Exploring architectural traits and ecophysiological responses in soybean under heat and water stress: implications for climate change adaptation

Corentin Maslard, Mustapha Arkoun, Christophe Salon, Marion Prudent

Exploring Architectural Traits and Ecophysiological Responses in Soybean under Heat and Water Stress: Implications for Climate Change Adaptation

Corentin Maslard

Forum des Jeunes Chercheurs

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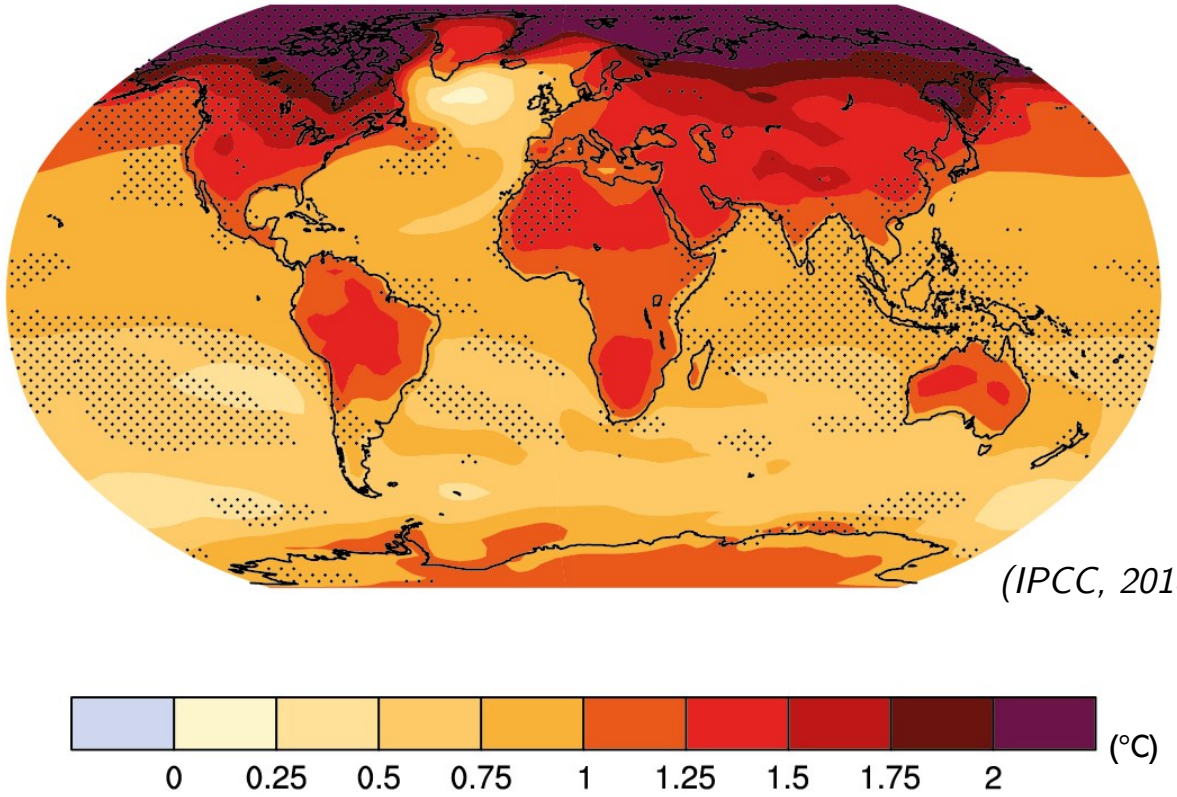
INRAE science for people, life & earth
Agroécologie Dijon Unité de Recherche
EcoLeg Ecophysiology of Grain Legumes
UBFC Université Bourgogne Franche-Comté
École Doctorale PRES I Bourgogne I Franche-Comté Environnements - Santé
中國農業大學 China Agricultural University 1905
Groupe Roullier

Predictions indicate a global average temperature increase of up to 6°C by 2100

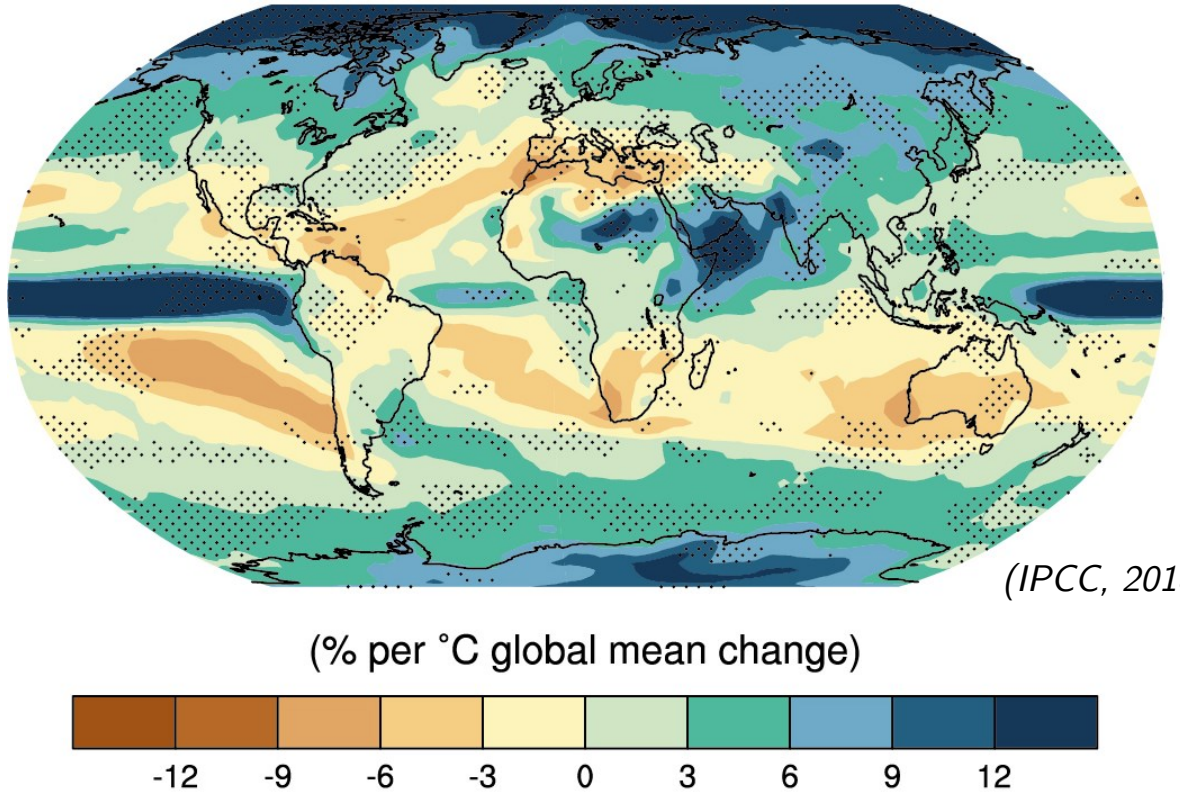
Evolution of the average surface temperature (between 1986-2005 and 2081-2100)



(IPCC, 2018)

Some mid-latitude regions, such as the Mediterranean, will experience more intense drought events

Evolution of average precipitation (between 1986-2005 and 2081-2100)



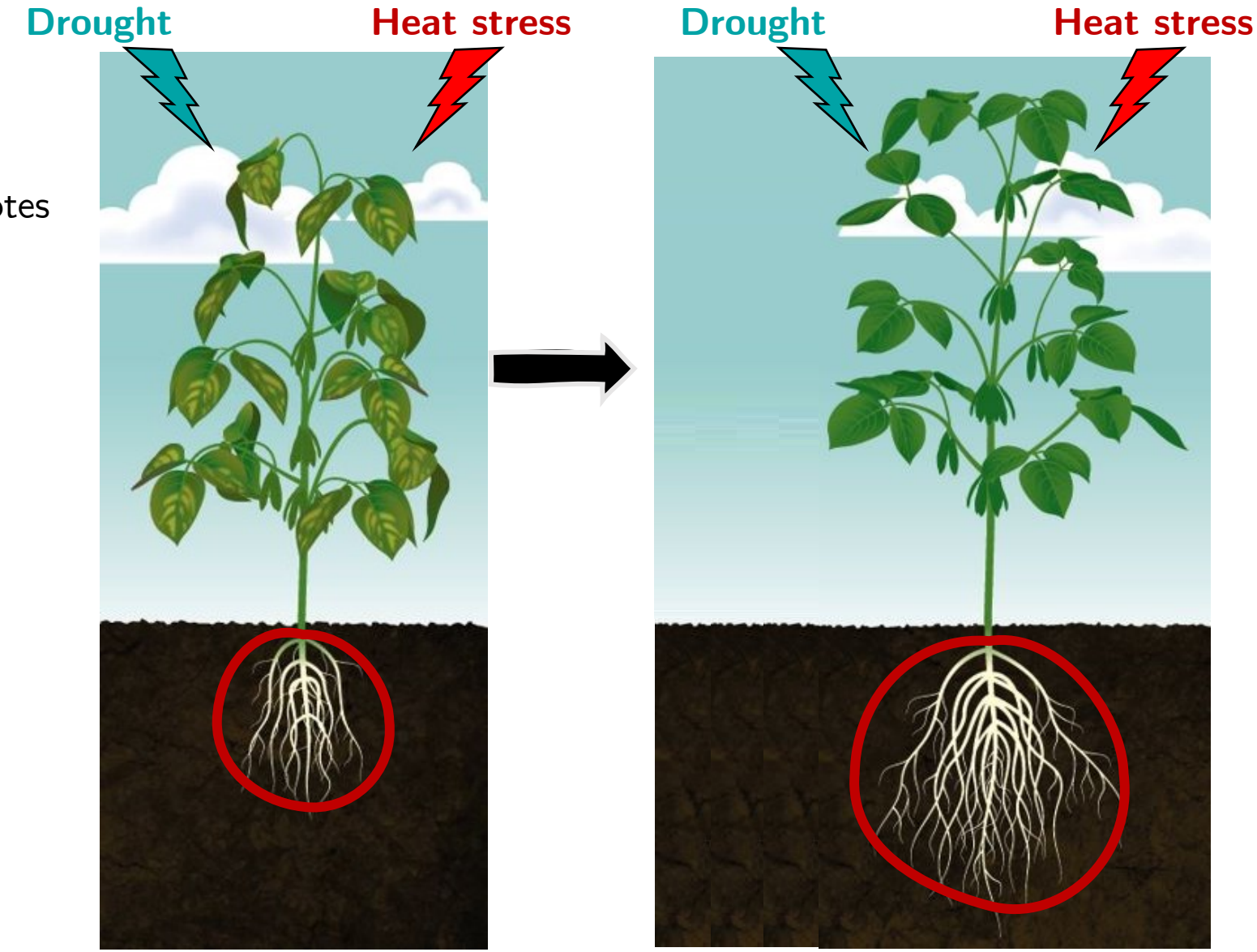
(IPCC, 2018)

According to several models, if we observe predicted scenarios in Europe, soybean yields are projected to decrease by approximately 50%.

How to reduce the detrimental impacts of climate change on yields?

Hypothesis :

There is a root architecture that promotes resistance to **water** and **heat stress**



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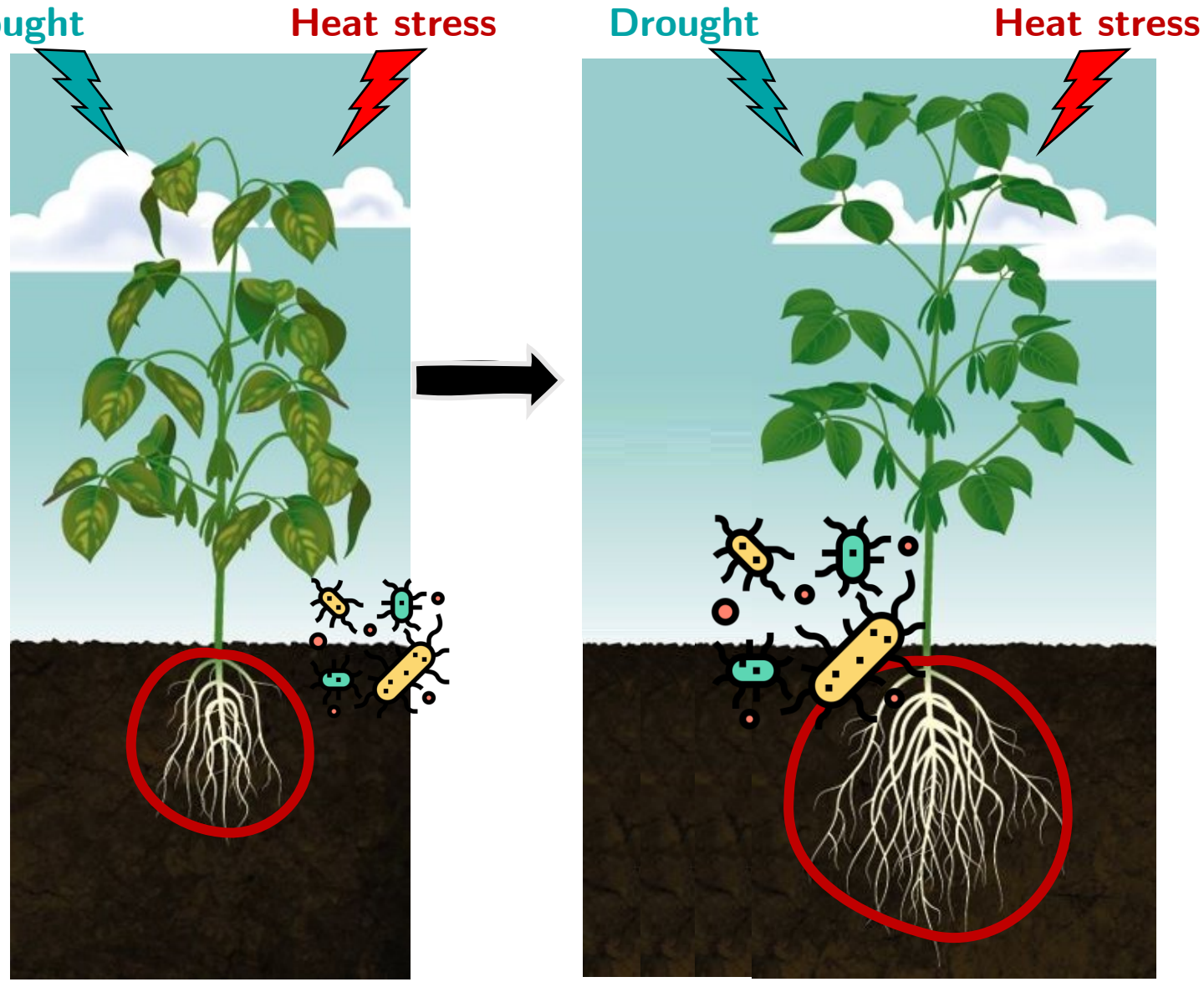
Architectural profile changes can influence the microbial community, particularly at the root level.



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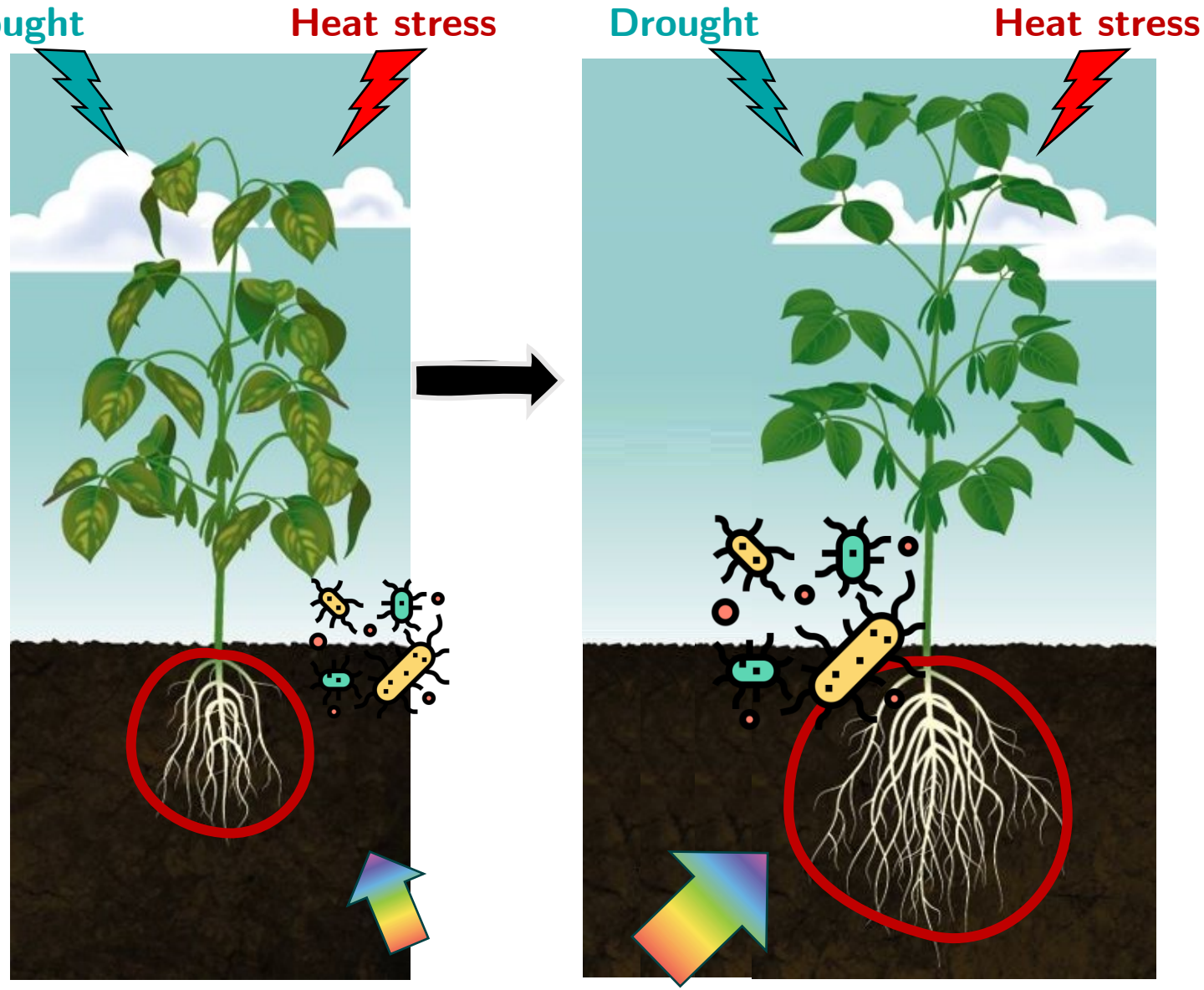
Changes in root architecture can modify mineral absorption



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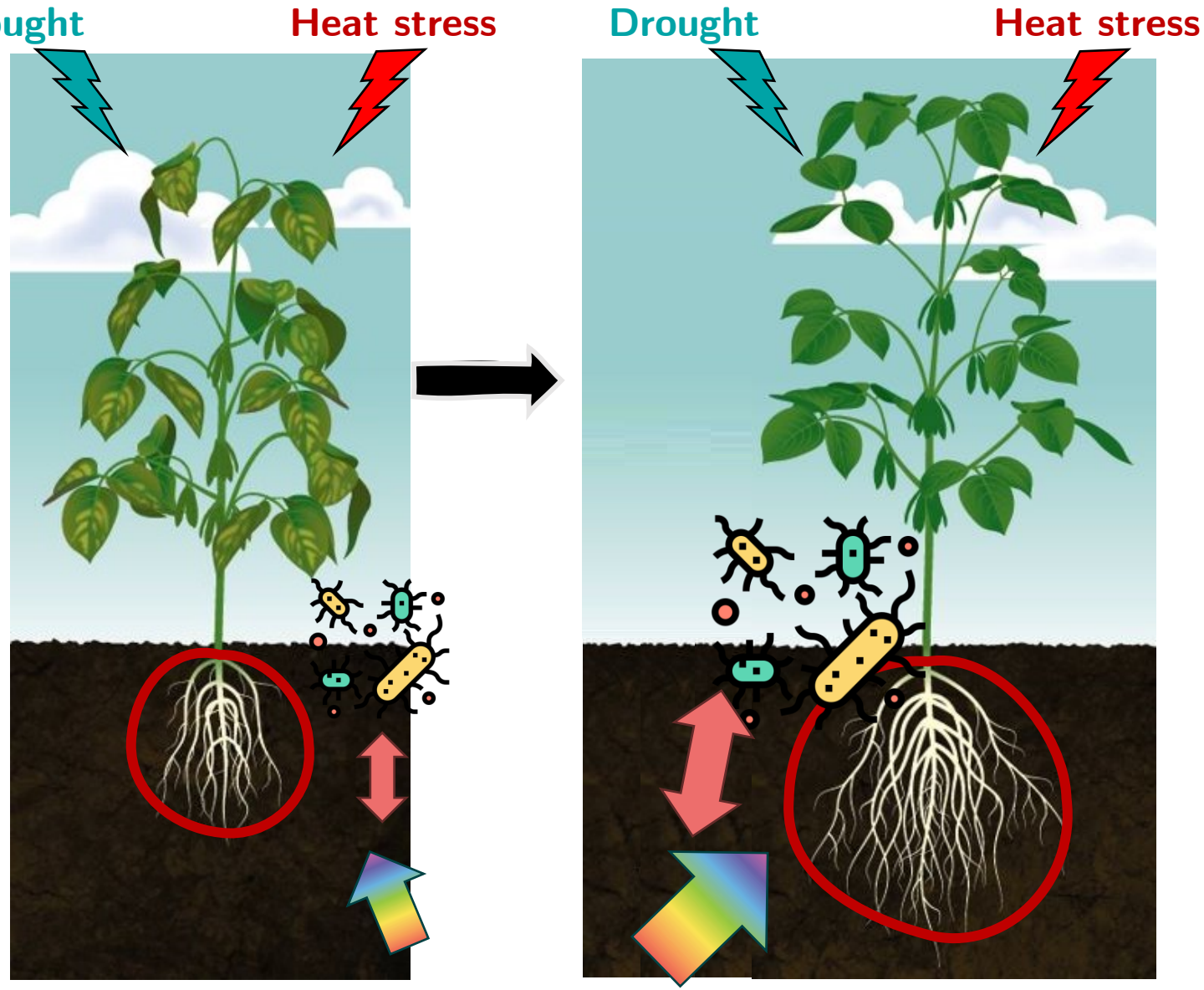
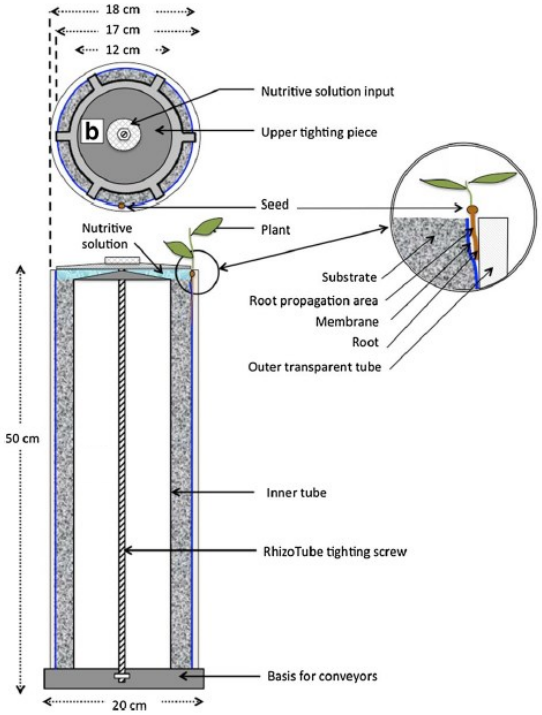
Changes in root architecture can modify mineral absorption

There is a strong link between mineral absorption and microbial communities, especially under stresses conditions.

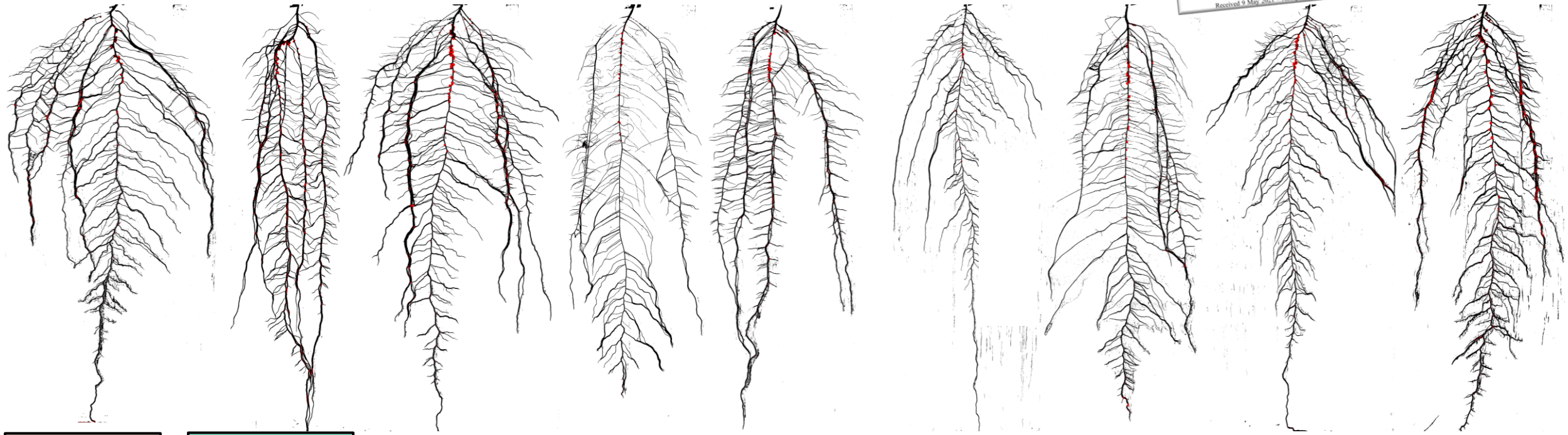


Architecture measurement with the 4pmi platform



Non-destructive phenotyping of roots over time, precise control of watering and greenhouse climate

Two genotypes with a different architecture among 9 european cultivars

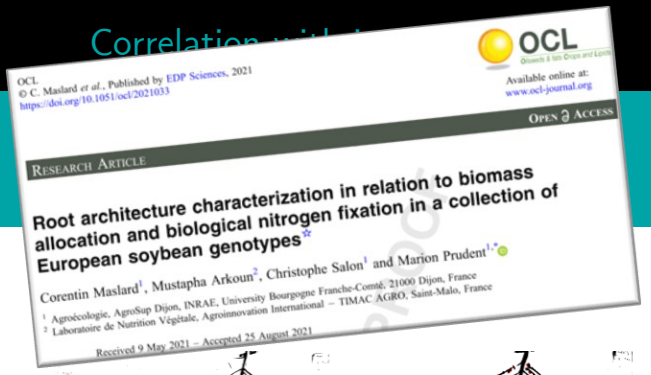


Stocata | Wendy

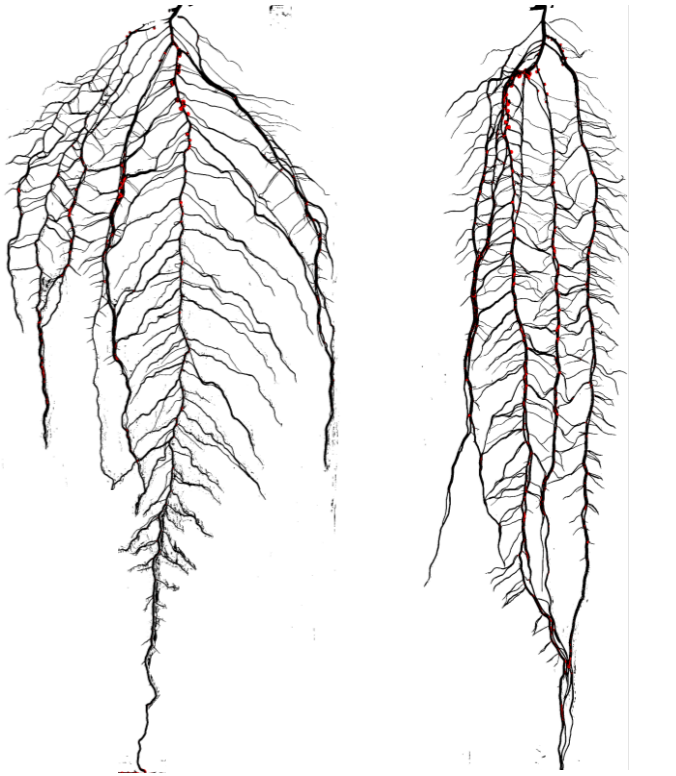
Two genotypes :
Use of two soybean genotypes with contrasted architecture

Difference between these two genotypes :

- Width of the root system
- Density of the root system
- Number of nodules



How does architecture vary under the influence of water and heat stress ? And which architecture would be the least sensitive to our stresses ?



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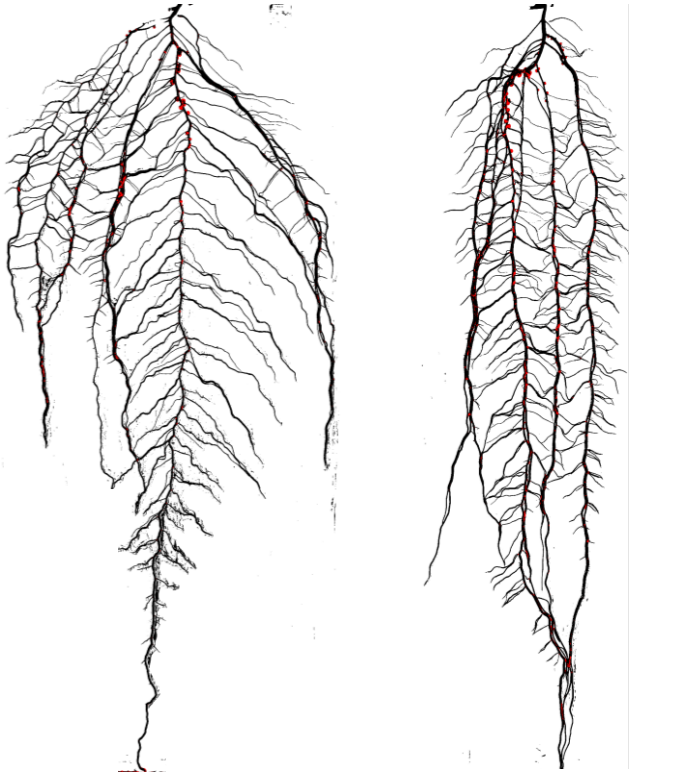

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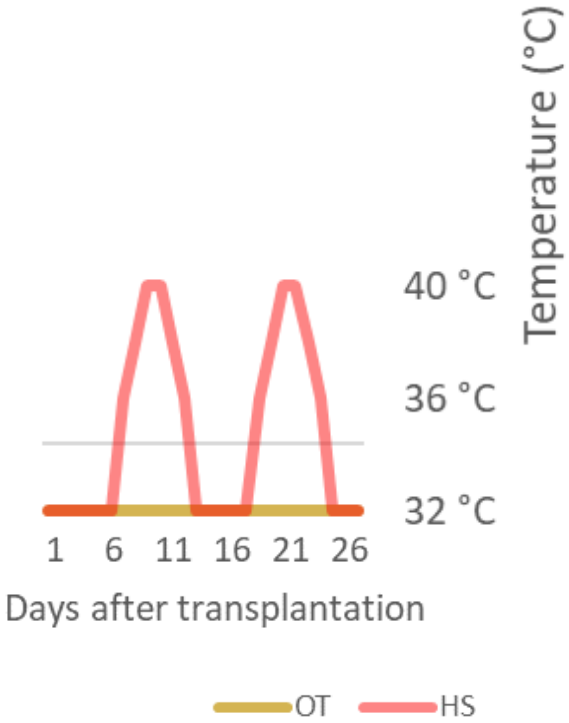

2 temperature condition :
- **Optimal temperature (OT)**
- **Heat Stress (HS)**

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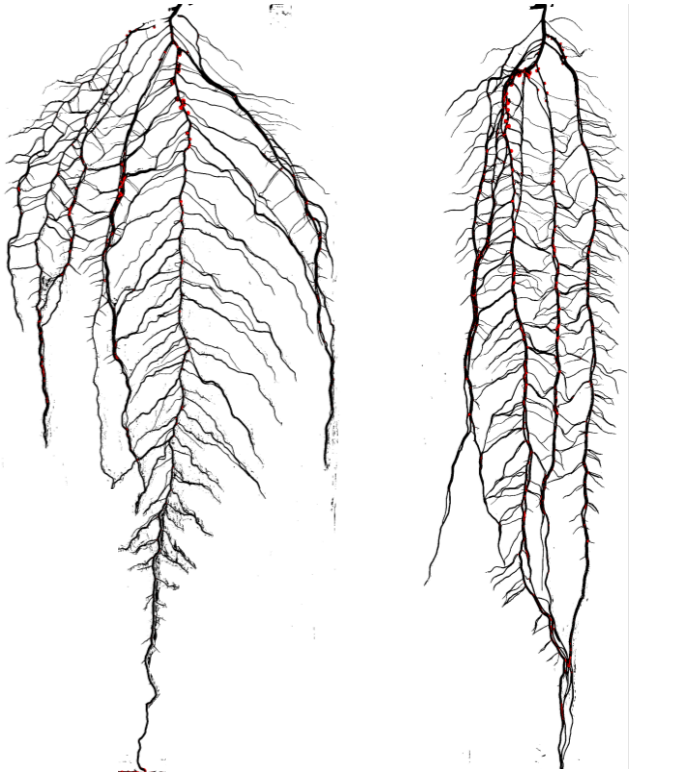

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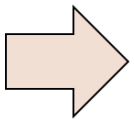

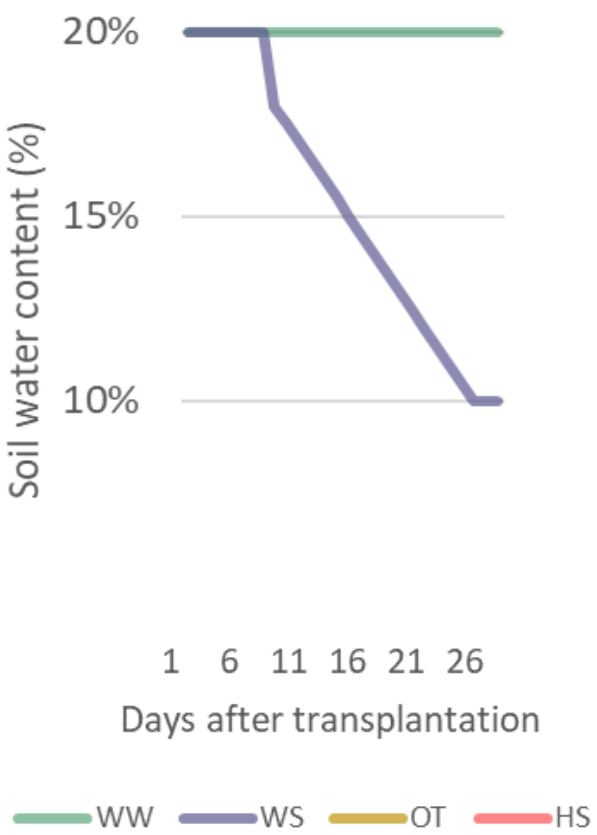

2 watering condition :
- **Well Watering (WW)**
- **Water stress (WS) a water deficit**

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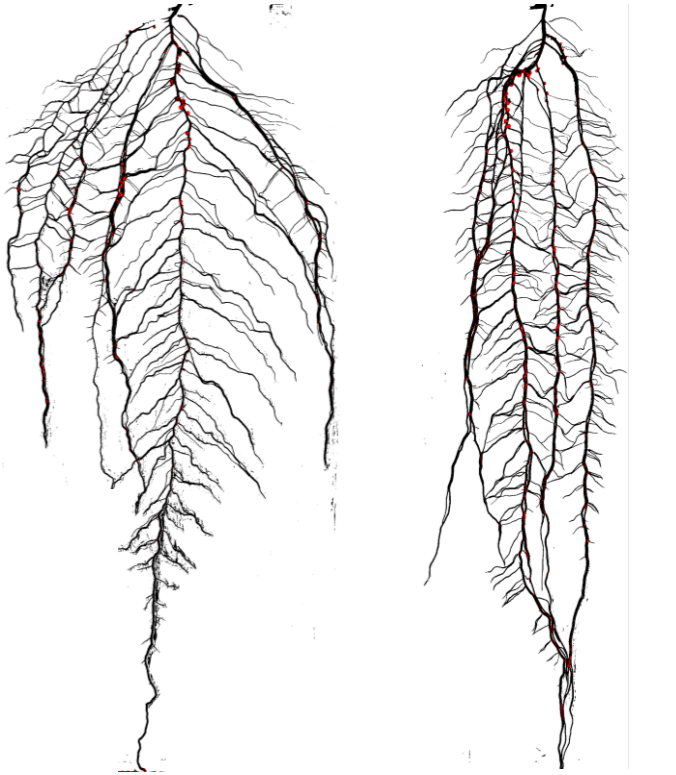

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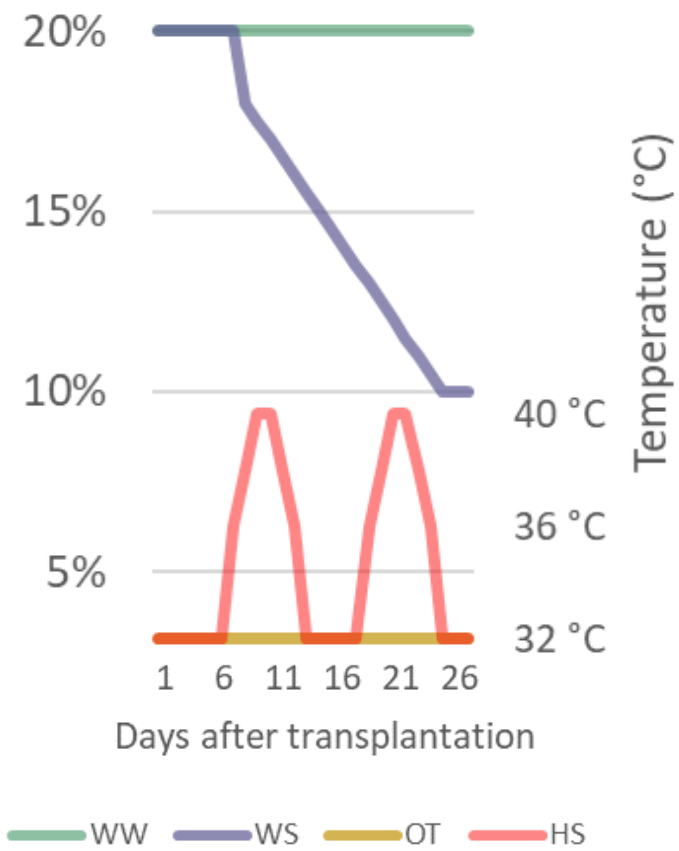

4 climatic conditions :
WW_OT / WS_OT / WW_HS / WS_HS

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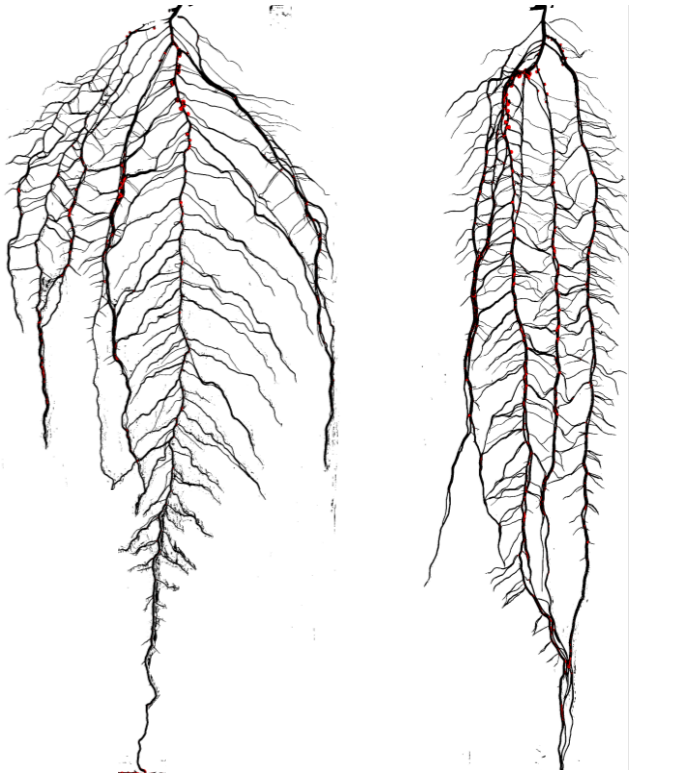

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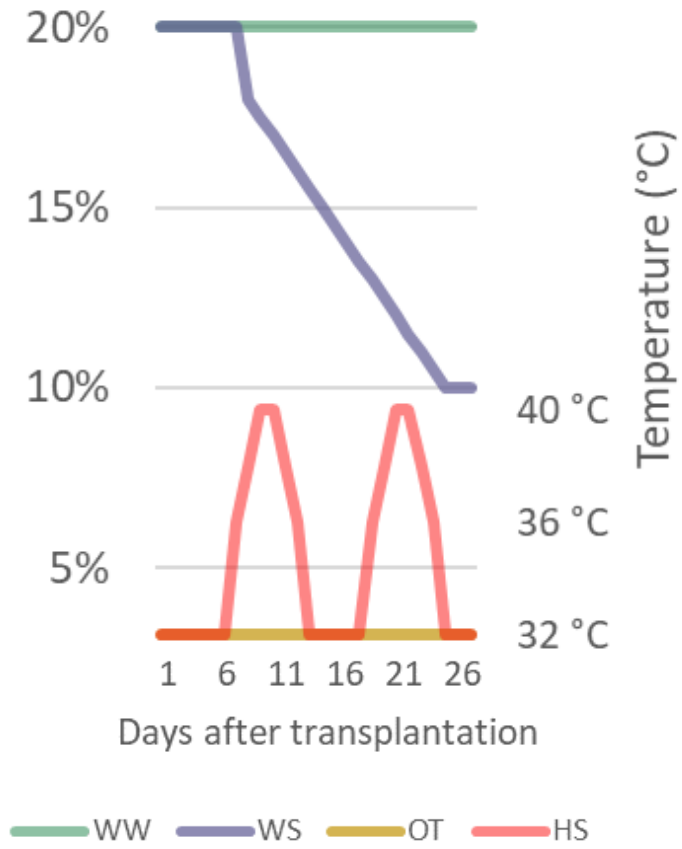

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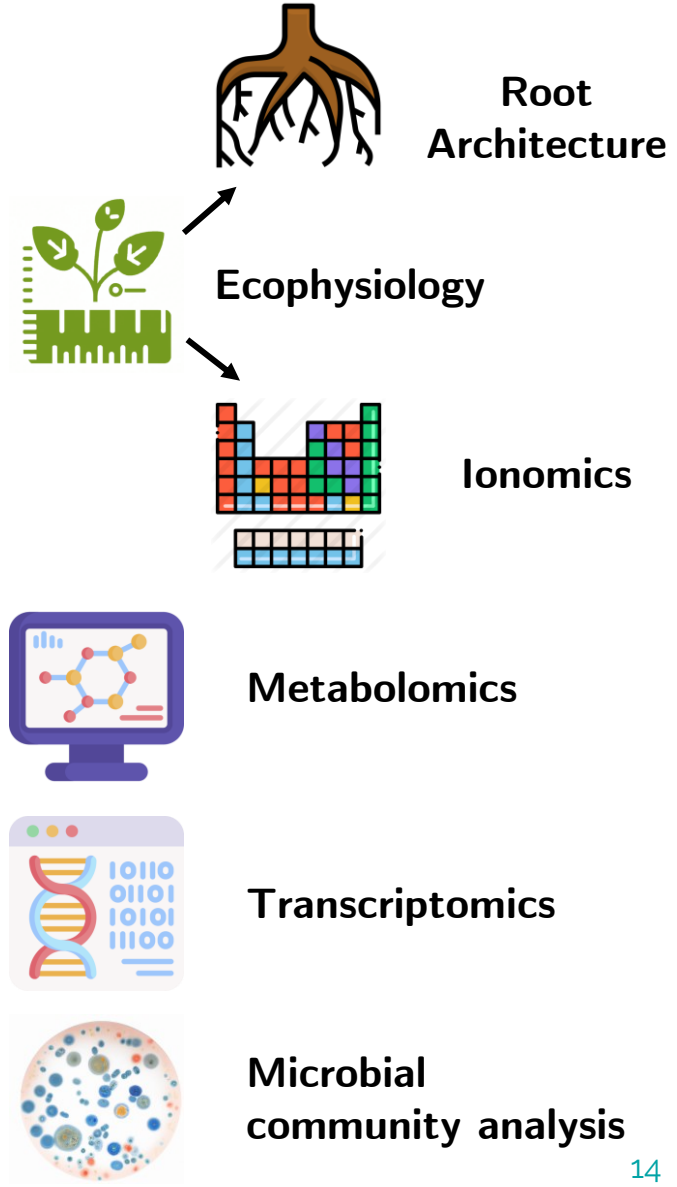

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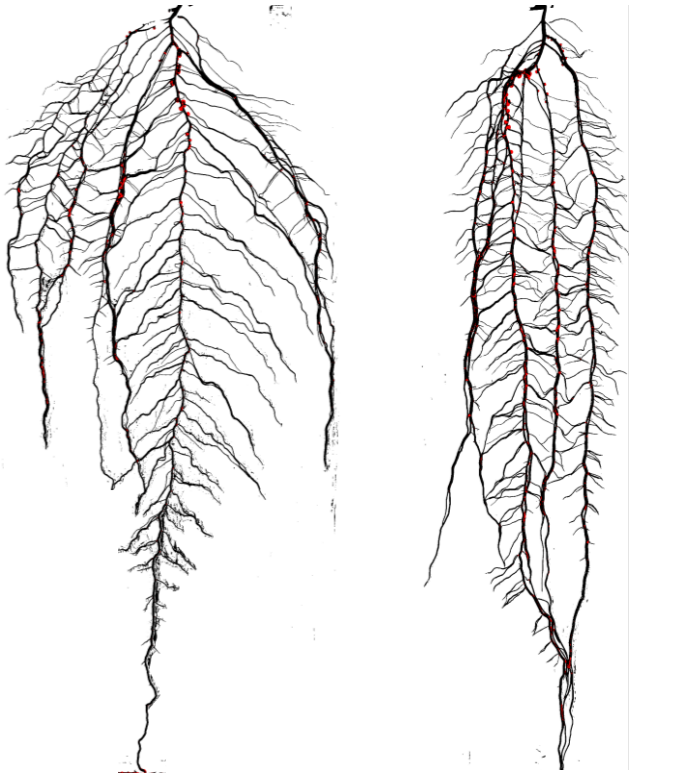

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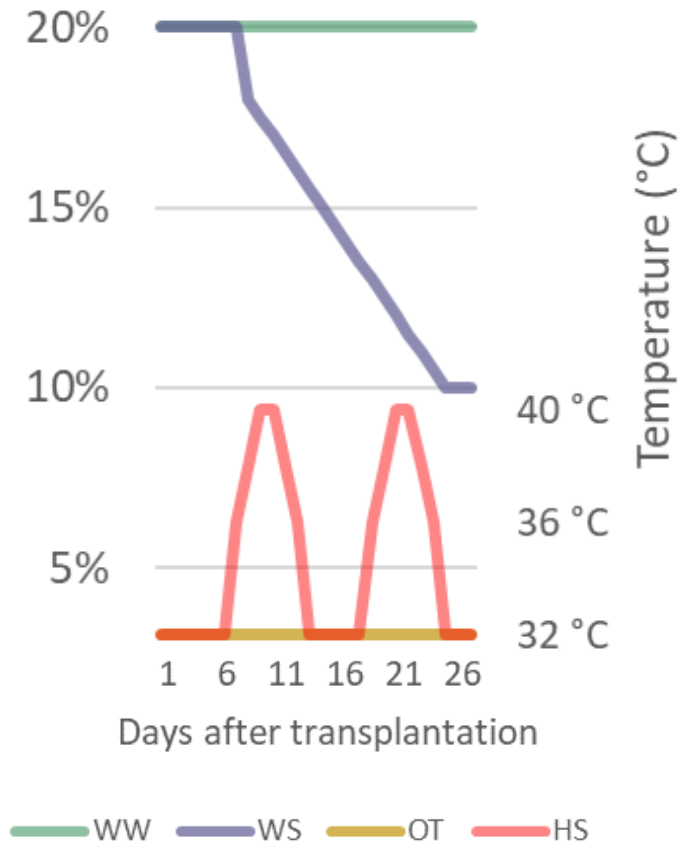

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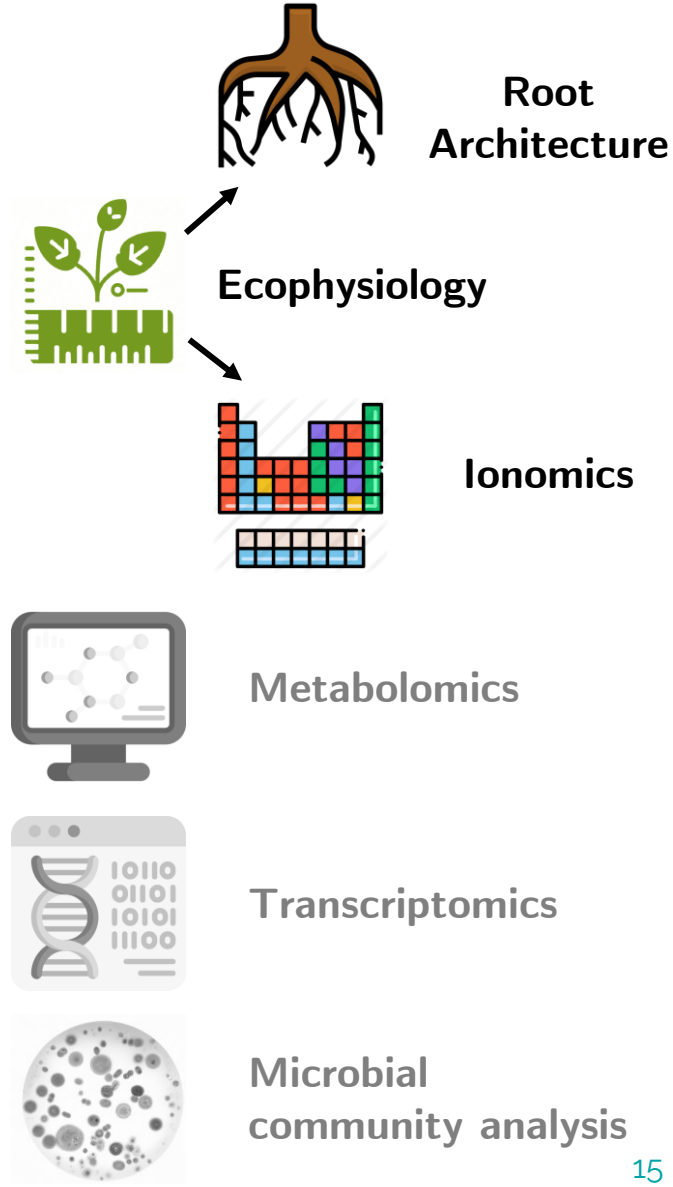
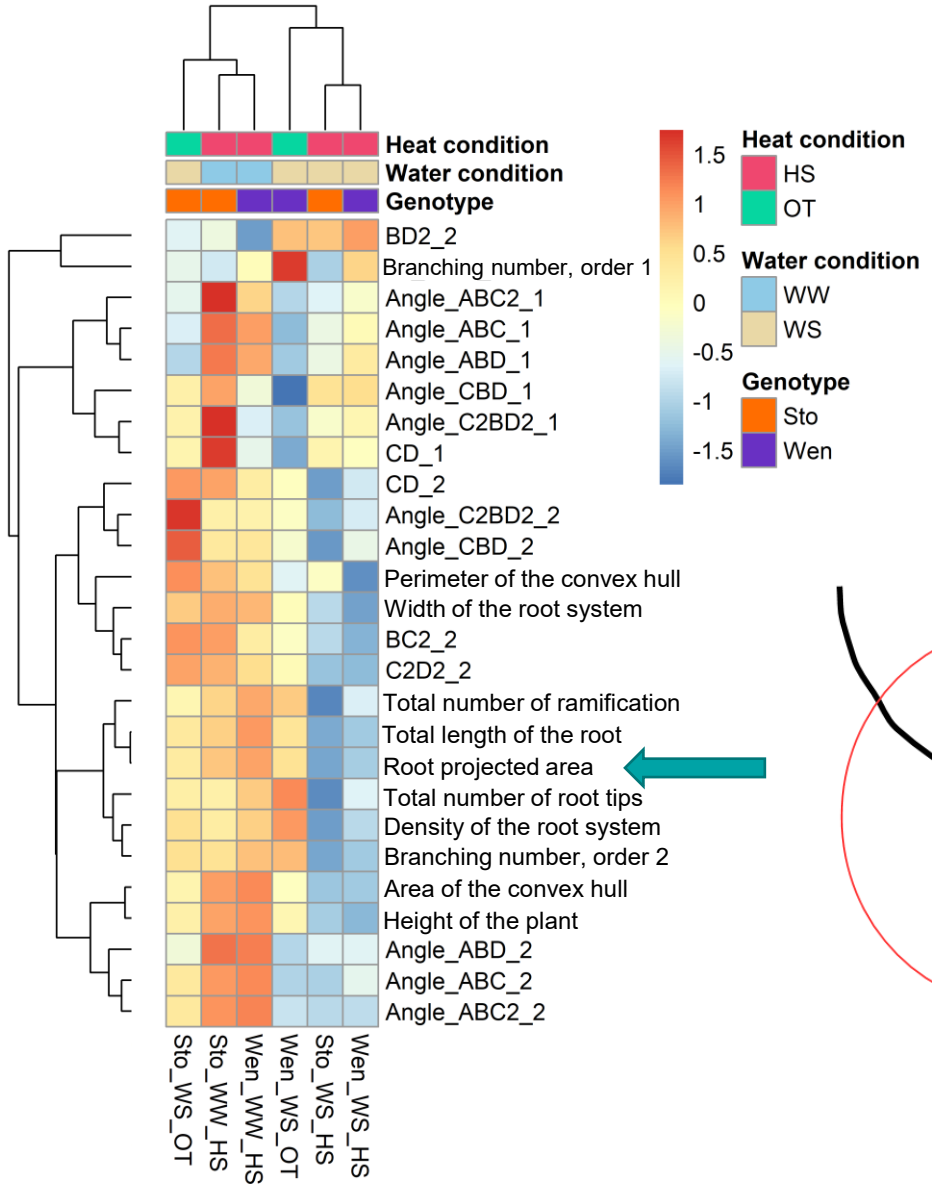
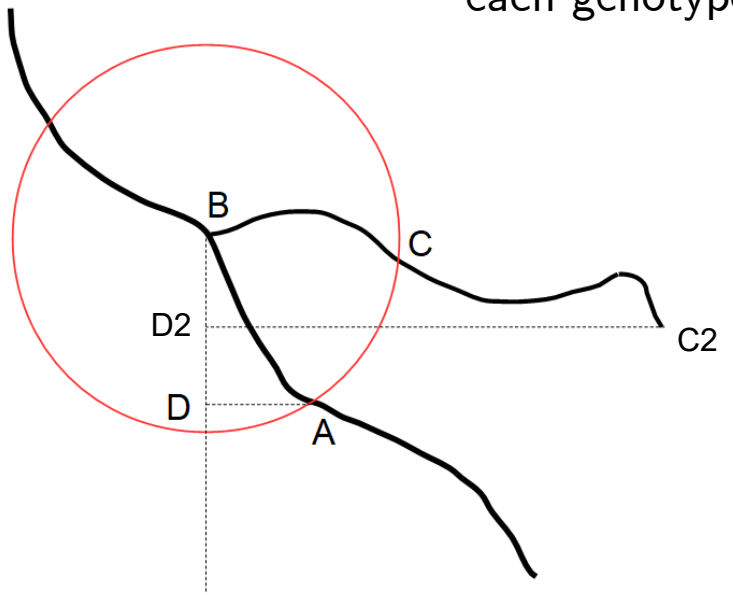


Log2 fold change of measured variables 19 days after start of experiment



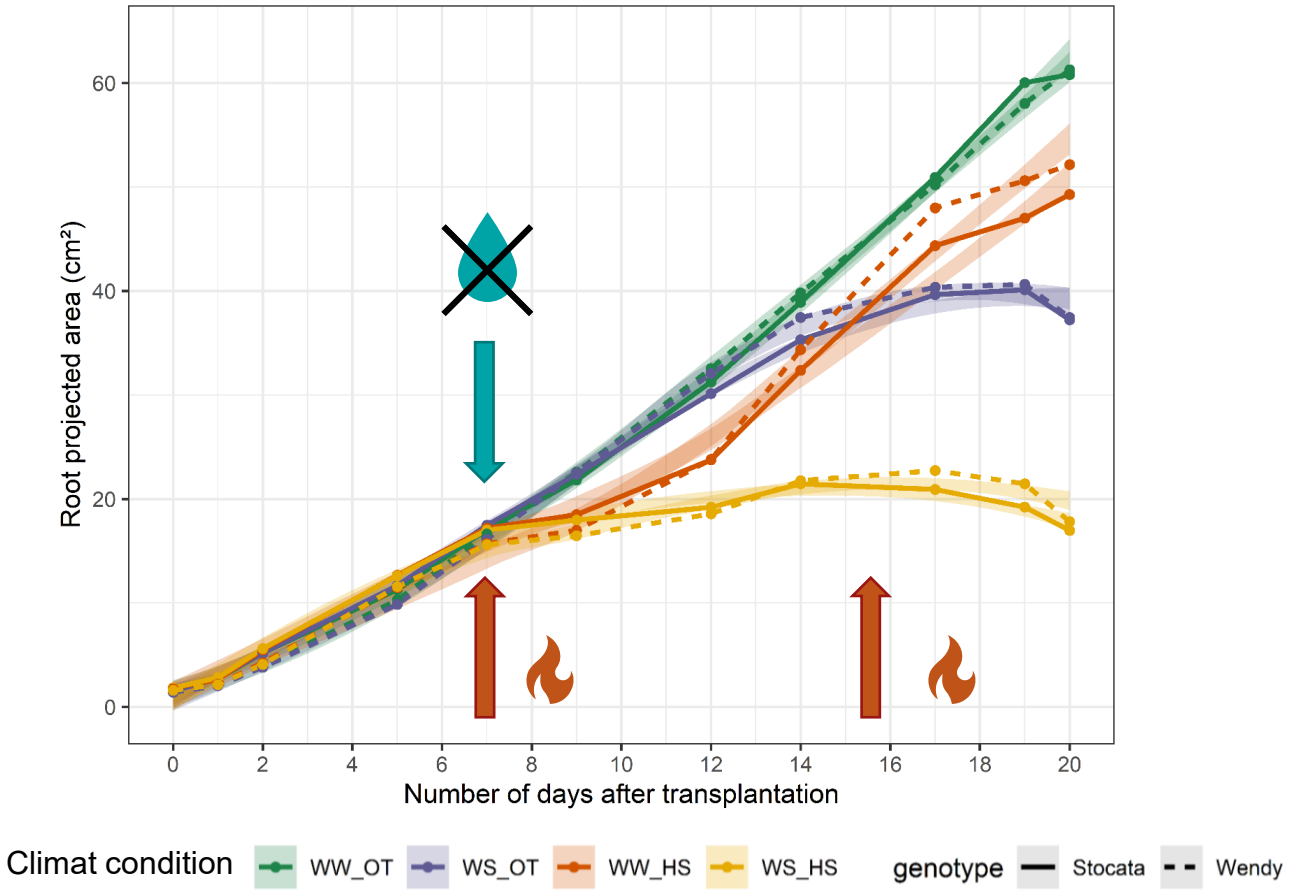
How does architecture vary under the influence of water and heat stress ?

- Numerous architectural variables were measured.
- The variables measured differed significantly for certain stresses compared with the respective control condition for each genotype.



The two genotypes seem to behave in the same way as a function of stress for measurements of root surface or root length, but the two genotypes differ when root angles are considered.

Example of the impact of water and/or heat stress on the root projected area



- Simple heat stress has a faster impact on the projected root area. Water stress is more progressive and causes more damage over the long term.
- Both stresses have a negative synergy on root architecture.
- There is little difference between the two genotypes in terms of root projected area.

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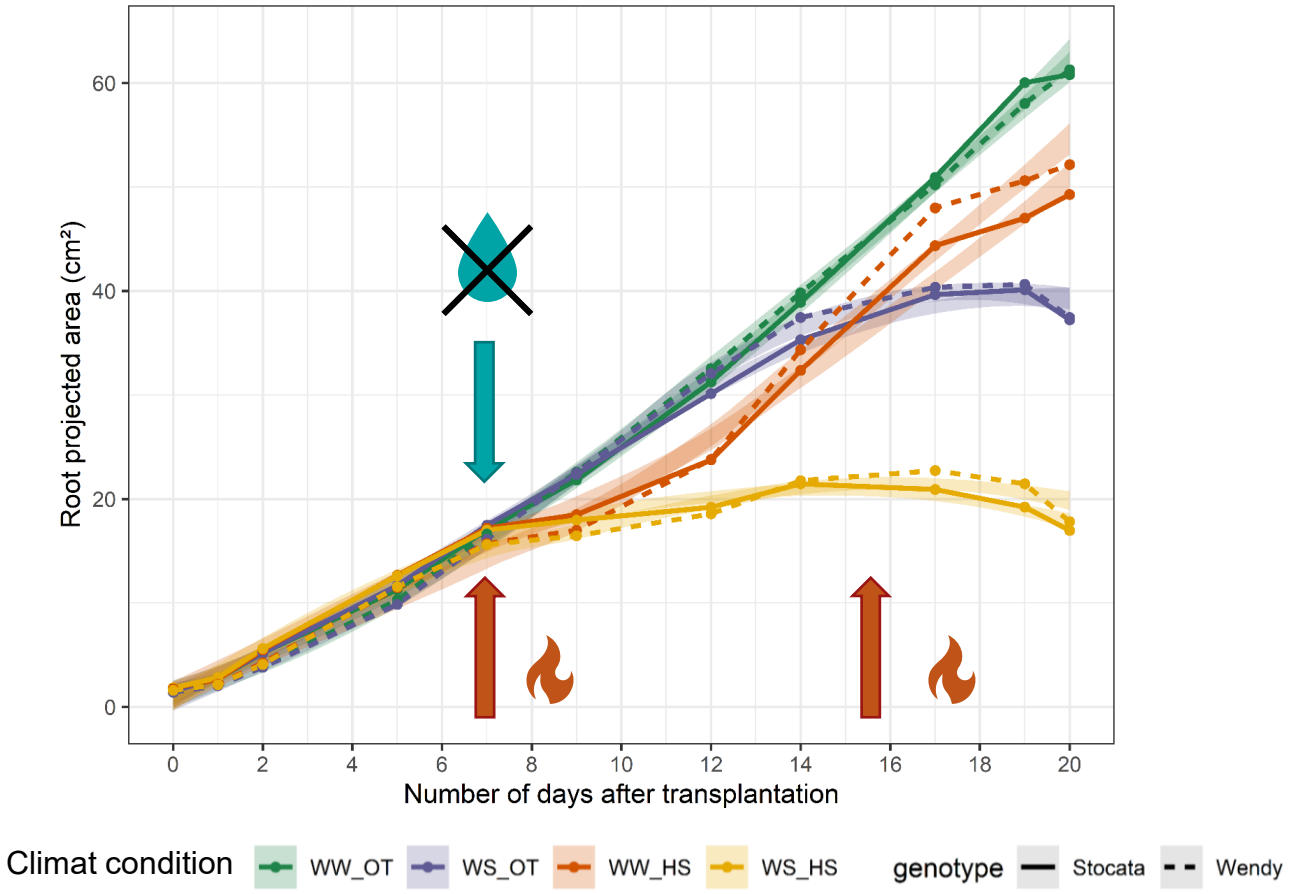

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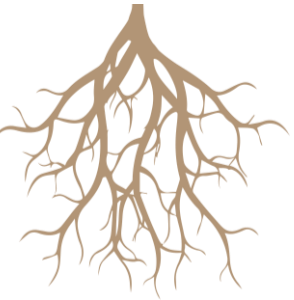
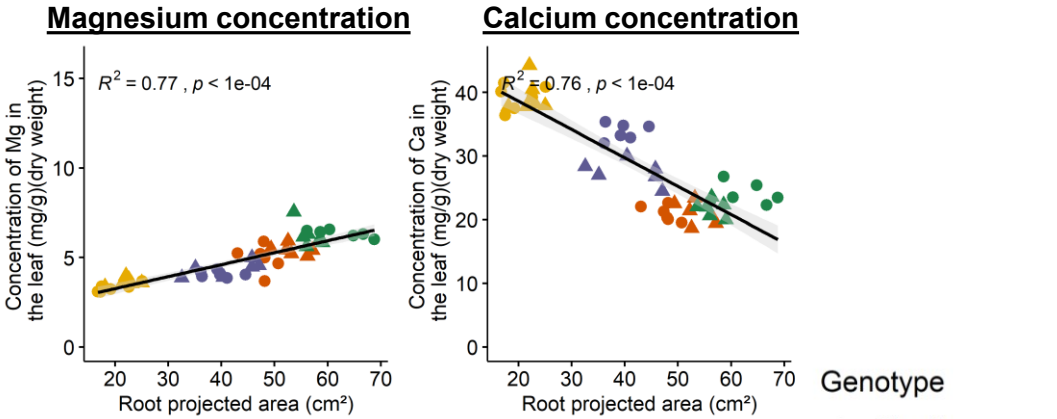
Can differences in architecture lead to differences in minerals absorption ?

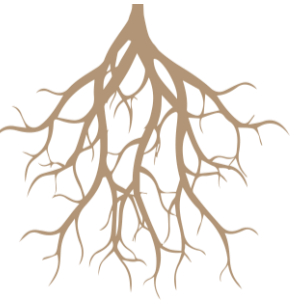
Contrasting Correlations of Magnesium and Calcium in Different Plant Organs

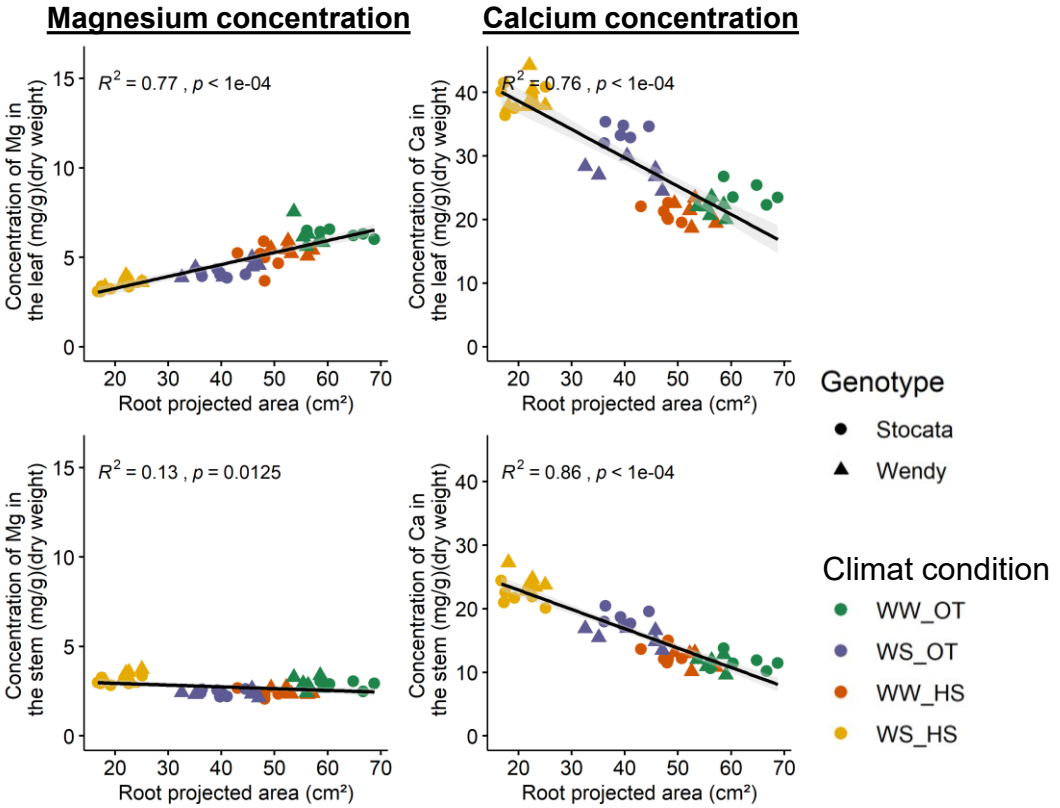




- As for the leaves, the greater the root surface area, the higher the concentration of magnesium and the lower the concentration of calcium in the leaves.

Contrasting Correlations of Magnesium and Calcium in Different Plant Organs





- As for the leaves, the greater the root surface area, the higher the concentration of magnesium and the lower the concentration of calcium in the leaves.
- For stems, the opposite is true. There is no correlation for magnesium, whereas there is a strong correlation for calcium.

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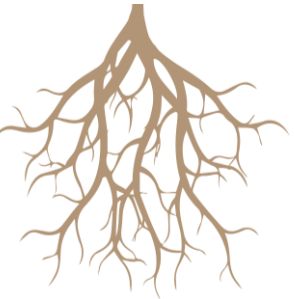

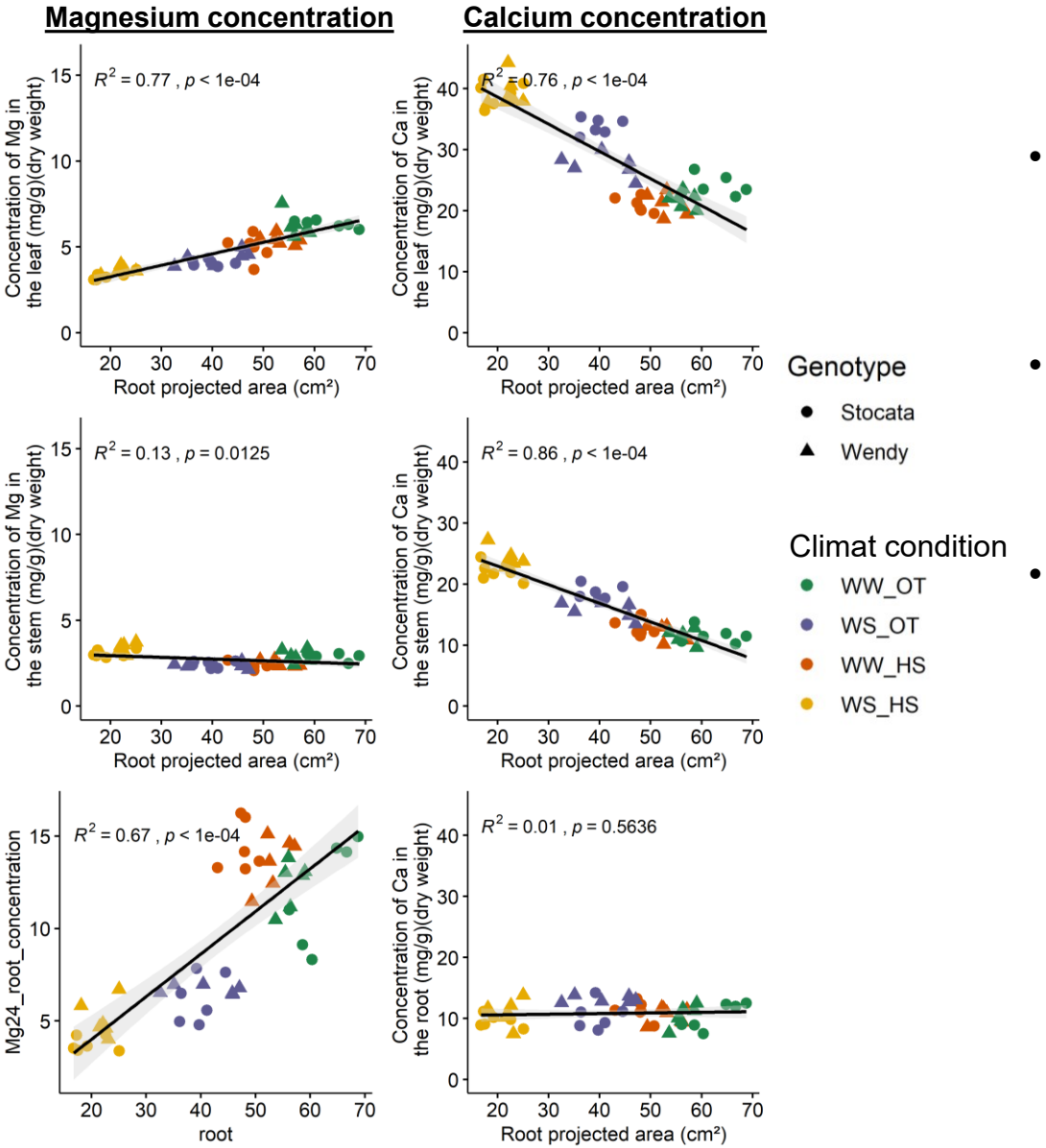

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- For stems, the opposite is true. There is no correlation for magnesium, whereas there is a strong correlation for calcium.
- There is a strong correlation between projected root surface and magnesium concentration in the roots, whereas there is no correlation for calcium.

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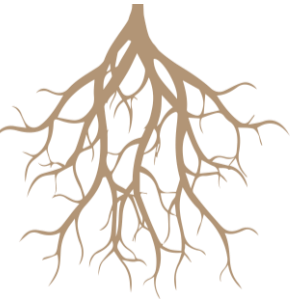

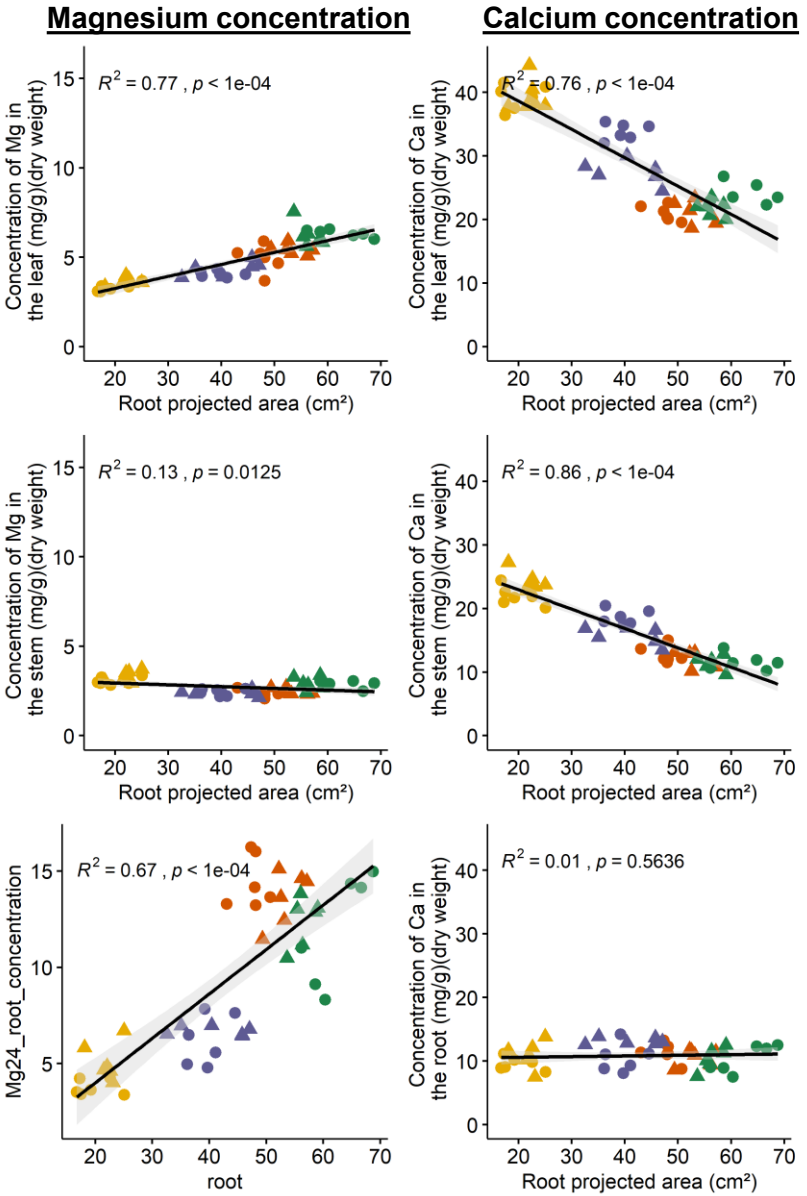

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Correlation is not cosine. Perhaps certain transporters are more effective in certain conditions. It will be interesting to compare these results with the root transcriptome or the metabolome. Case in progress 😉

Thank you for your attention, Merci pour votre attention

And a huge thank you, to all those who participated in the results presented today !!!