

The use of biodiversity to fight climate change: Unravelling the diverse mechanisms in banana for drought and heat tolerance

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Background

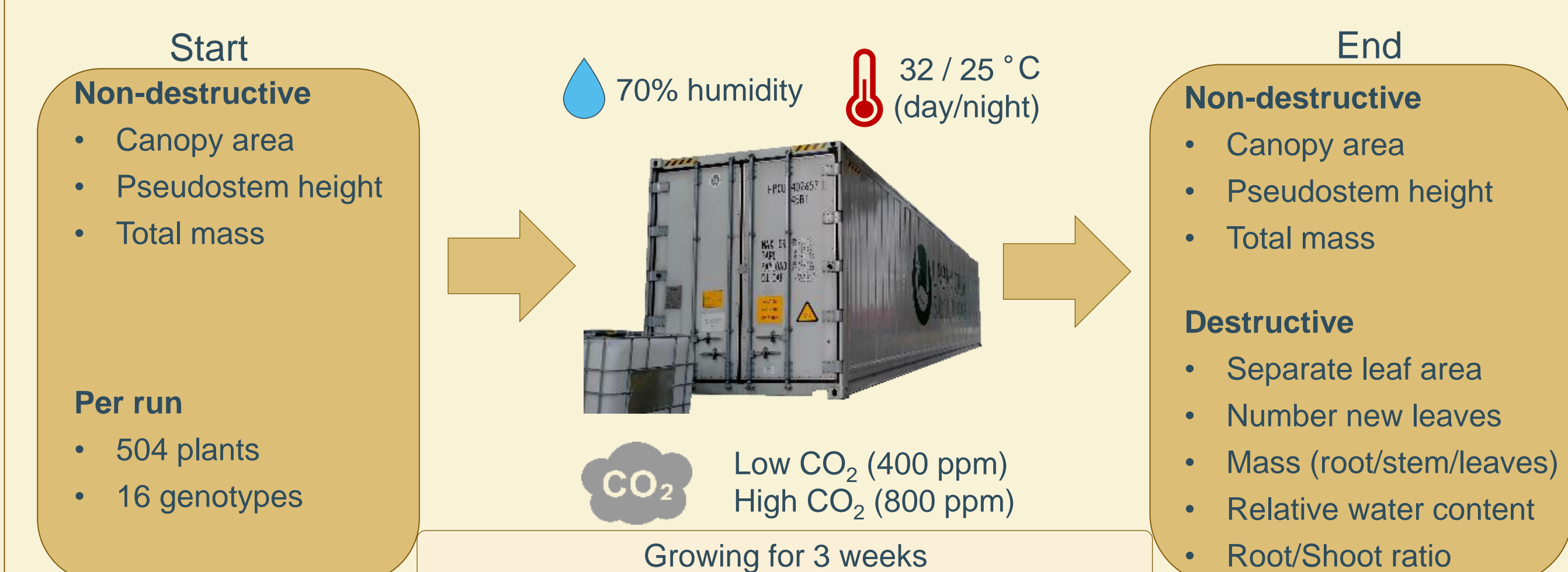
Banana (*Musa* spp.) is worldwide the most produced fruit, of which 85% is rain fed and for home consumption. Optimal banana production requires continuous and abundant water, while many agro-ecological zones have one or two dry seasons. Due to climate change, these become more difficult to predict, shift in time, tend to be more extreme and can cause major yield losses. This also makes it farmers difficult to predict planting and harvesting dates. To spread these risks, one possible solution is to increase the **intra-crop diversity**. While high water-consuming varieties can grow fast with a short drought avoiding crop cycle, more drought tolerant varieties can withstand extreme weather conditions and safeguard food security. Bioversity International hosts the largest germplasm bank worldwide with over 1600 accessions. 116 gene bank accessions have been screened for **growth-temperature responses** under current and future climates and are currently being tested for **heat and drought tolerance or avoidance traits**. However, the **molecular mechanisms** behind these traits are poorly understood and are being elucidated by a transcriptomics and proteomics approach. Therefore, this project aims to gain fundamental insight in drought tolerance at the physiological and genetic level.

Methods

High-throughput phenotyping in simulated climate

Goal: Effect of simulated climate on plant growth after 3 weeks

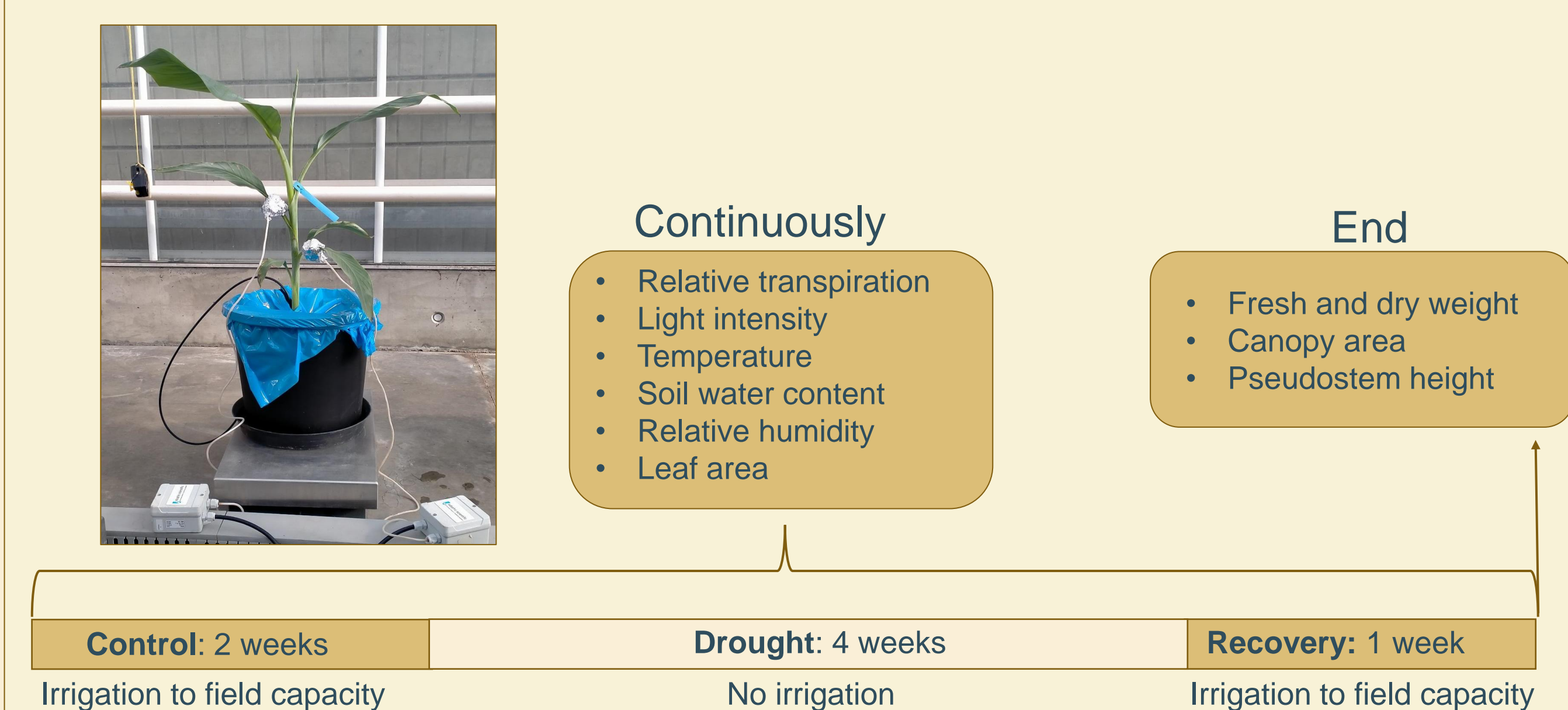
Hypothesis: Plants close their stomata at high CO₂ concentrations and will therefore heat up



High-throughput transpiration phenotyping

Goal: Model maximum relative transpiration (E_{max}) in function of environmental variables light intensity (Q_{in}), vapor pressure deficit (VPD) and soil water content (SWC)

$$E_{model} = E_{max} * f1(VPD) * f2(Q_{in}) * f3(SWC)$$



Results

- The impact of **high CO₂** on plant growth under a **warm climate** is genotype-specific (Figure 1): Heat combined with high CO₂ levels significantly impacts plant growth of some genotypes positively or negatively

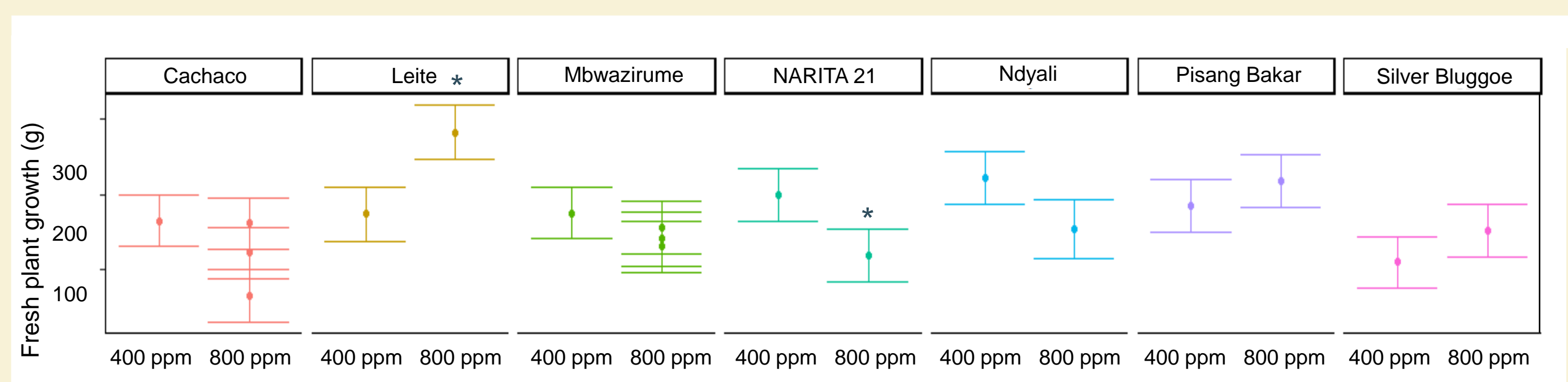


Figure 1: Fresh plant growth (g) of 7 different genotypes in low CO₂ (400 ppm) and high CO₂ (800 ppm) treatment. The mean and standard deviation are shown (n = 30). Cachaco and Mbwezirume are reference genotypes that are present in every run (n = 42). Data was analysed using two-way ANOVA, followed by Tukey post-hoc test. Significant differences (p < 0.05) are indicated by * ($\alpha = 0.05$).

- Genotypic differences in transpiration behavior (Figure 2 a,b) and root/shoot ratio (Figure 2,c)
- A) **Critical soil water content** (dashed) ~ sensitivity to reducing soil water content
 - A) **Slope** ~ reaction speed of transpiration reduction
 - A) **E_{max}** ~ growth potential
 - B) **Vapor pressure deficit (VPD)** ~ sensitivity to air dryness
 - C) **Root/Shoot ratio** ~ allocation of biomass to roots and shoots

→ Allows for identification of **drought avoidance traits** (high root/shoot ratio, low critical soil water content, high sensitivity to VPD) in different genotypes

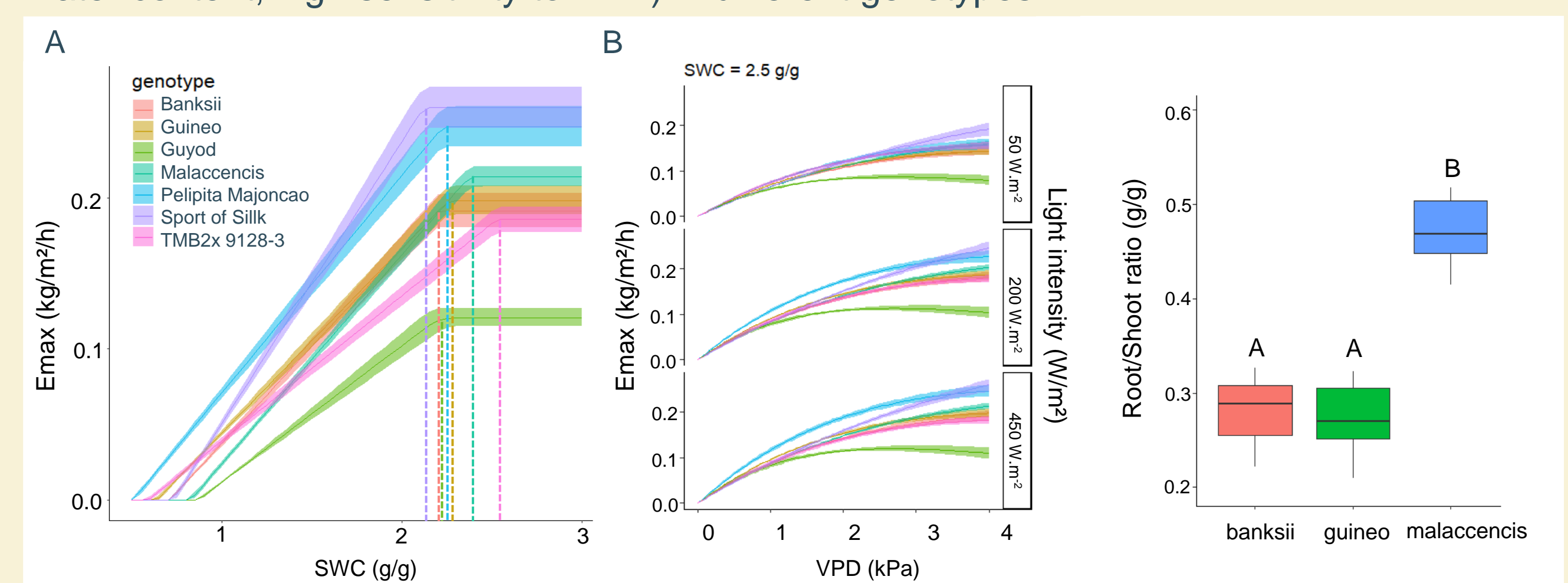


Figure 2: a) E_{max} in function of gravimetric soil water content (SWC) (g/g) and b) E_{max} in function of light intensity (W/m^2) and vapour pressure deficit (VPD) (kPa). 95% confidence intervals are constructed by bootstrapping. C) Root/shoot ratio of three different genotypes. Different letters show significant differences (p < 0.05) between genotypes ($\alpha = 0.05$).

Conclusion and future planning

- Diversity within *Musa* is significant with a significant **difference in avoidance mechanisms** to various plant behaviors to changing environmental conditions.
- 7 genotypes have been phenotyped in more detail under a warm climate and many more are in the process of being screened.
- Modelling maximum relative transpiration in function of the environment illustrated diversity.
- Genotypes with a negative impact of future climates on plant growth might benefit from agroforestry systems.

- Further research questions:

Hydraulic conductance as drought avoidance trait

How does the **water transport** through the plant react to different environmental conditions?

Field validation of transpiration behavior

Does the transpiration behavior translate to **field conditions**?
What is their **yield**?

Transcriptomics + proteomics on guard cells and roots

Which **alleles** and **proteins** are related to drought tolerance phenotype?

