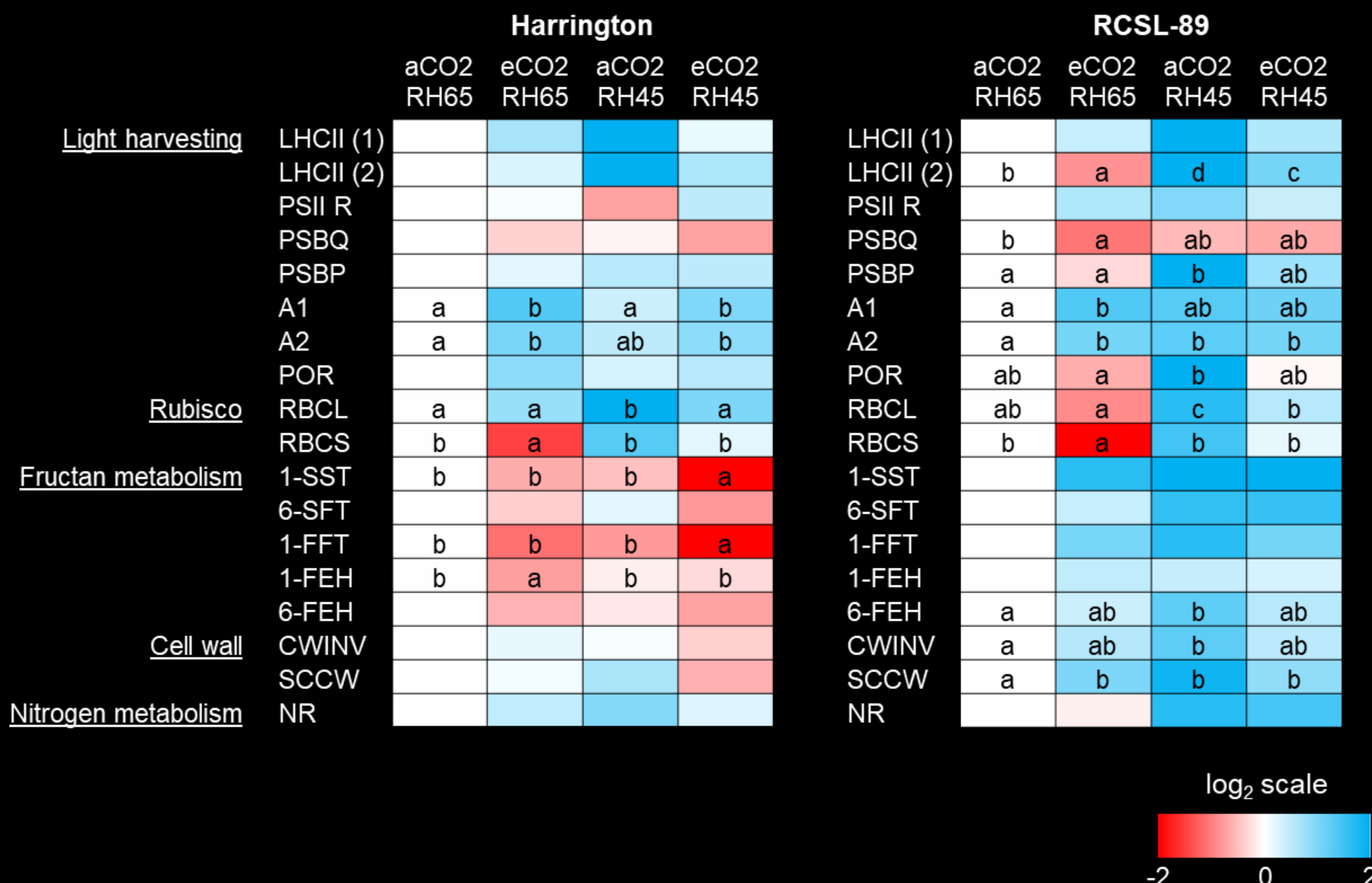
eCO_2 inhibited leaf N metabolism. However, ear N content highlighted that eCO_2 enhanced N assimilation and/or translocation to the ears (total ear N)

→ large availability of C skeletons for the synthesis of N compounds?

45% RH (higher Tr) decreased ear N content but combined with a high C supply (eCO_2) favoured N assimilation and translocation to ears



Gene expression analyses by qRT-PCR



Summary

- eCO_2 stimulated nutrient allocation to grain filling in well-fertilised barley plants, particularly when transpiration rate was stimulated by lower RH in a genotype-specific manner

- Although a higher carbohydrate-storage capacity in stems can help to maximize the photosynthetic capacity under elevated CO_2 in RCSL-89 genotype [Torralbo *et al*. (2019) *J Exp Bot*], this does not seem an advantage when N assimilation is not limited by soil moisture or transpiration rate.

- Relative humidity is an important factor to take into account for the understanding of plant responses to climate change

Acknowledgements

IRNASA Instituto de Recursos Naturales y Agrobiología de Salamanca

IdAB Instituto de Agrobiotecnología Agrobioteknologiako Institutua

CSIC Consejo Superior de Investigaciones Científicas

Thank you for your attention

University of the Basque Country

ITQB Universidade Nova de Lisboa