

# Common bean (*Phaseolus vulgaris* L.) nutritional profile & soil microbiome community is affected by elevated atmospheric carbon dioxide (CO<sub>2</sub>)

Rafael D.C. Duarte<sup>a</sup>, Marta Nunes da Silva<sup>a</sup>, Juan Quirós-Vargas<sup>b</sup>, Onno Muller<sup>b</sup>, Marta W. Vasconcelos<sup>a\*</sup>

<sup>a</sup> Universidade Católica Portuguesa, CBQF - Centro de Biotecnologia e Química Fina – Laboratório Associado, Escola Superior de Biotecnologia, Rua Diogo Botelho 1327, 4169-005 Porto, Portugal  
<sup>b</sup> Institute of Biogeosciences, IBG2: Plant Sciences, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany  
<sup>\*</sup> Corresponding author e-mail: mvasconcelos@ucp.pt



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PORTO

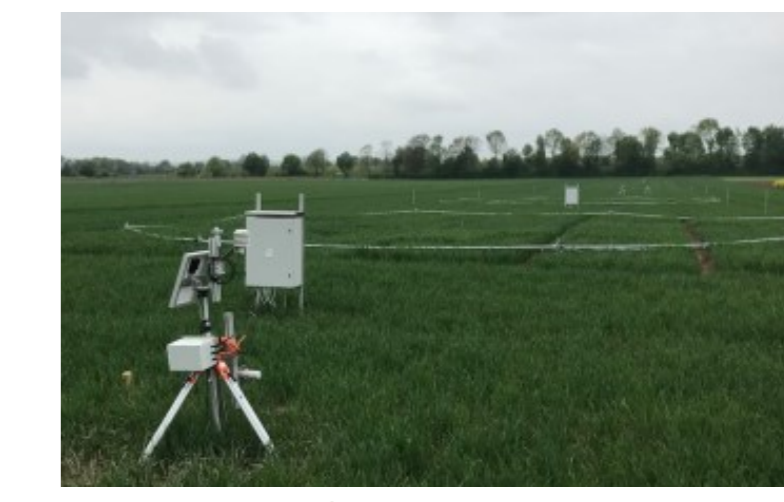
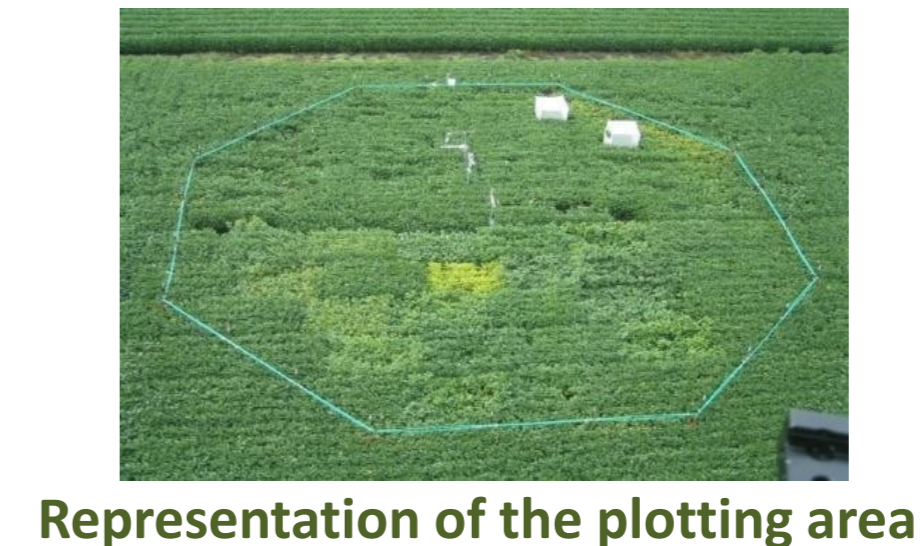
## Introduction

Legume crops, such as common bean (*Phaseolus vulgaris* L.), are key contributors of essential nutrients for human health while playing a pivotal role in the sustainability of agroecosystems. Unfortunately, they are also sensitive to rampant climate change nefarious effects, such as elevated concentrations of atmospheric CO<sub>2</sub> (eCO<sub>2</sub>), exacerbating dietary challenges and the unsustainable use of agronomic resources.

Thus, the need to unravel the intraspecific effects of eCO<sub>2</sub> on biomass yield, nutritional value, microbial communities and genetic regulation of food crops is of utmost importance to anticipate potential shortcomings to human nutrition and expedite mitigation strategies.

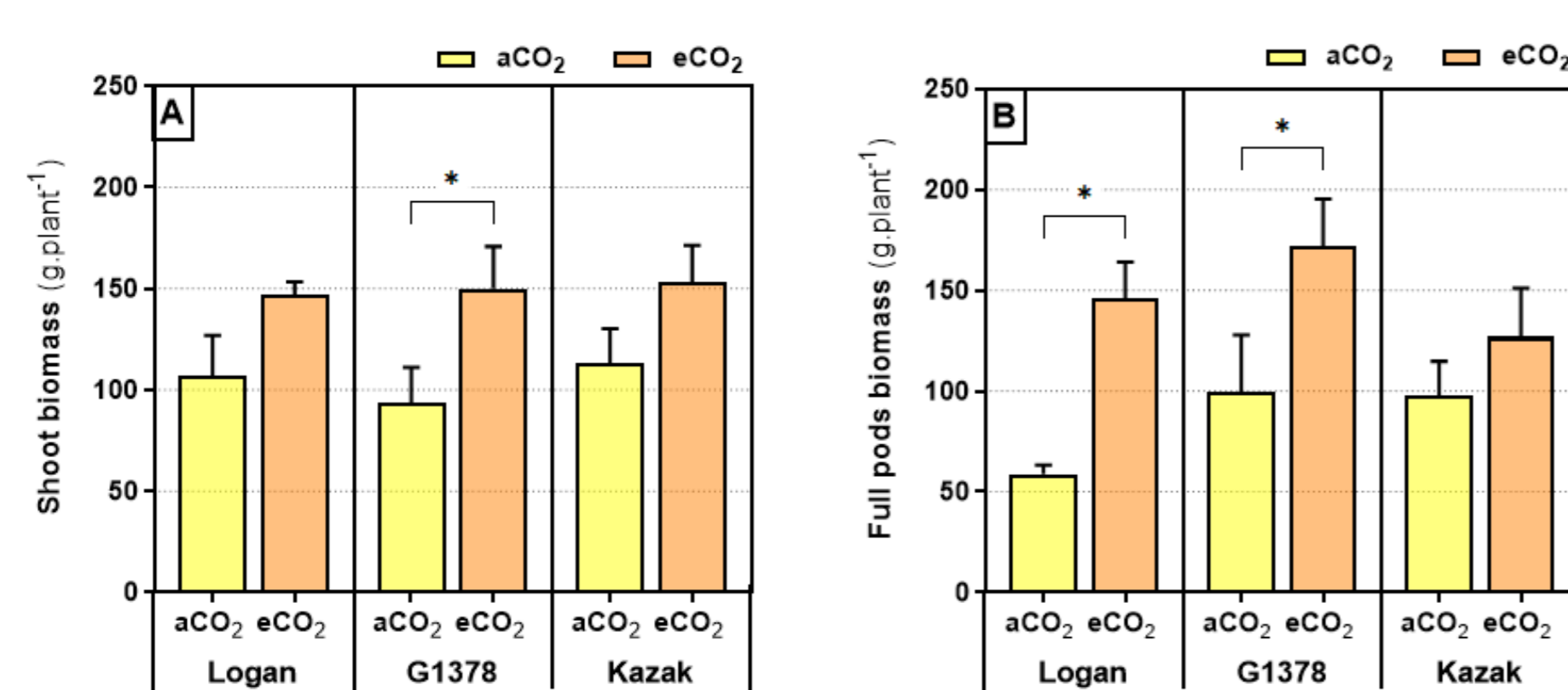
## Methods

- ✓ *Phaseolus vulgaris* L. genotypes 'Logan', 'G1378' and 'Kazak';
- ✓ Plant growth in field conditions (Jülich FACE platform, Germany) under ambient CO<sub>2</sub> (400 ppm, control aCO<sub>2</sub>) or elevated CO<sub>2</sub> (600 ppm, eCO<sub>2</sub>);
- ✓ At plant maturity, evaluation of biomass yield, mineral profile, microbial communities and related gene expression.



FACE  
Free Air CO<sub>2</sub>  
Enrichment

## Results & Discussion



**Figure 1** – Shoot (A) and full pods (B) biomass of Logan, G1378 and Kazak grown under ambient or elevated atmospheric CO<sub>2</sub>. Each value represents the average ± SEM and asterisks indicate significant differences at p<0.05.

### 1. Plant biomass

Exposure to eCO<sub>2</sub> resulted in a significant **increase of plant biomass** in Logan and G1378 (between 1.2- to 2.1-fold). Kazak appeared to be less impacted.

**Intraspecific variability in responding to eCO<sub>2</sub>**

### 3. Gene expression

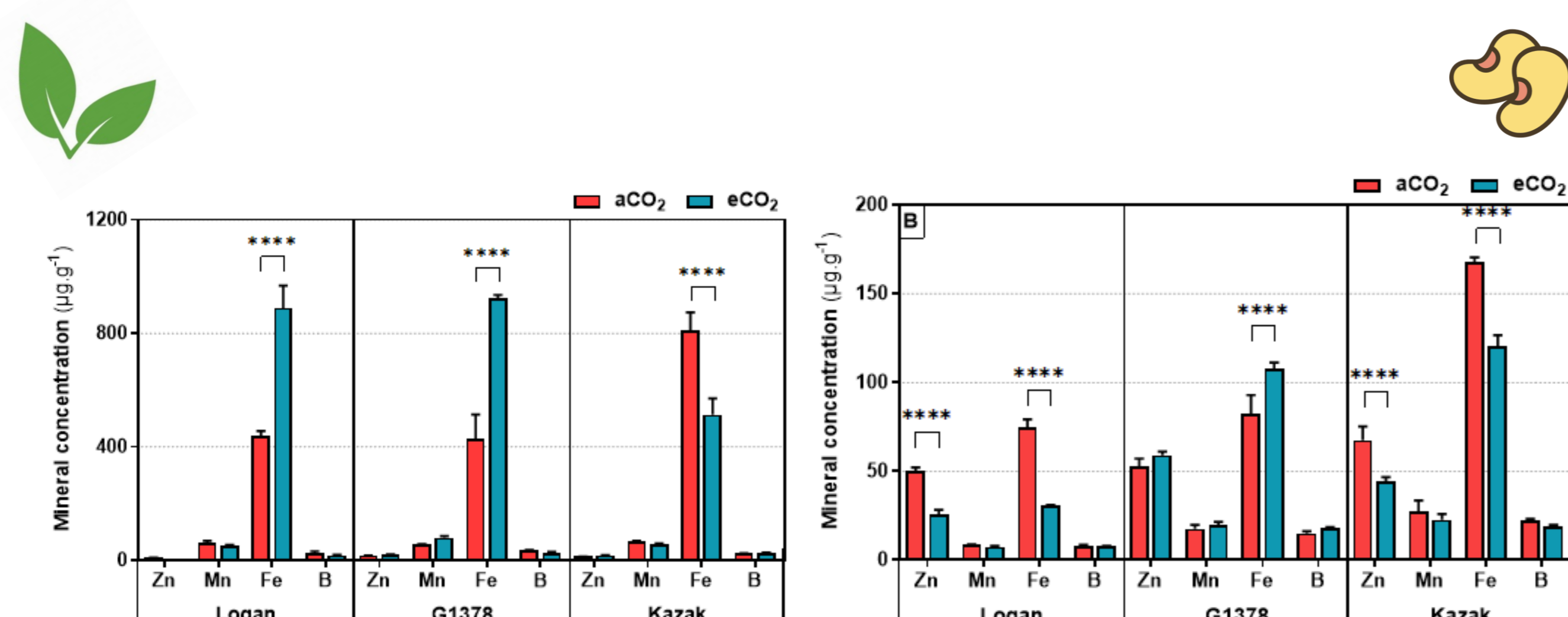
Gene	Logan LEAF	Logan ROOT	G1378 LEAF	G1378 ROOT
FRO2	2.4	1.1	1.4	0.9
FER1	1.1	1.0	1.1	0.7
NRAMP6	1.0	1.7	0.8	0.9
NRAMP7	0.8	0.6	0.8	0.8
ZIP1	2.2	1.1	2.4	0.8
ZIP16	0.2	5.0	0.8	2.6
ERN1	0.8	1.1	0.5	1.3
RAM1	1.2	1.0	2.1	1.0
RAM2	0.8	1.0	1.3	0.9
TCR1	1.0	0.4	1.0	2.1
TCR2	0.9	0.4	1.4	2.0
HLH54	1.0	1.1	0.9	0.7
HLH148	1.6	1.1	0.9	0.9

Under eCO<sub>2</sub>, **TCR1** and **TCR2**, which regulate stress response, were downregulated in Logan roots and upregulated in the roots of G1378- **higher susceptibility** of this genotype to eCO<sub>2</sub>.

**FRO2** was upregulated in the leaves of Logan, agrees with the higher [Fe] observed.

eCO<sub>2</sub> plant effects seemed to be **regulated** by genes involved not only in plant **nutrition** but also plant response to **stress**.

**Figure 3** - Heatmap of relative fold of expression of genes involved in plant nutrition, stress response and microbiome symbiosis: FRO2, FER1, NRAMP6, NRAMP7, ZIP1, ZIP16, ERN1, RAM1, RAM2, TCR1, TCR2, HLH54 and HLH148 in shoots and roots of *Phaseolus vulgaris* genotypes Logan and G1378 grown under ambient or elevated CO<sub>2</sub>. In green: no alteration or downregulation of gene expression; in gray/red: upregulation of gene expression



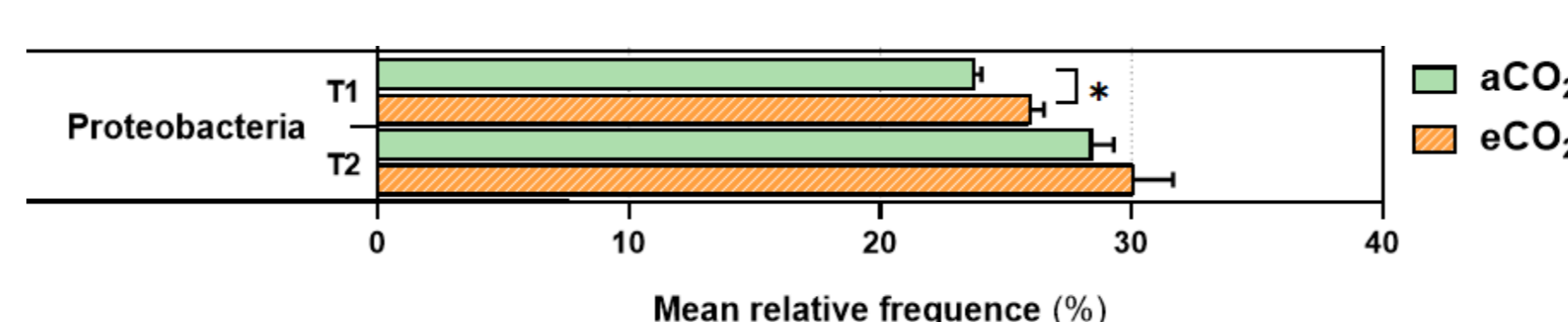
**Figure 2.** Leaf and pod mineral concentration (important micronutrients) of Logan, 'G1378' and 'Kazak' genotypes. Each value represents the mean ± SEM. Asterisks represent statistically differences at p < 0.05.

### 2. Mineral Profile

**Zn** and **Fe** accumulation in Logan was significantly **reduced** by eCO<sub>2</sub> in grains, whereas in Kazak it **decreased** in shoots and grains. Contrarily, in G1378 [**Fe**] **increased** in both shoots and grains.

Again, different genotypes displayed contrasting behaviors, with **Logan** and **G1378** appearing to be **more resilient** to nutritional losses caused by eCO<sub>2</sub>

### 4. Microbial community



**Figure 4** – Proteobacteria mean relative frequency of Logan genotypes exposed to ambient or elevated CO<sub>2</sub> for 15 (T1) or 30 days (T2). Each value represents the average ± SEM and asterisks indicate significant differences at p<0.05.

**↑ Proteobacteria** reported

Important phylum to the biogeochemical nutrient cycling playing a role in **enhancing plant growth** (as previously observed)

## Conclusions

- Elevated atmospheric CO<sub>2</sub> impairs common bean productivity and nutritional quality in an intraspecific manner.
- Genotypes such as Logan may present higher resilience to this environmental stress with shifts in soil microbiome.
- The identification of resilient genotypes could lead to the implementation of improved crops as an adaptive strategy to mitigate nutritional shortcomings under predicted eCO<sub>2</sub> conditions.



## Acknowledgements

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