Ecophysiological processes underlying soybean mineral nutrition under individual or combined heat and water stresses

Corentin Maslard, Mustapha Arkoun, Christophe Salon, Jingjing Peng, Marion Prudent

What are the ecophysiological processes underlying mineral nutrition of soybean under individual or combined heat and water stresses ?

Corentin Maslard

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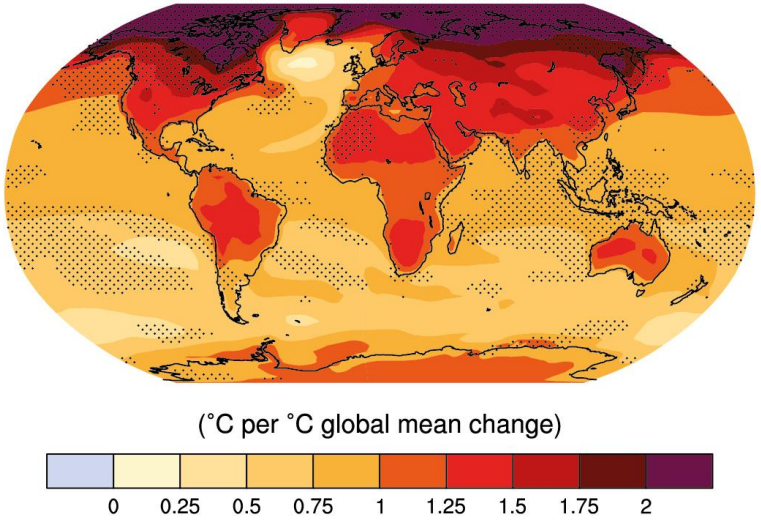
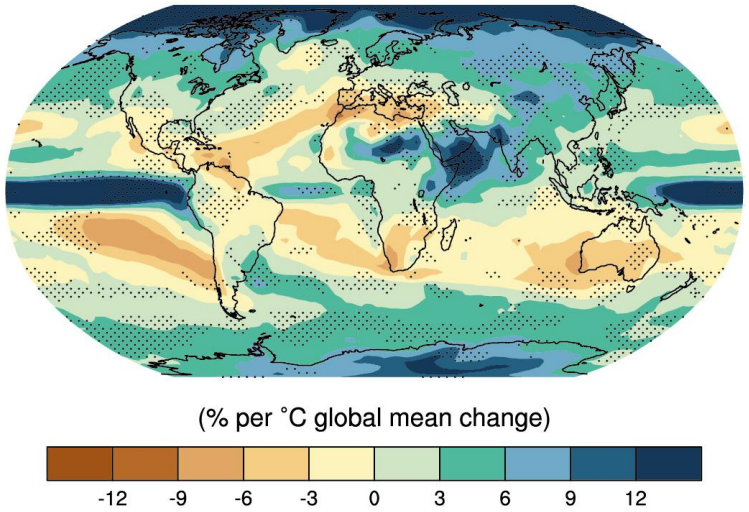
November 29, 2022

Predicted loss of yield due to global warming

A prediction of a 50% decrease in soybean yields by 2100



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



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

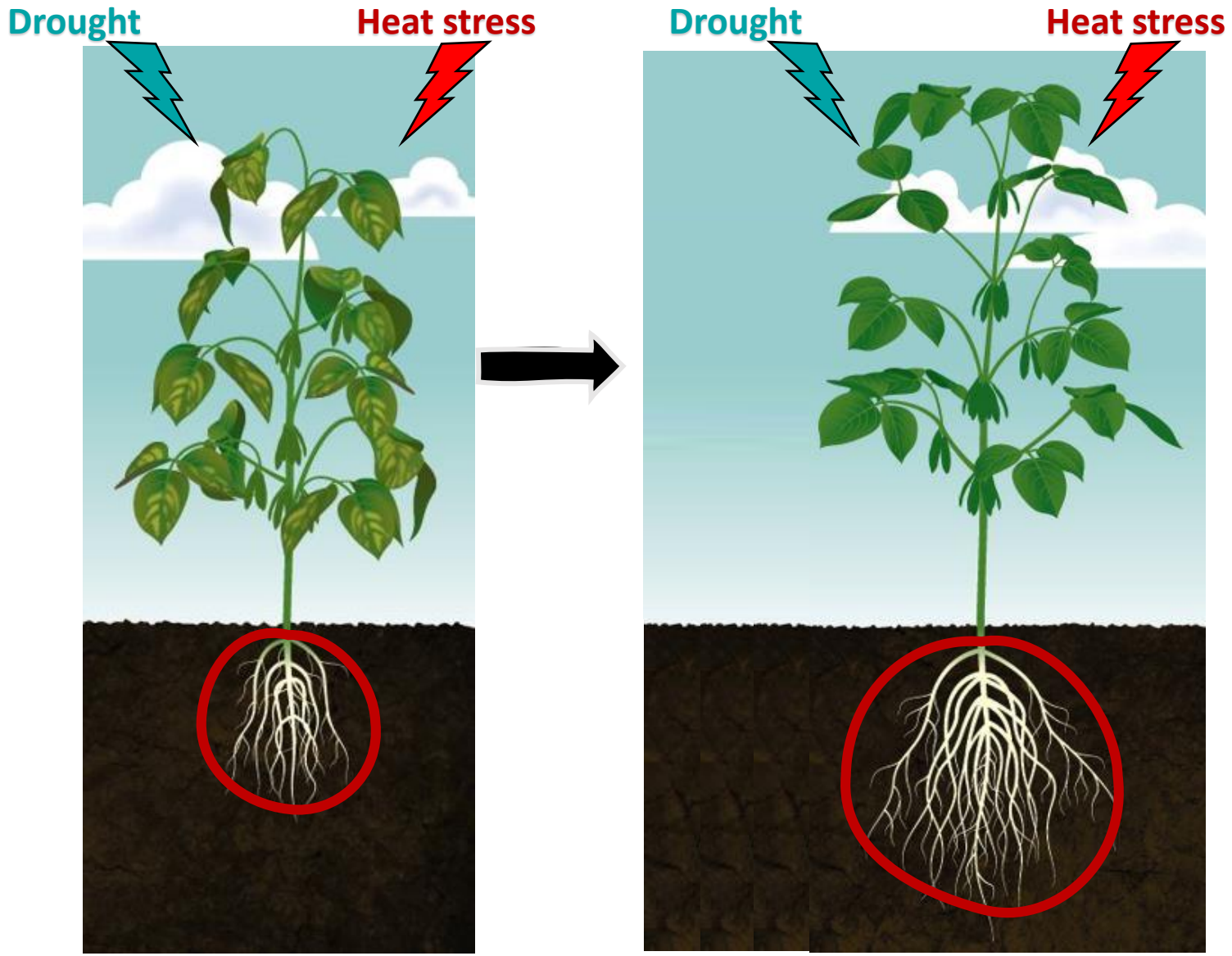
(IPCC, 2018)

According to several models, if we observe in Europe, in 2100, an **increase in temperatures of more than 2°C on average** and an **average of 35 consecutive days without rain**, **soybean yields will decrease by about 50%.**

(Schlenker and Roberts, 2009)

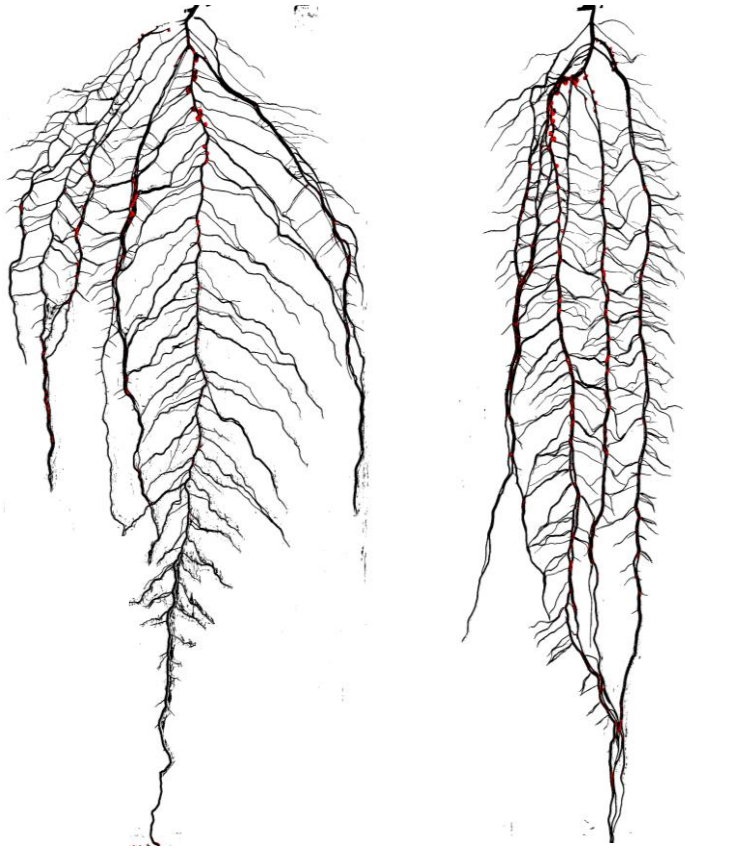
Hypothesis:

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



But how does the soybean react to these two stresses from an ecophysiological point of view ?

Noticeable differences in the root architecture

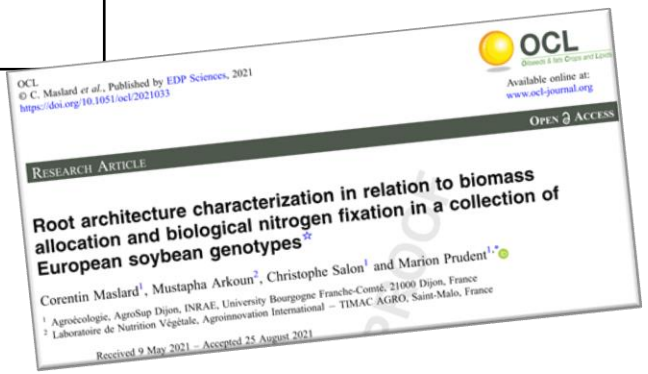


Stocata

Wendy

Two genotypes :
Use of two soybean genotypes with contrasted architecture

1st experiment to choose the two genotypes
Difference between these two genotypes
• Width of the root system • density of the root system • number of nodules



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RESEARCH ARTICLE

Root architecture characterization in relation to biomass allocation and biological nitrogen fixation in a collection of European soybean genotypes☆

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(Maslard et al.*, 2021)*

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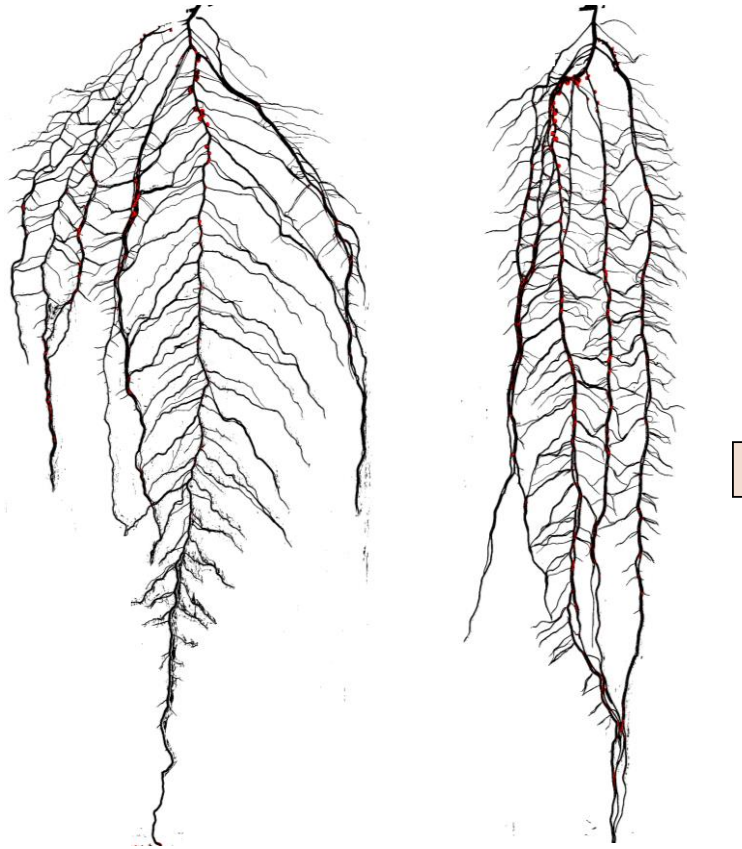
Experimental design



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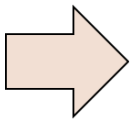

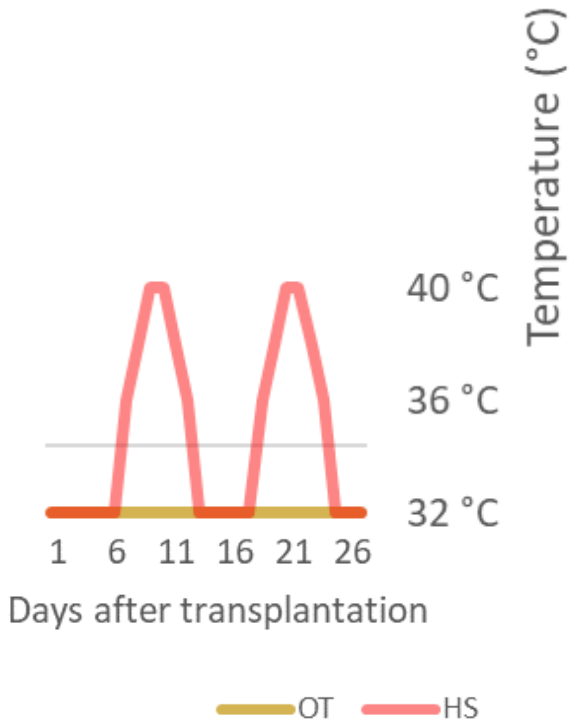

Two genotypes :
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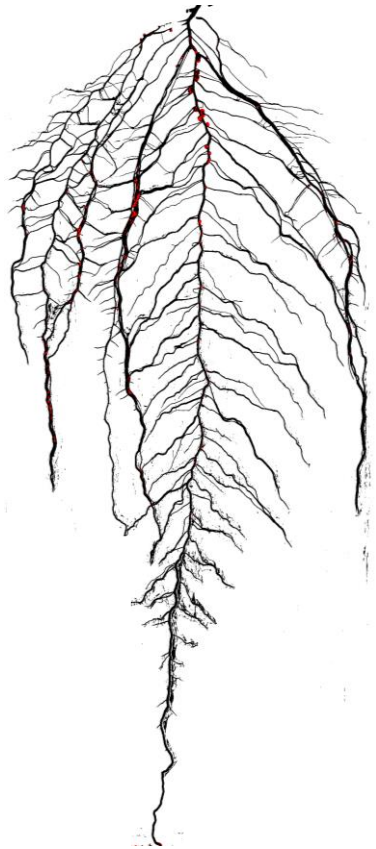
2 temperature condition :

- **Optimal temperature (OT)**
- **Heat Stress (HS)**

But how does the soybean react to these two stresses from an ecophysiological point of view ?

Experimental design



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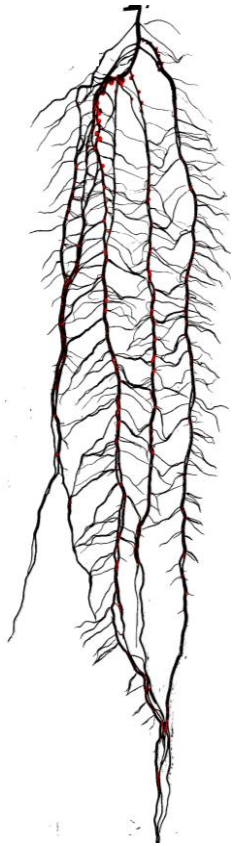

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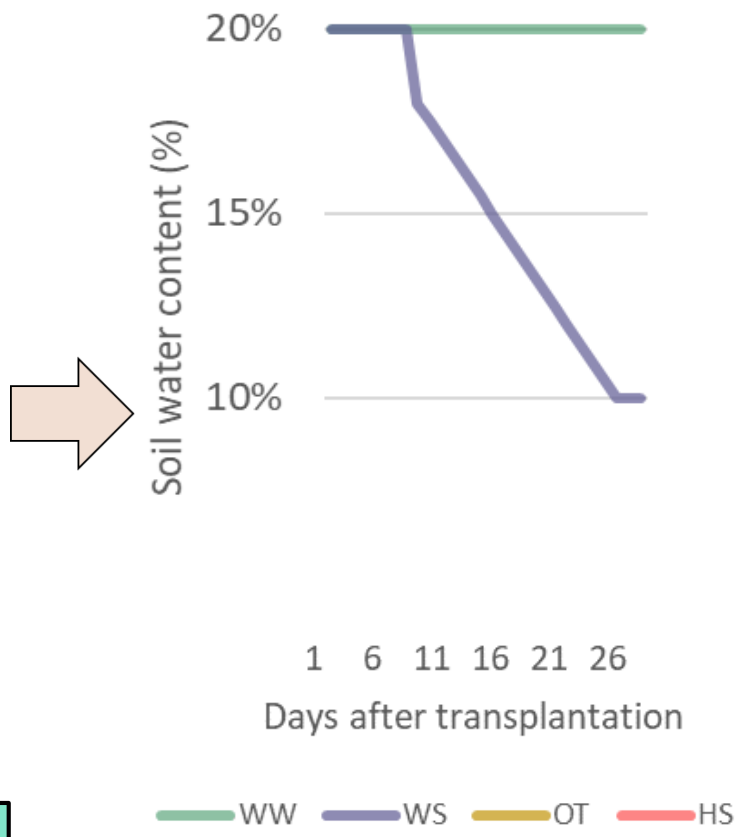

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2 watering condition :

- **Well Watering (WW)**
- **Water stress (WS)**

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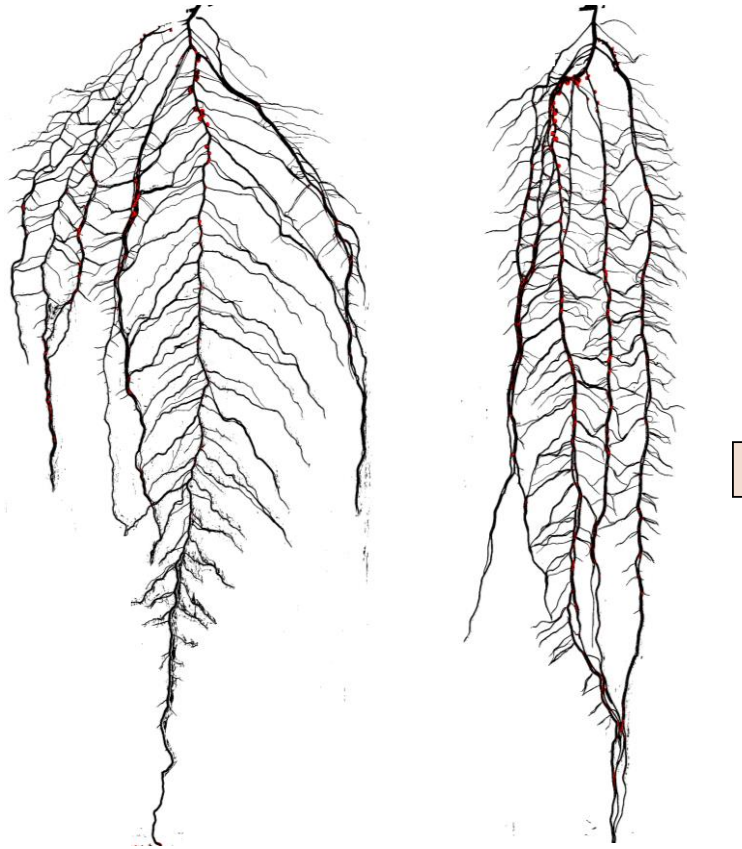
Experimental design



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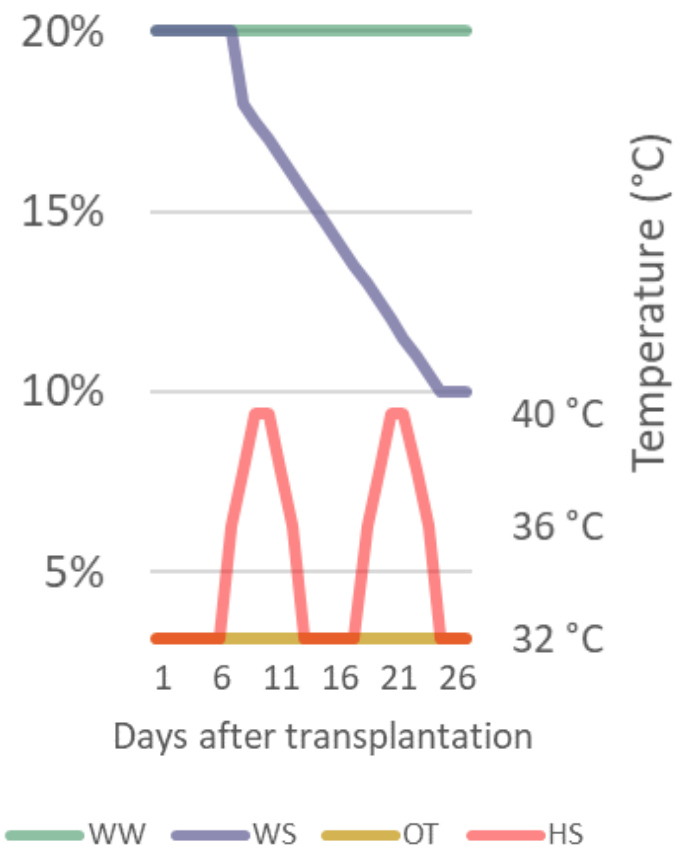

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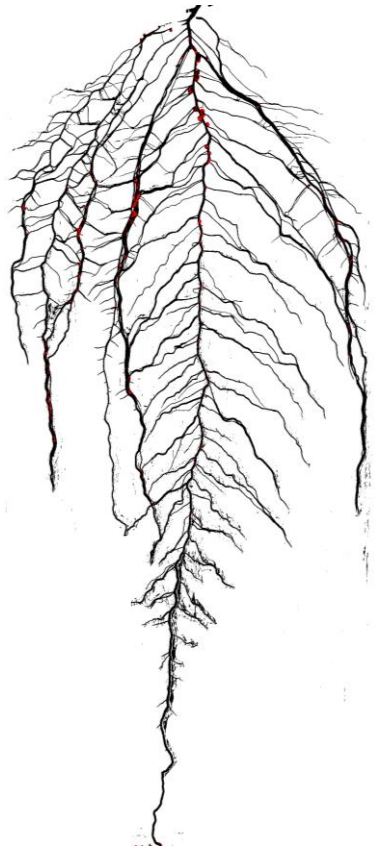

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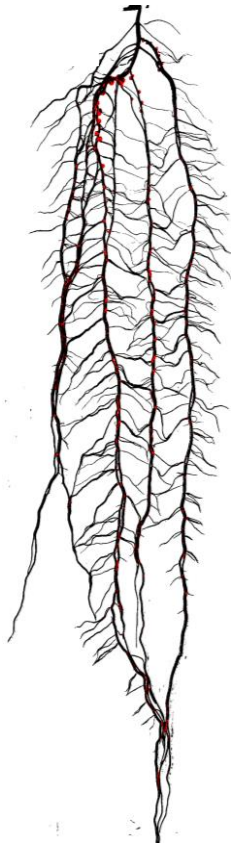

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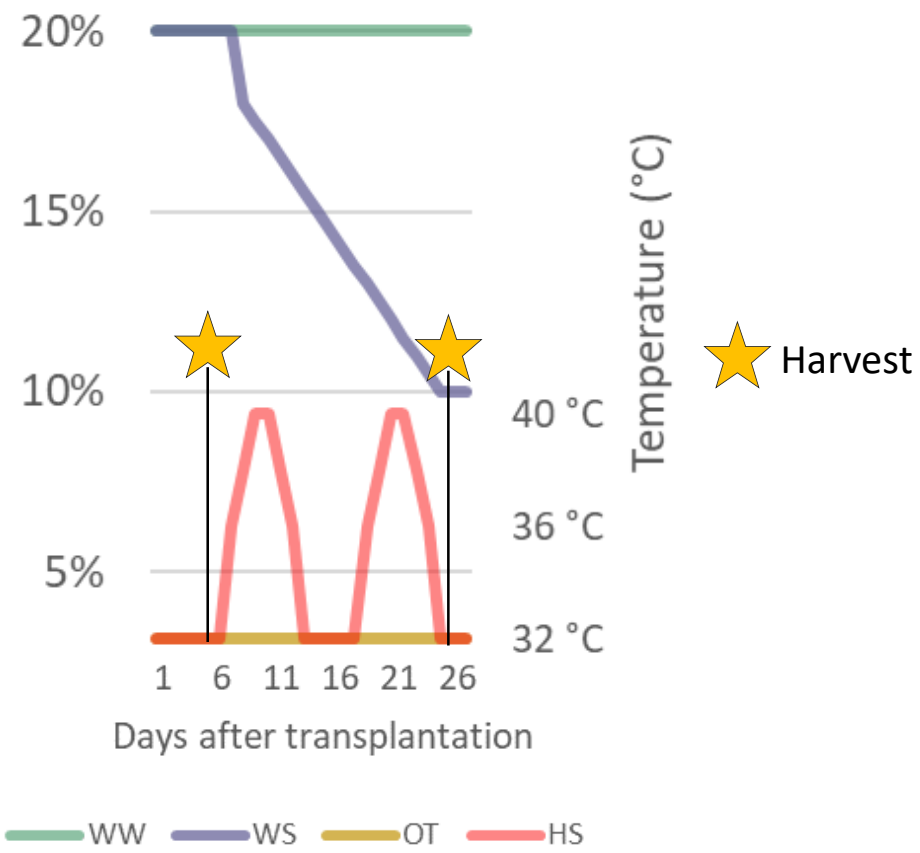

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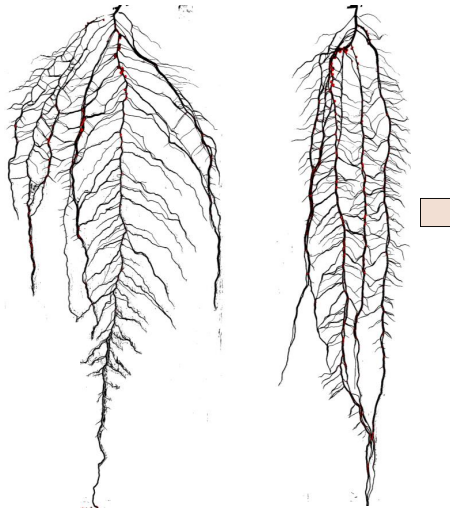
Experimental design 4 type of harvest



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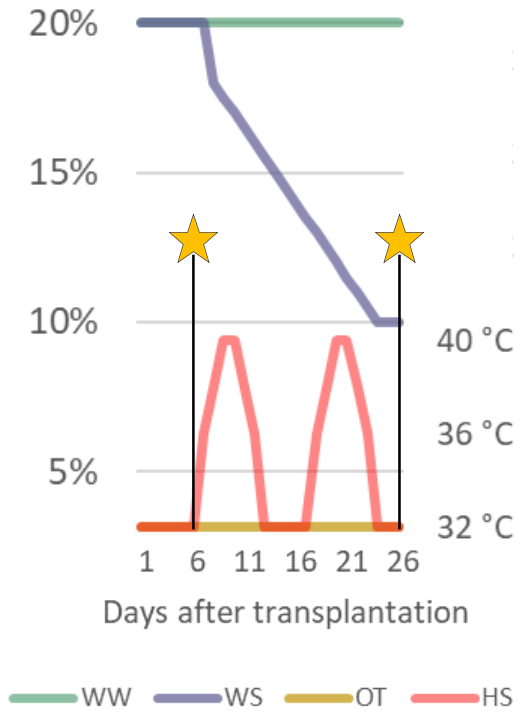

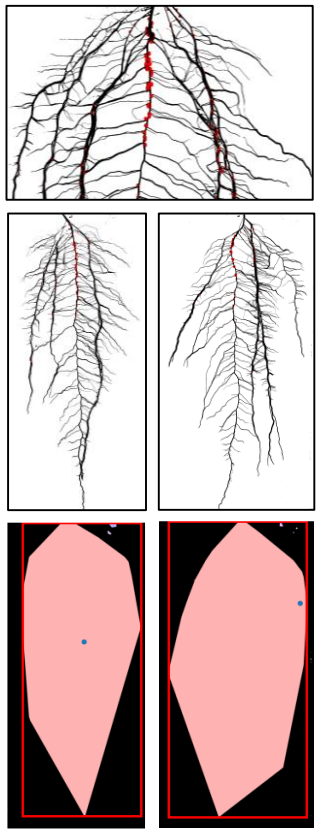

python

MACHINE LEARNING

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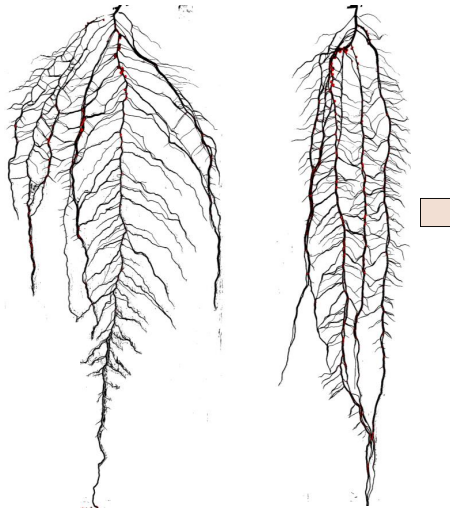

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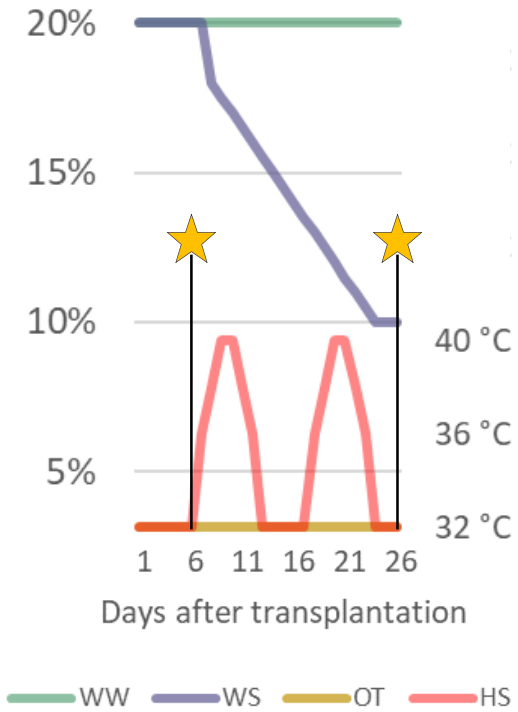

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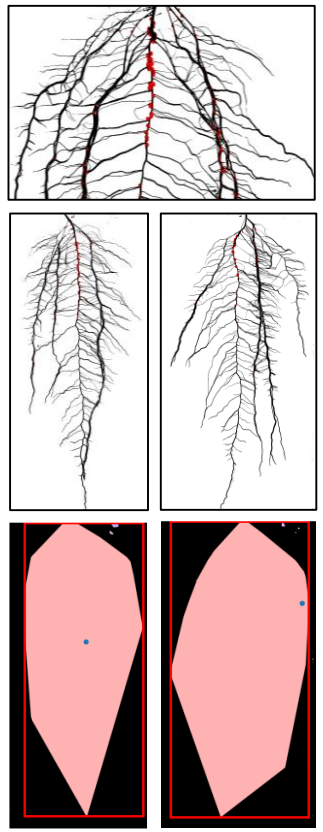
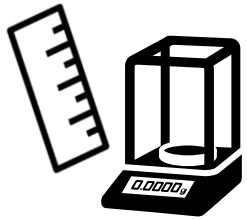
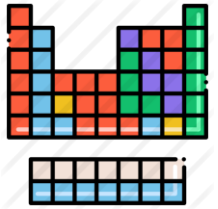


1 **Plant for ecophysiological and Ionomic analysis**





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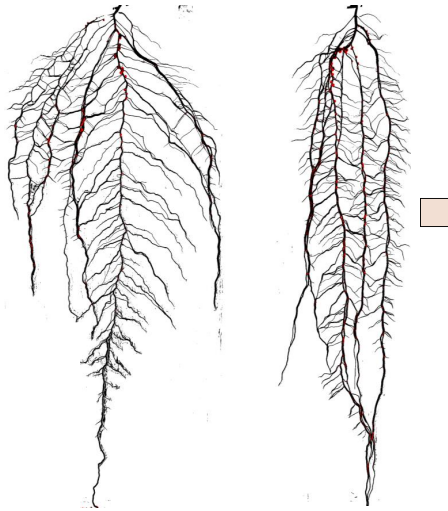

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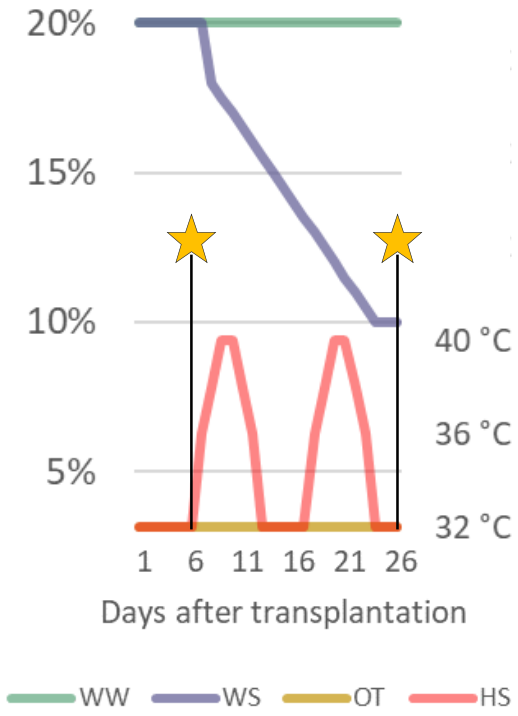

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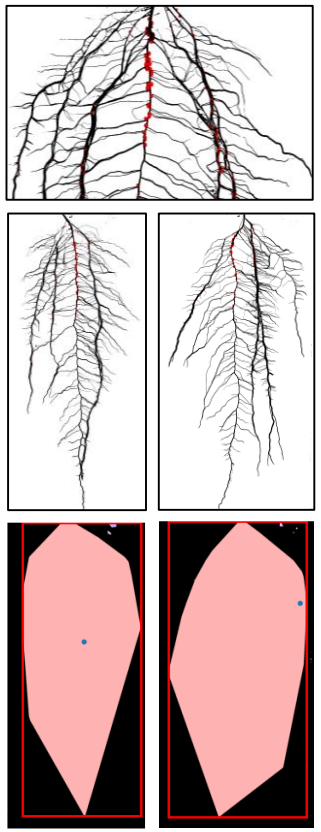

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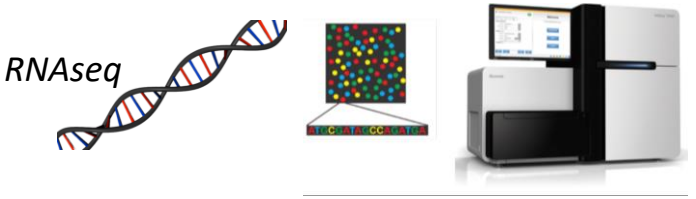
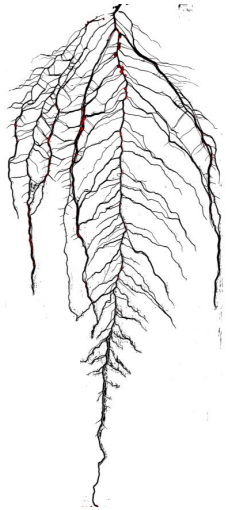
RNAseq



Metabolomics on root, leaf, stem and soil

But how does the soybean react to these two stresses from an ecophysiological point of view ?

Experimental design 4 type of harvest



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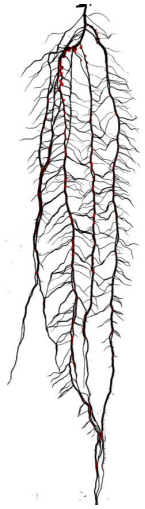

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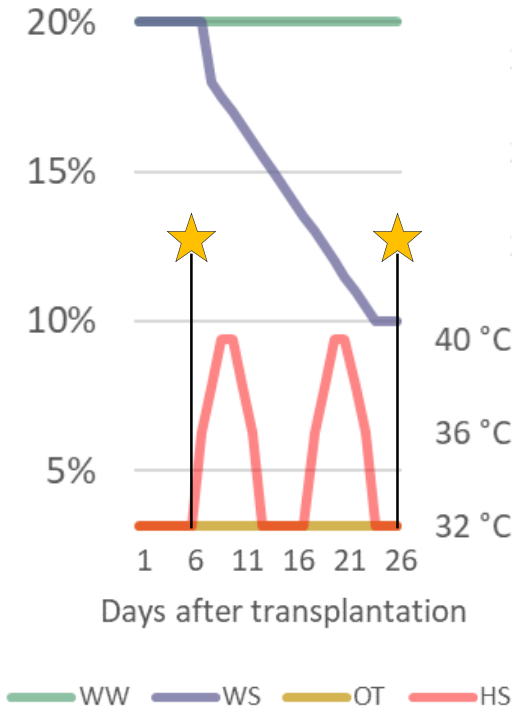

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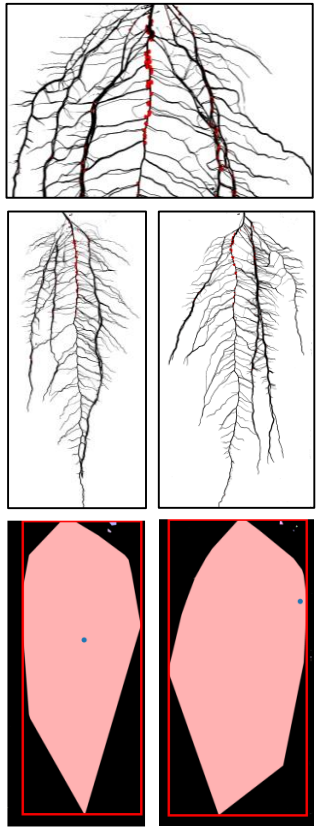

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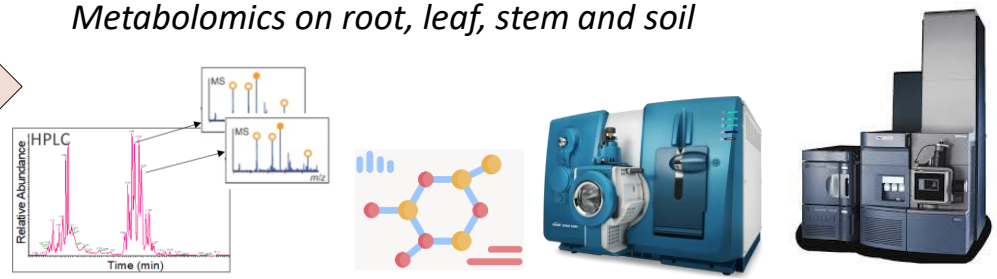
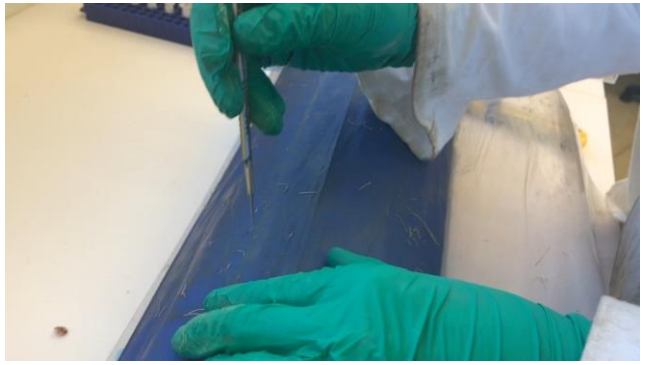


Soil microbial analysis



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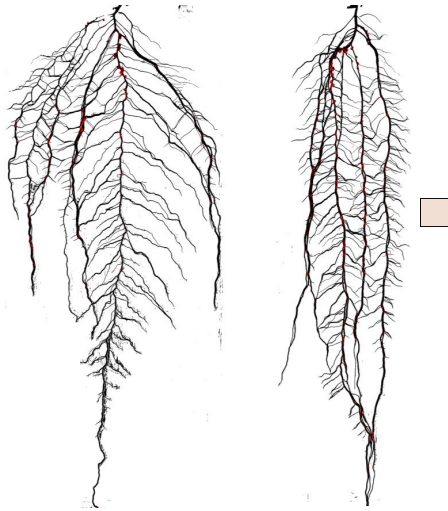
Experimental design 4 type of harvest



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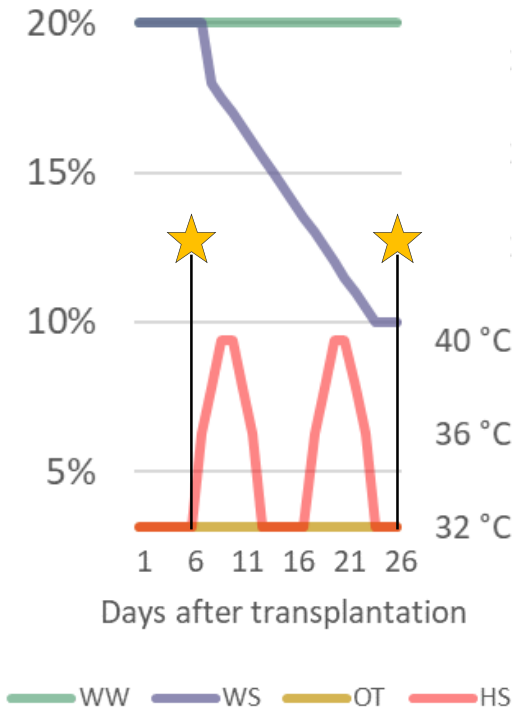

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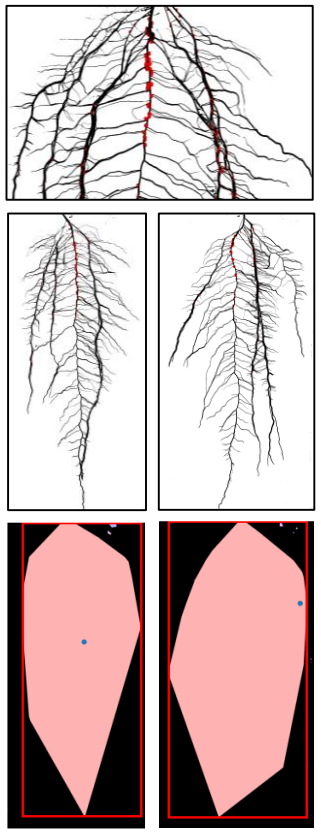

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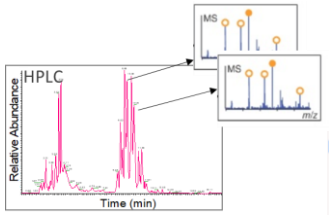
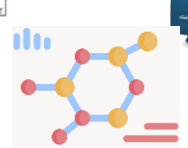
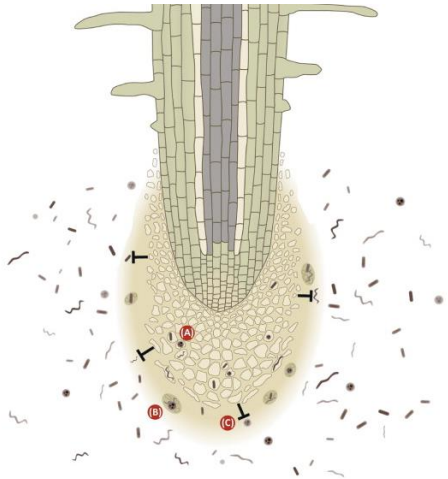
3. **Plant for root exudate analysis**

Metabolomics on exudation







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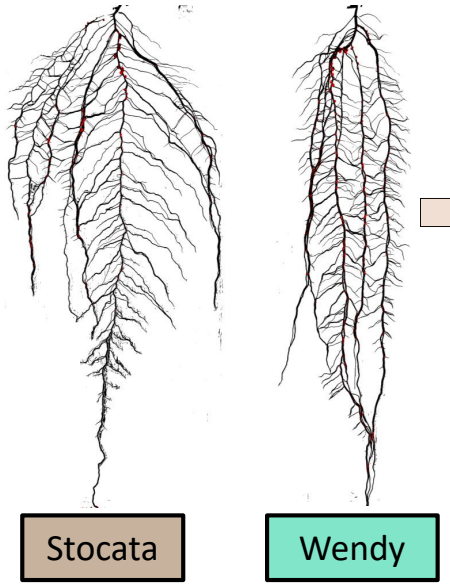

Stocata | Wendy

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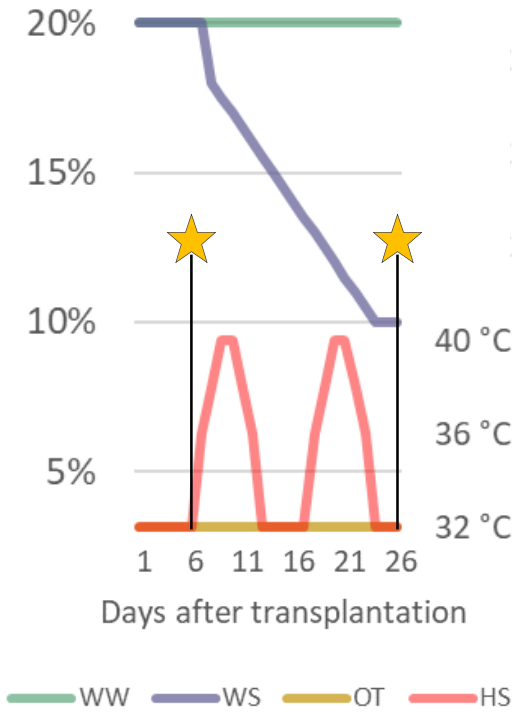

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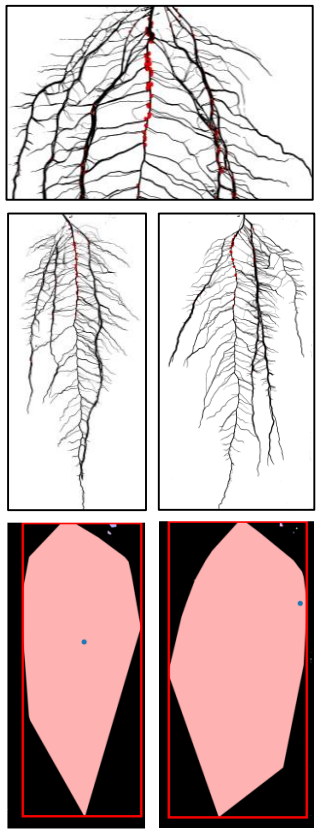

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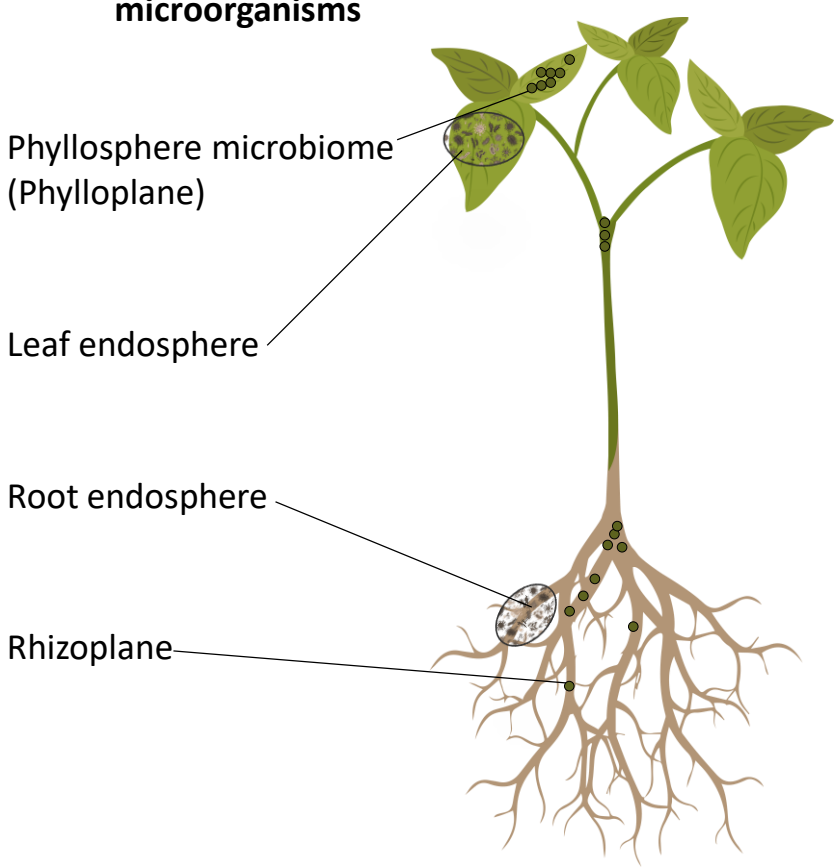
4. **Harvested for analysis of endo and ectosymbiotic microorganisms**



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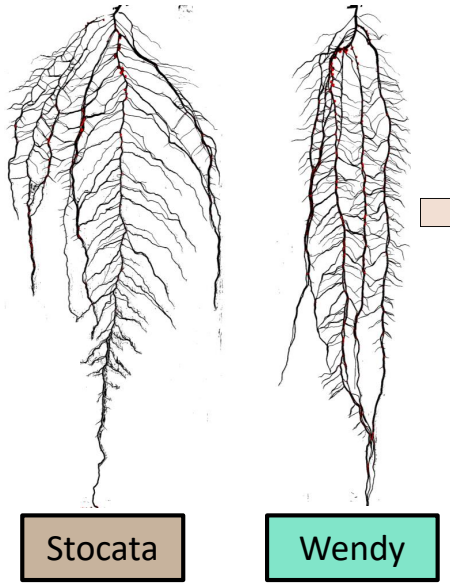

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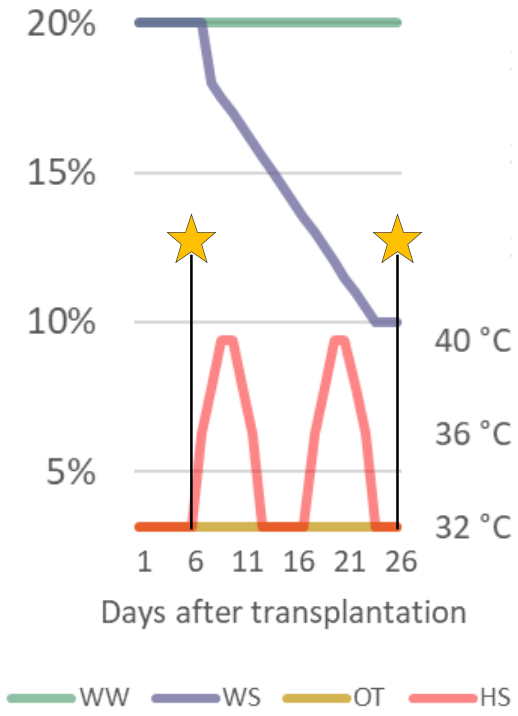

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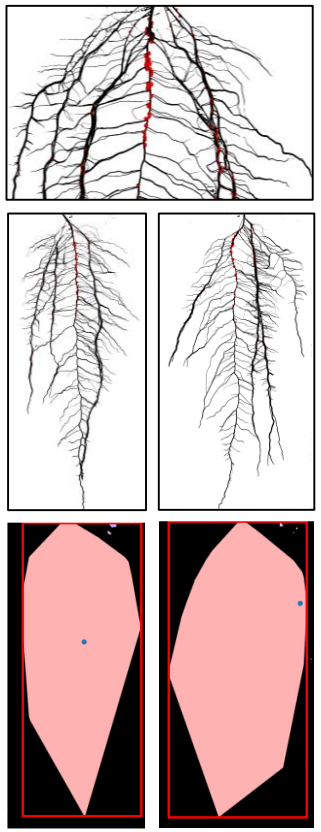

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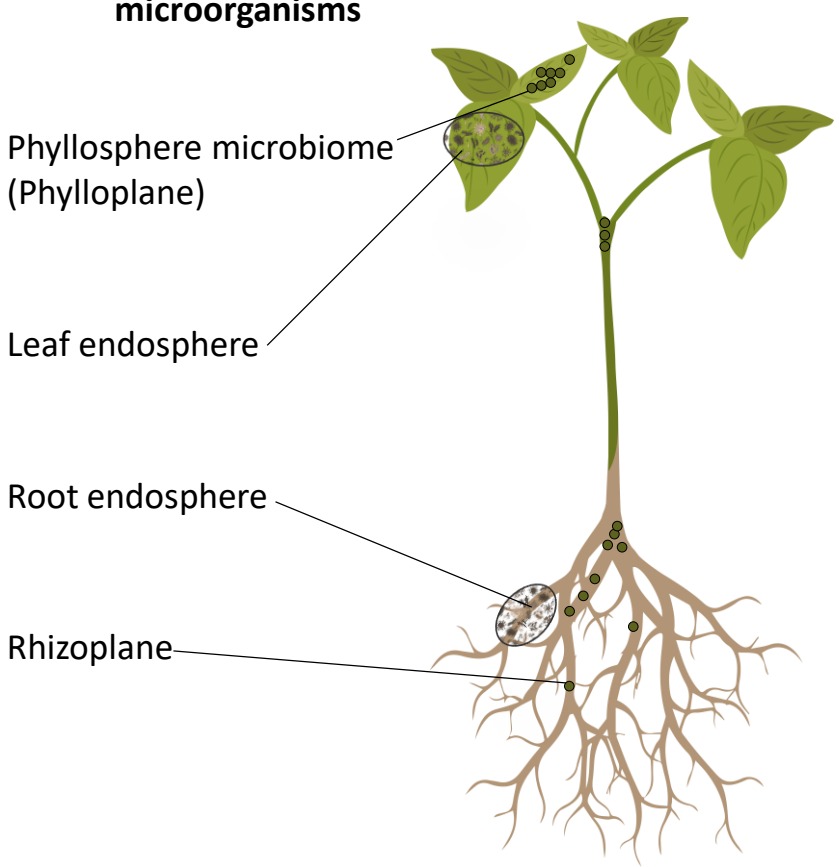
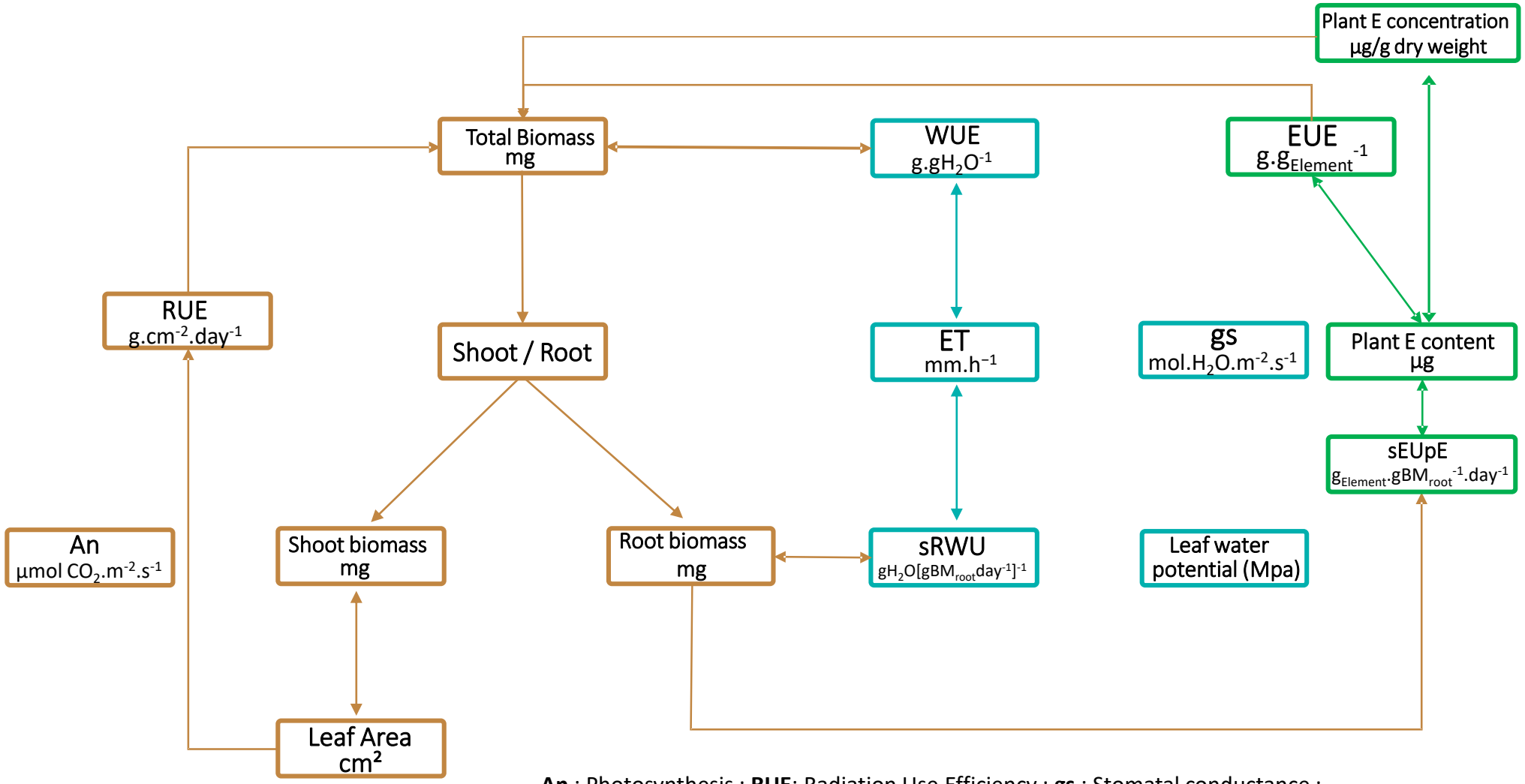


But how does the soybean react to these two stresses from an ecophysiological point of view ?

Conceptual structure-function ecophysiological framework



An : Photosynthesis ; **RUE**: Radiation Use Efficiency ; **gs** : Stomatal conductance ;
WUE: Water Use Efficiency ; **sRWU**: specific Root Water Uptake ; **ET** : Evapotranspiration ;
EUE : Element Use Efficiency ; **sEUpE** : specific Element Uptake Efficiency

But how does the soybean react to these two stresses from an ecophysiological point of view ?

Conceptual structure-function ecophysiological framework

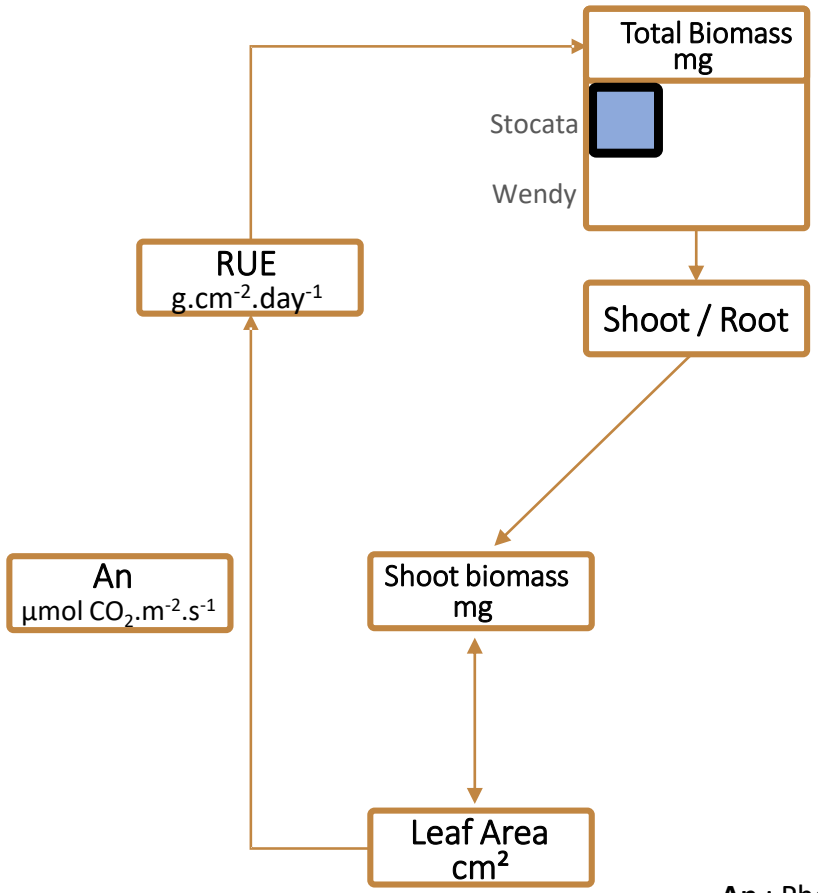
Rate of change of the variable compared to the controls (%) :

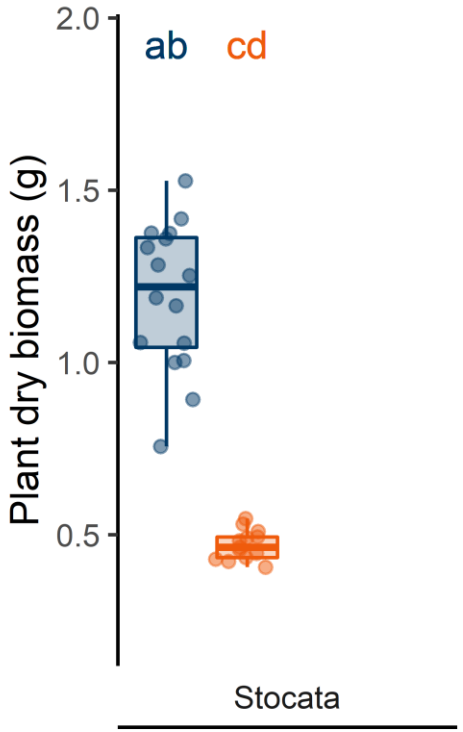
-100%	-50%	0%	50%	100%

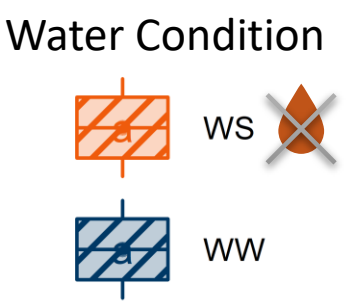
Treatment :

Water Stress

Stocata







An : Photosynthesis ; **RUE**: Radiation Use Efficiency

But how does the soybean react to these two stresses from an ecophysiological point of view ?

Conceptual structure-function ecophysiological framework

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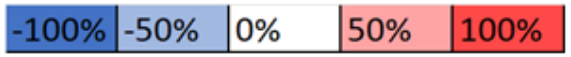
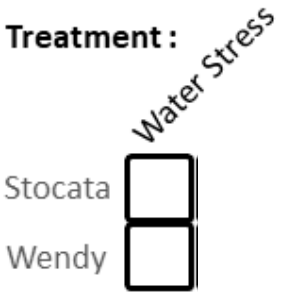
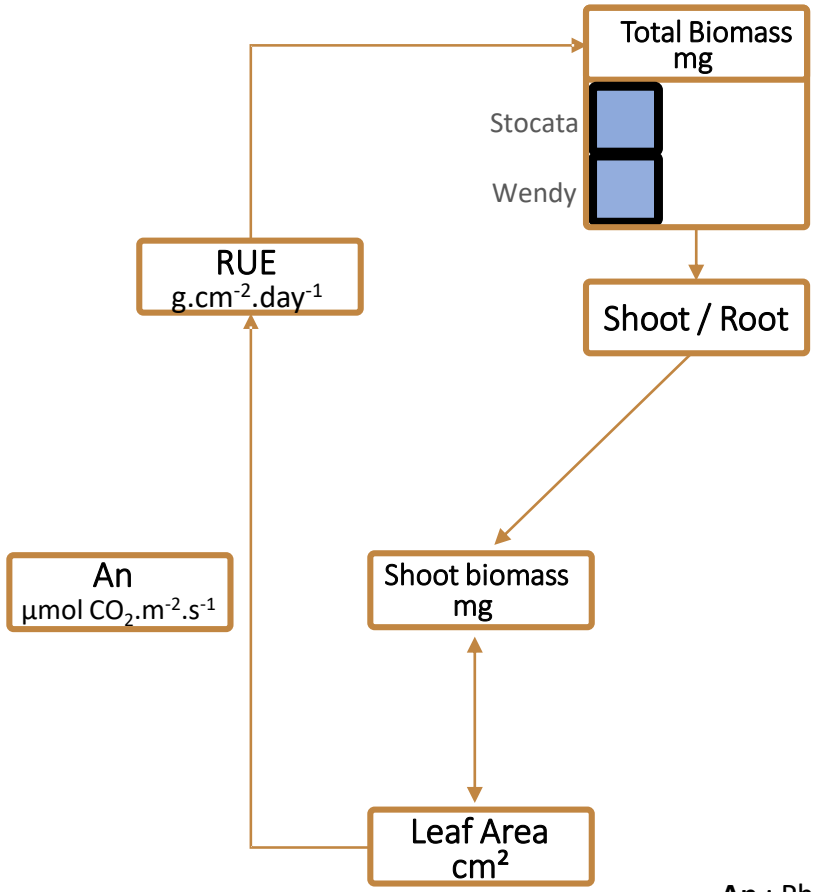
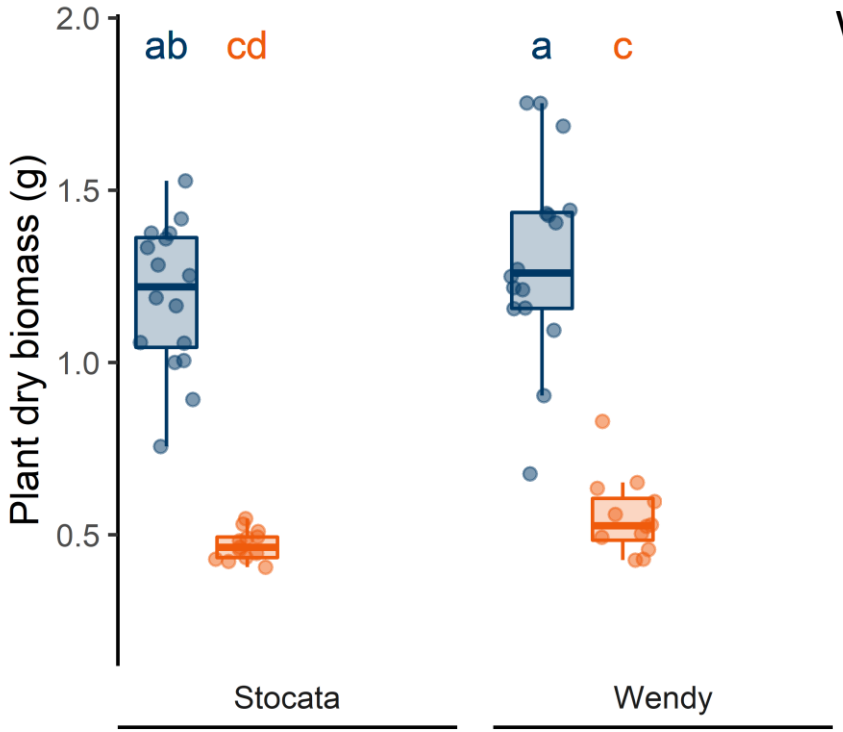
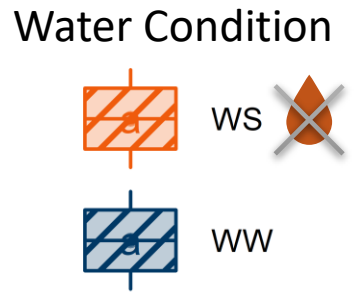


Treatment :









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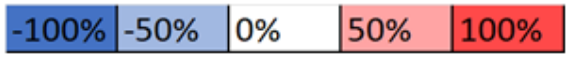
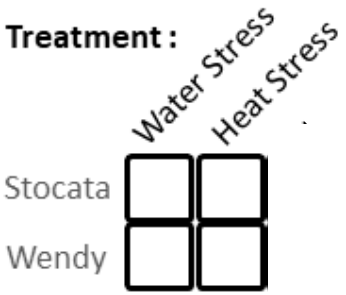
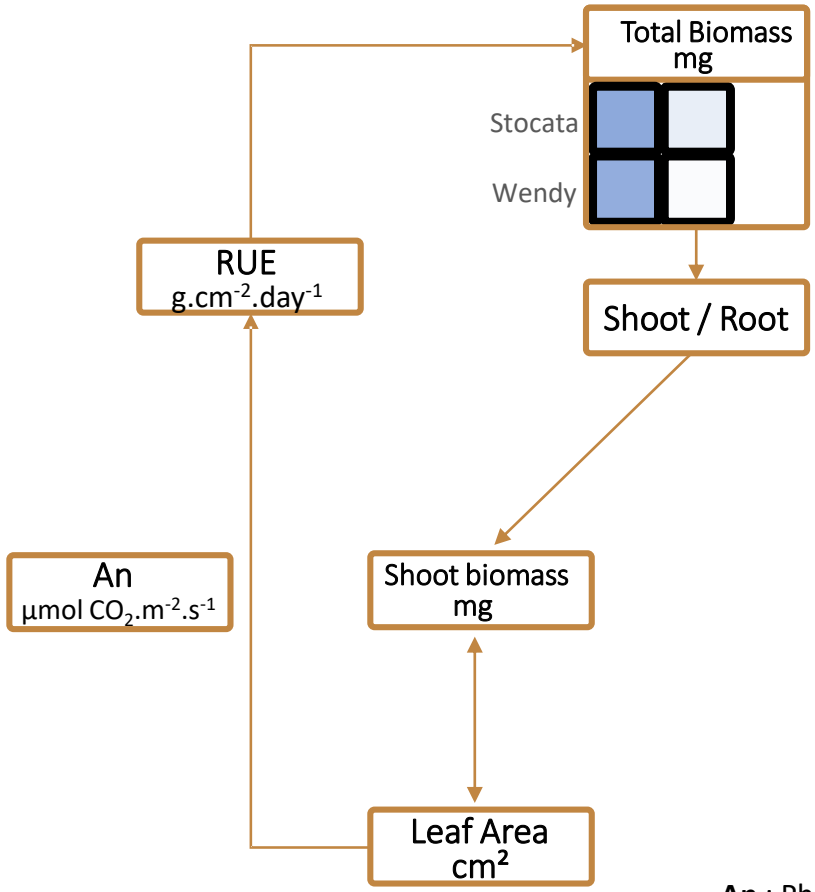
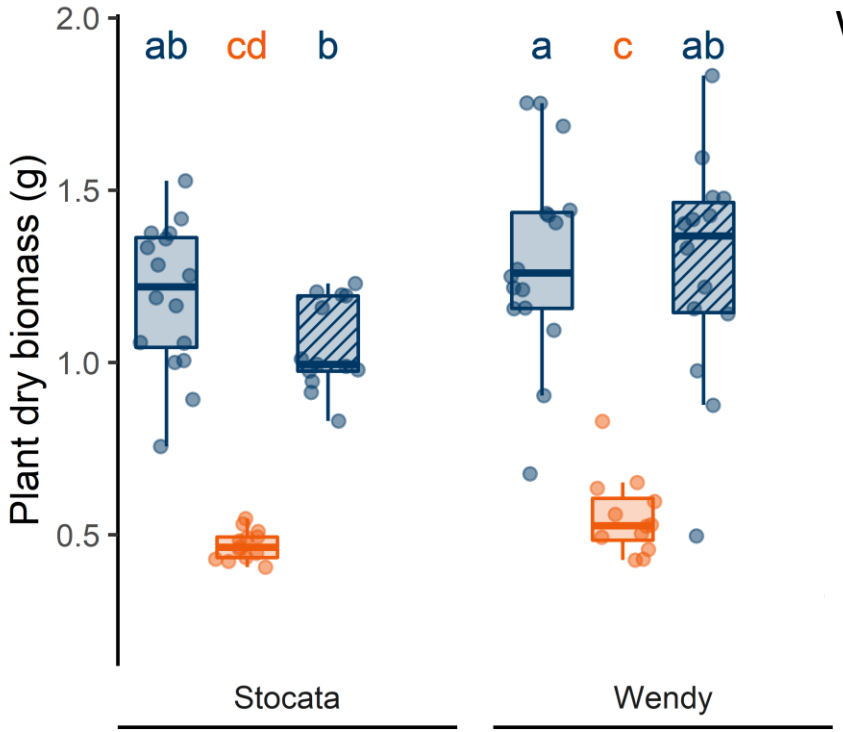
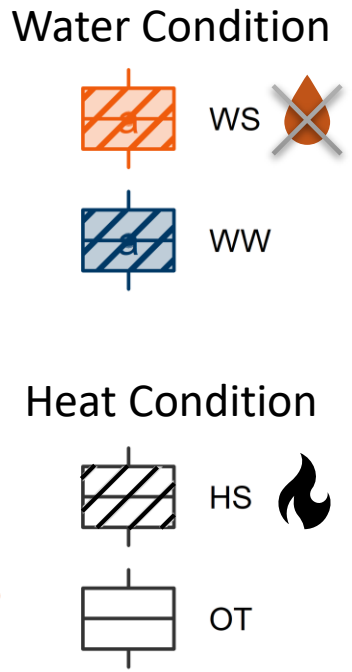


Treatment :









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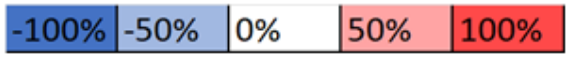
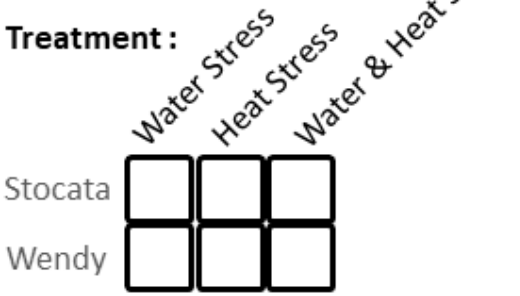
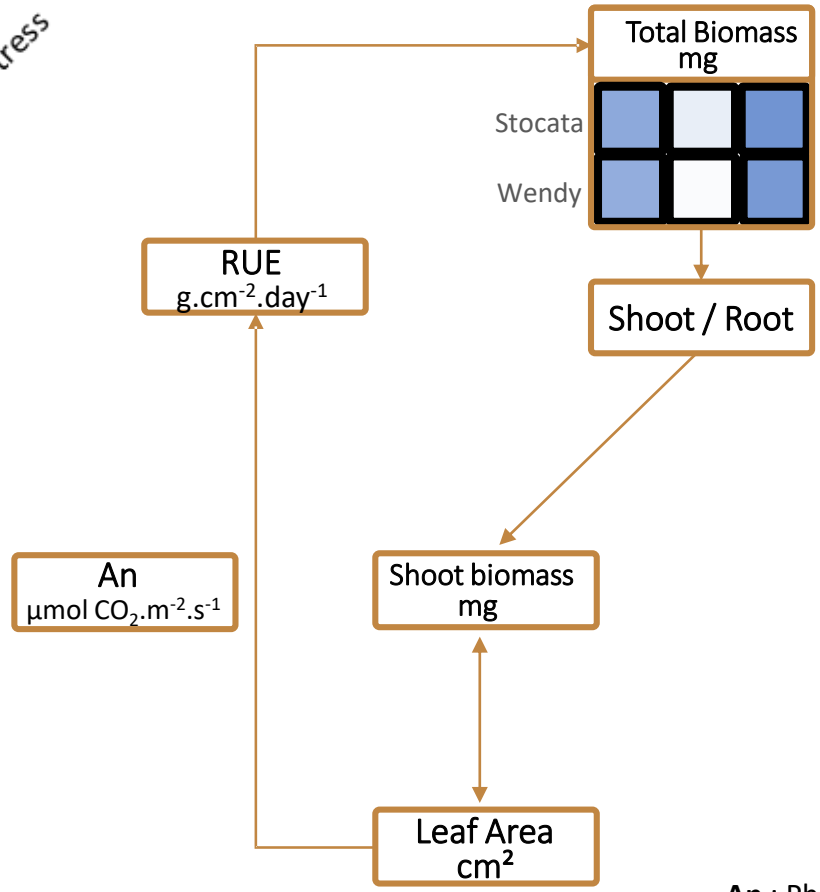
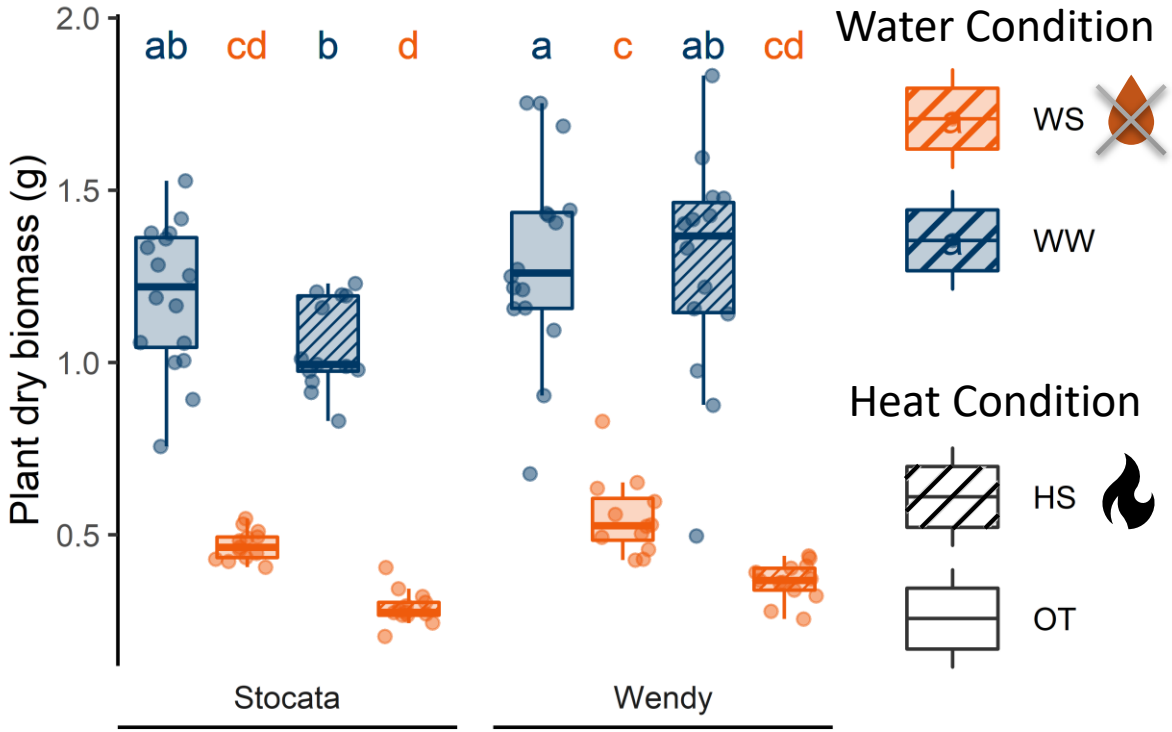


Treatment :







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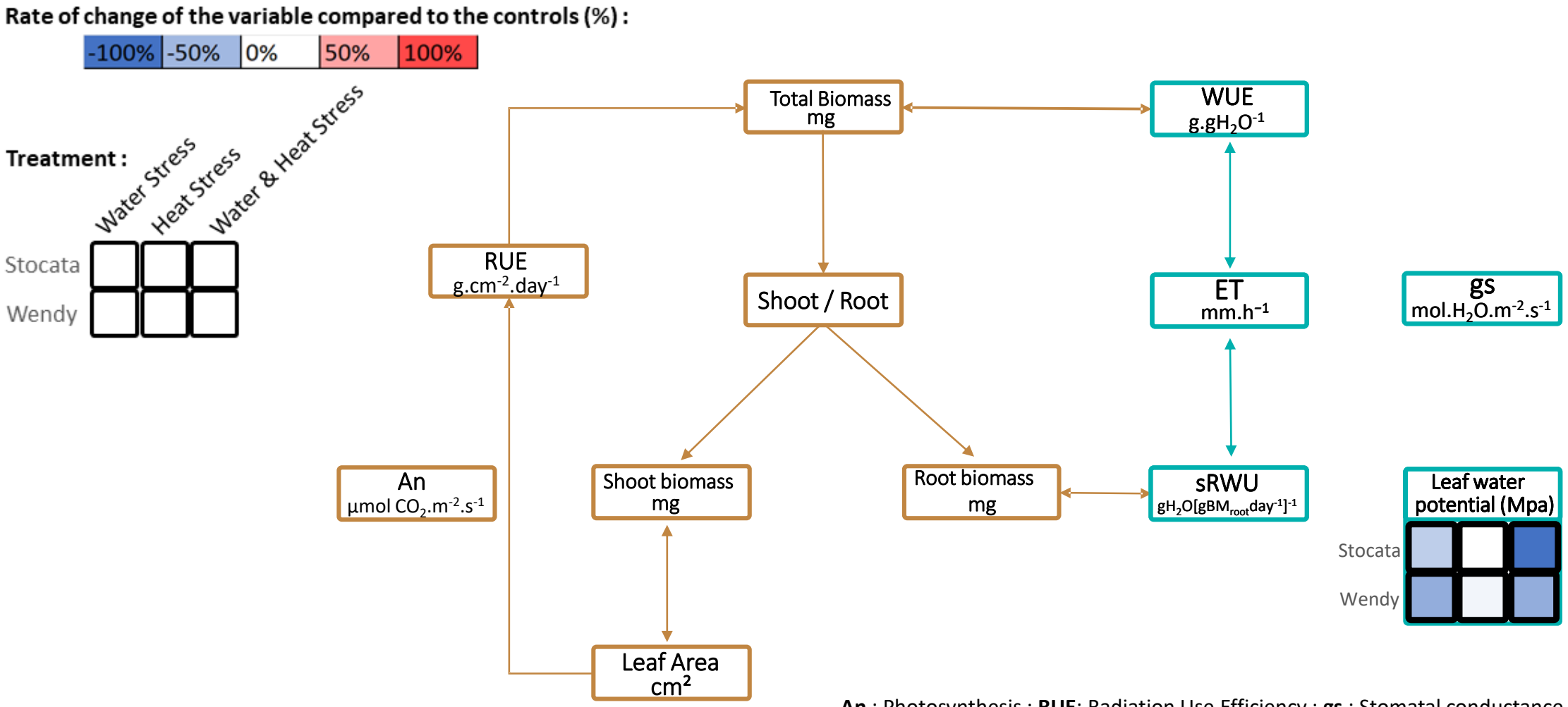
But how does the soybean react to these two stresses from an ecophysiological point of view ?

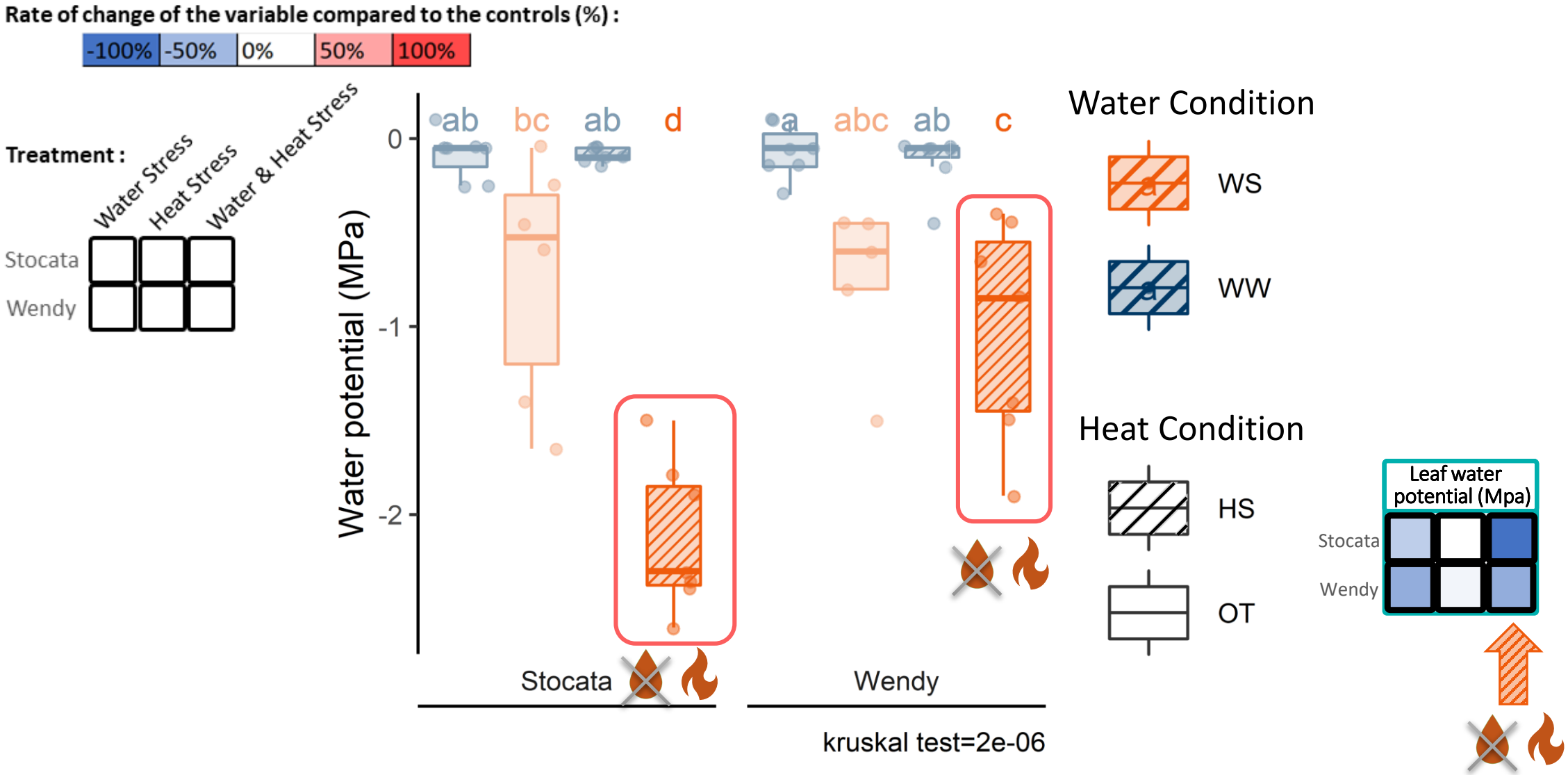
Conceptual structure-function ecophysiological framework



An : Photosynthesis ; **RUE**: Radiation Use Efficiency ; **gs** : Stomatal conductance ;
WUE: Water Use Efficiency ; **sRWU**: specific Root Water Uptake ; **ET** : Evapotranspiration

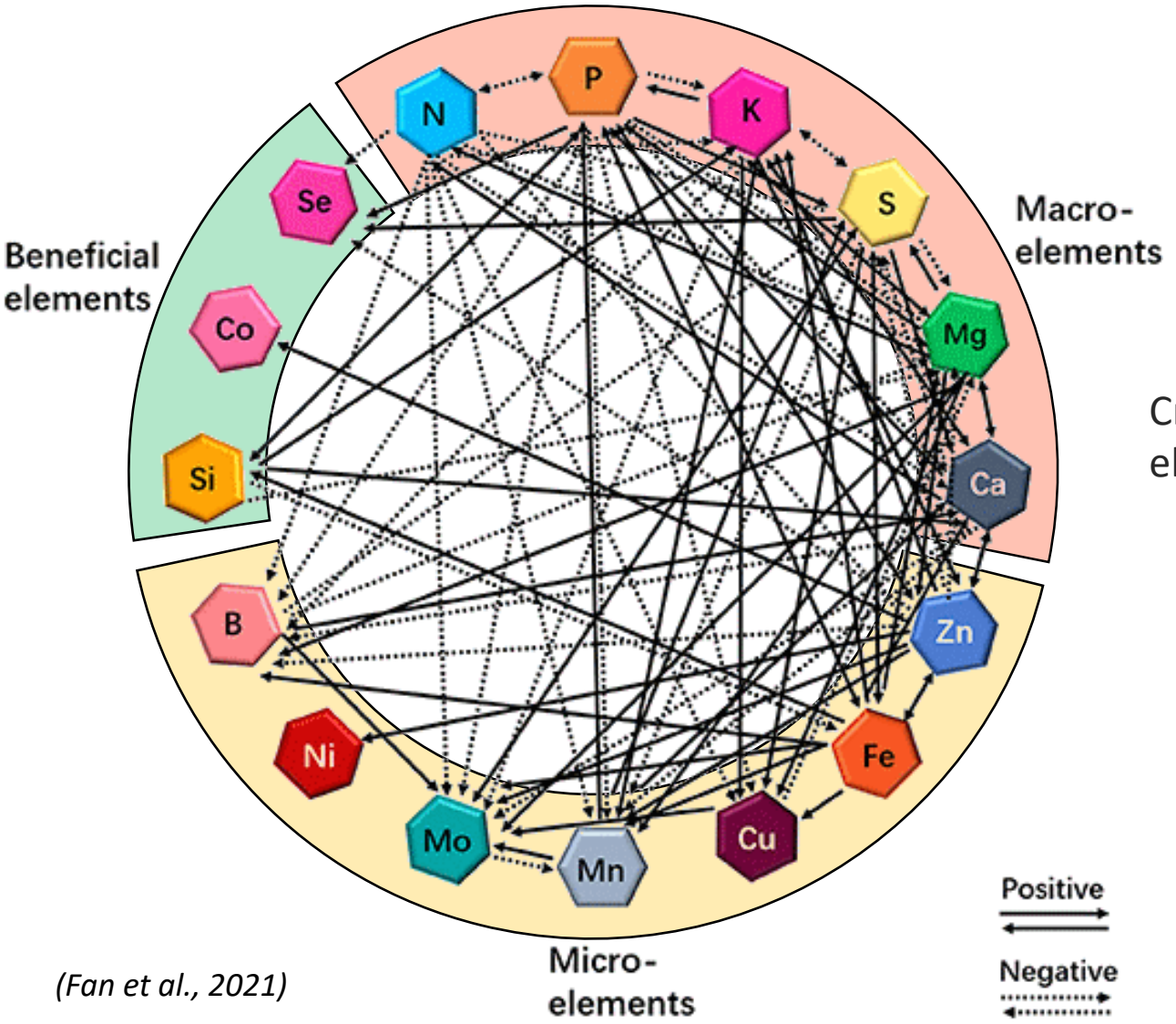
But how does the soybean react to these two stresses from an ecophysiological point of view ?

Differences between the two genotypes concerning the leaf water potential



How is the element concentration in the plant affected by these two stresses ?

Cross-Talks Between Macro- and Micronutrient Uptake and Signaling in Plants



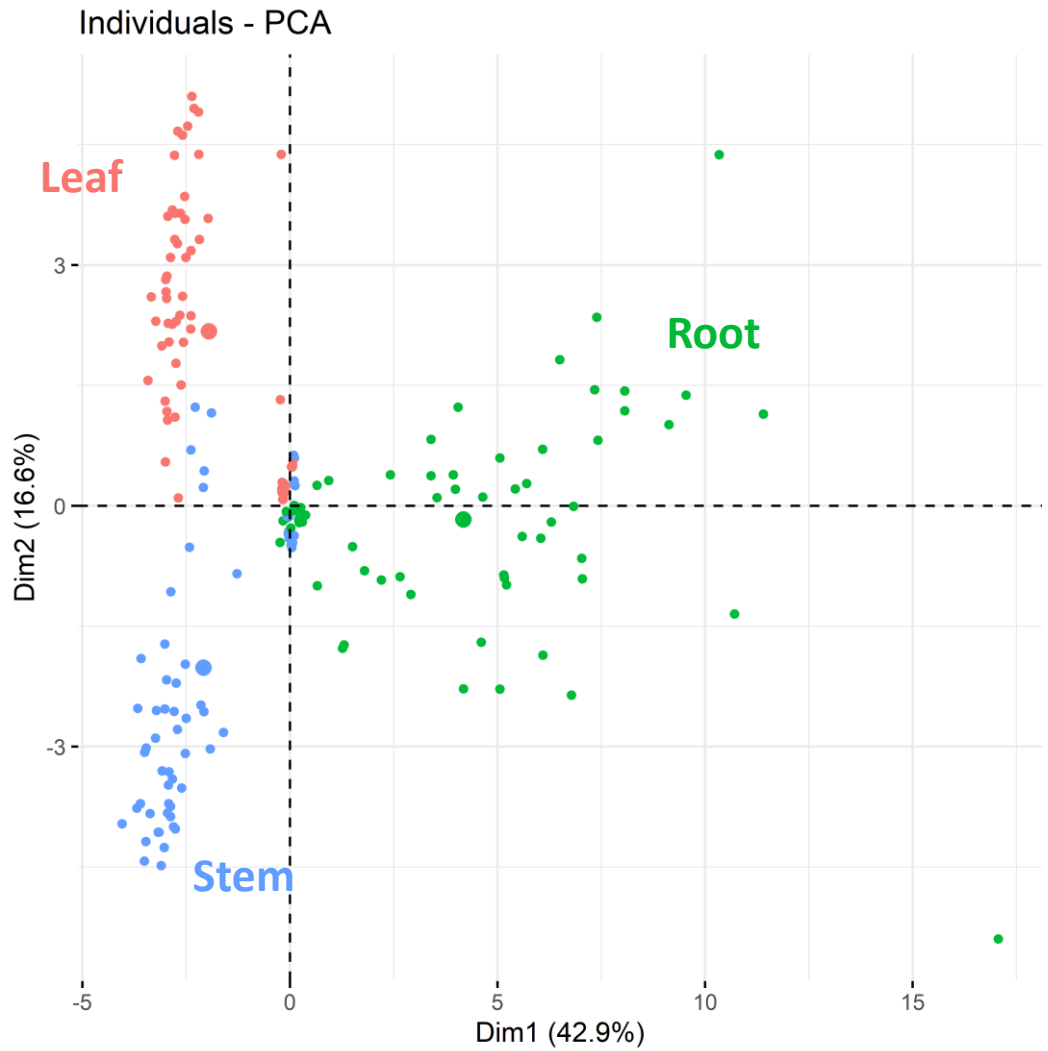
(Fan et al., 2021)

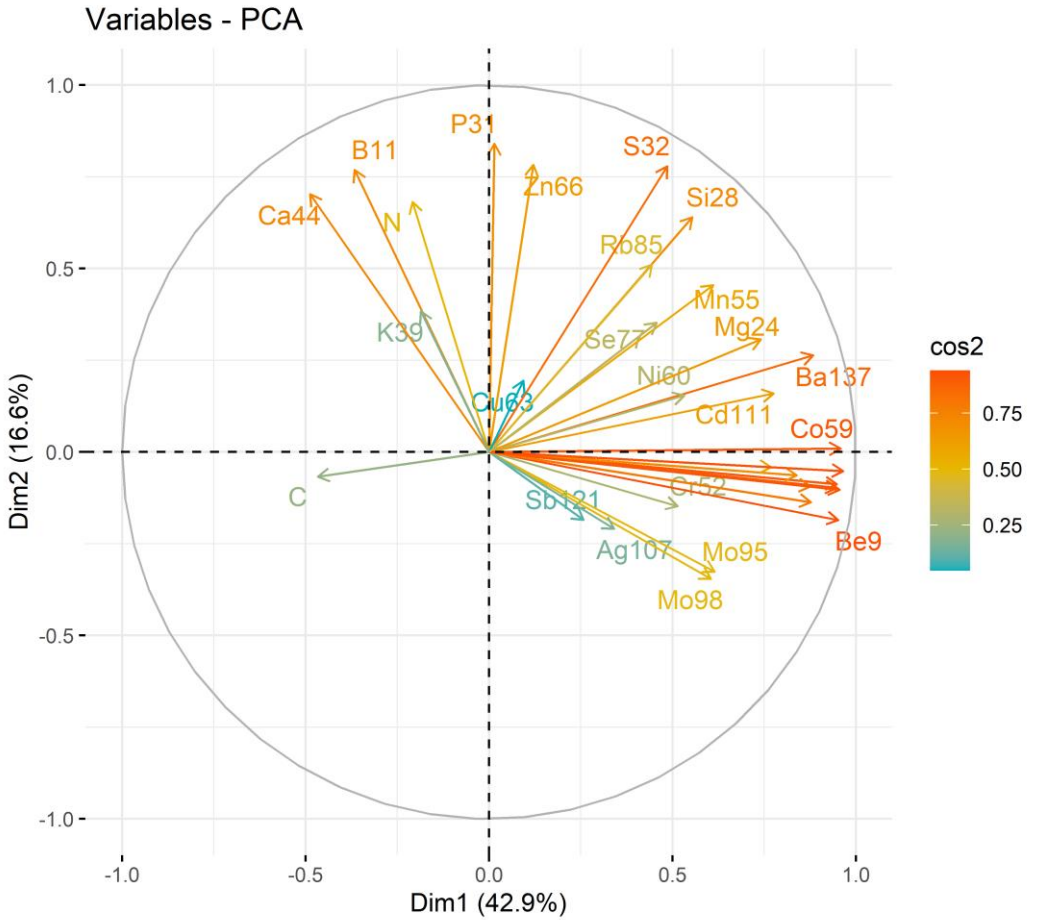
Cross-talks between macro- and micro-elements or beneficial elements in plants in response to individual mineral deficiency.

How is the element concentration in the plant affected by these two stresses ?

It is easy to differentiate the different compartments with a PCA analysis

Ionomics





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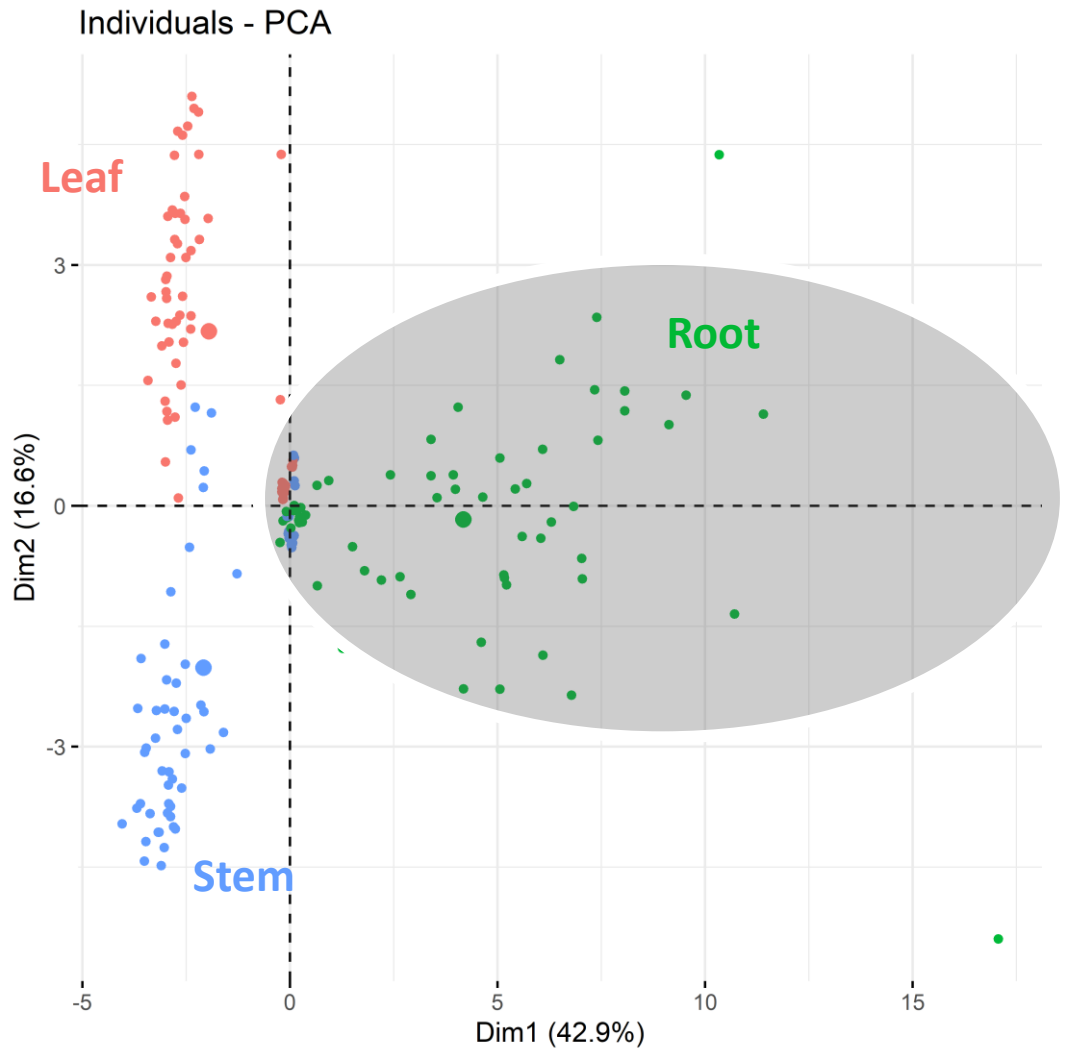
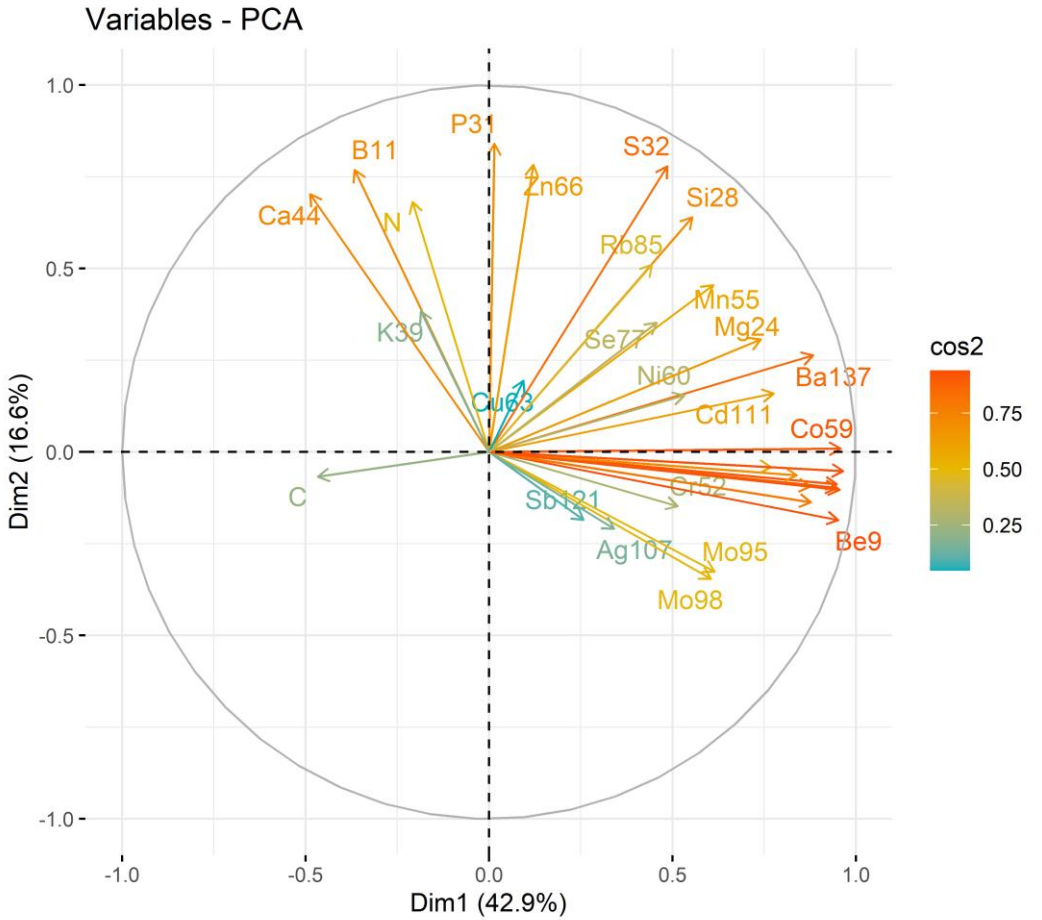
Ionomics

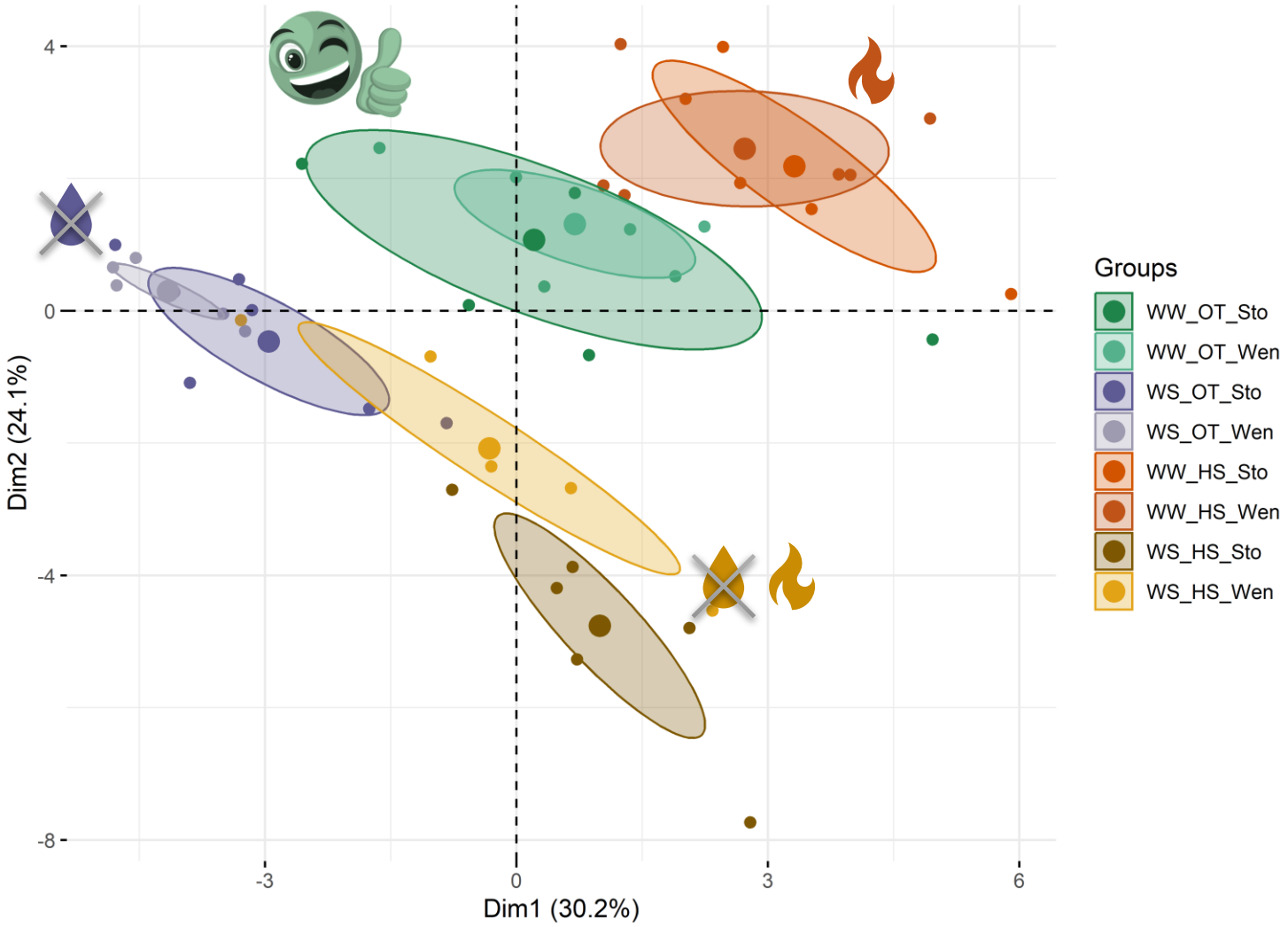


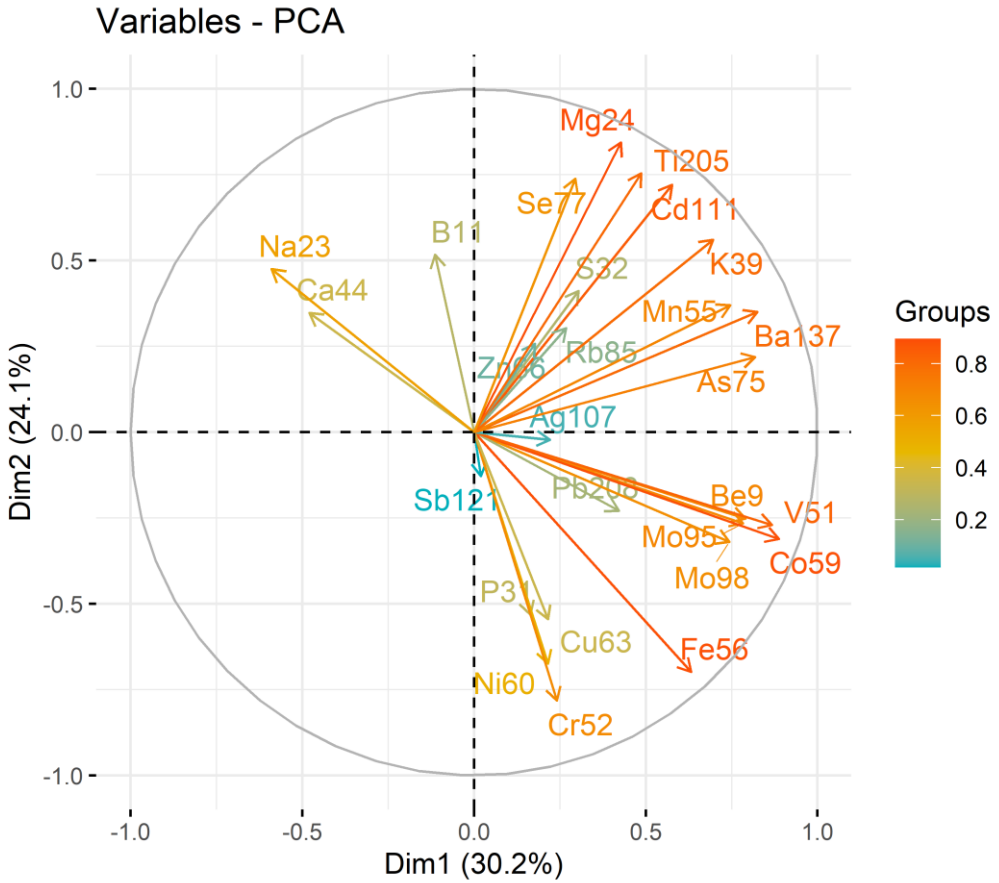


How is the element concentration in the plant affected by these two stresses ?

It is easy to differentiate the different CONDITIONS with a PCA analysis for the root

Ionomics





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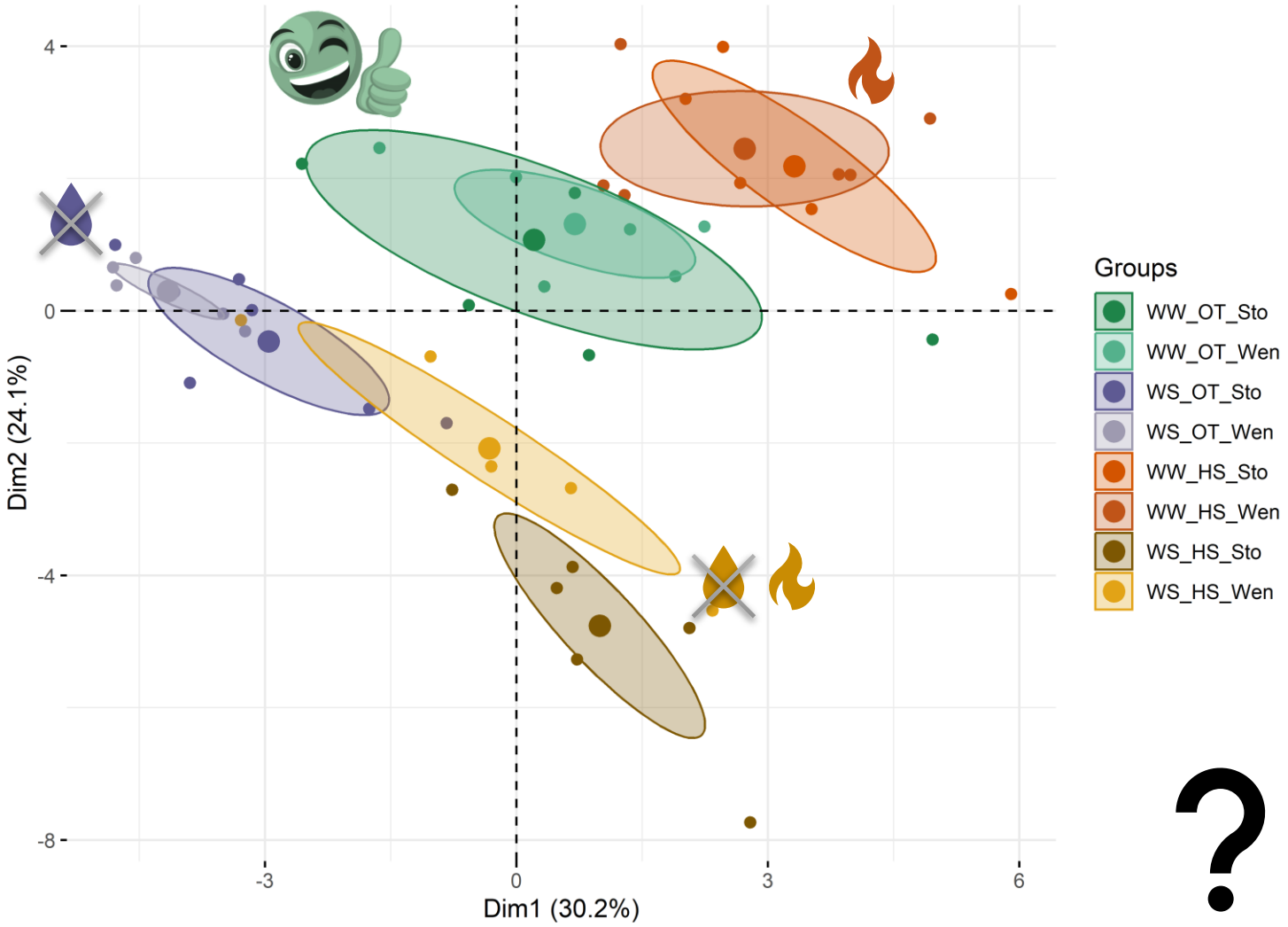
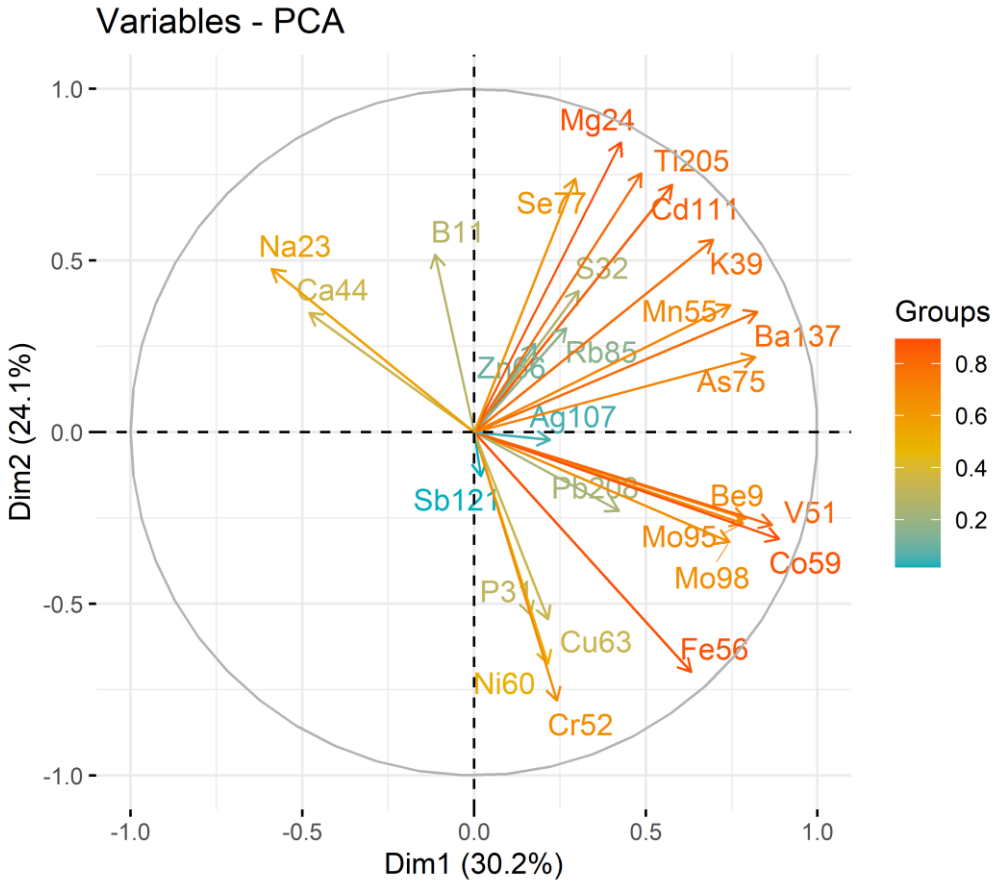
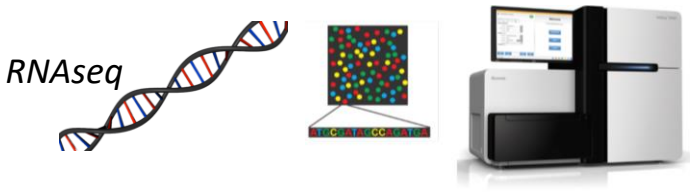


Groups
- WW_OT_Sto
- WW_OT_Wen
- WS_OT_Sto
- WS_OT_Wen
- WW_HS_Sto
- WW_HS_Wen
- WS_HS_Sto
- WS_HS_Wen

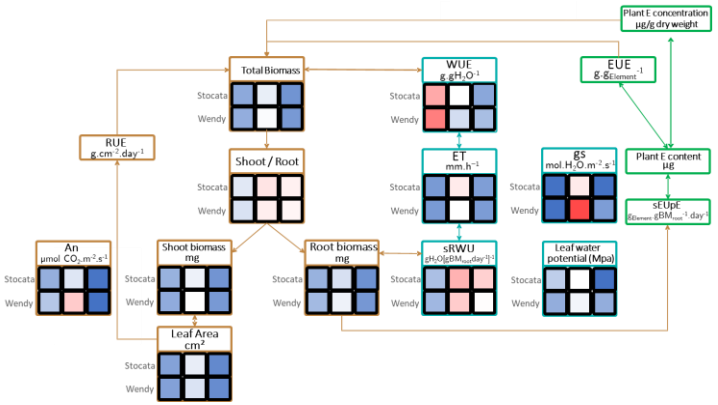


?

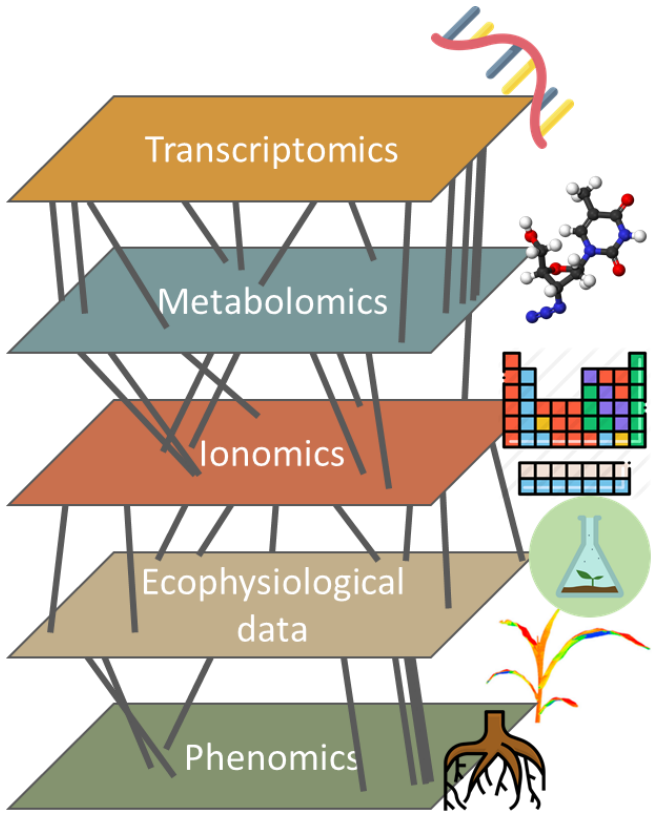


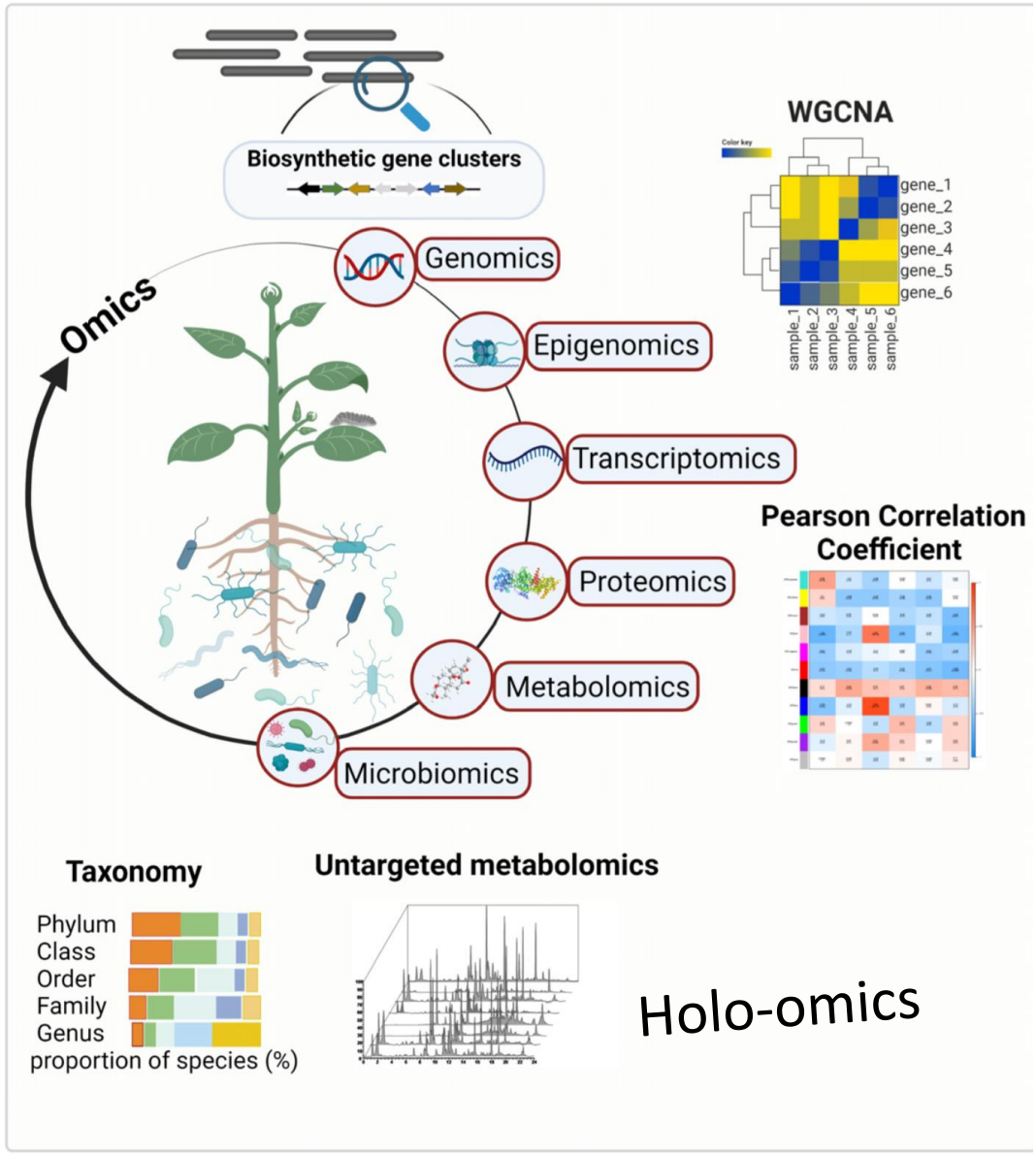
Conclusion

- We observed more severe negative impact in Stocata genotype than in Wendy under combined conditions.
- This does not seem to be due to morphological characteristics (leaf surface, root architecture, etc.) but rather to functional differences, especially with regard to water uptake.
- Regarding the mineral nutrition of the plants under the different stresses, the preliminary results are in line with the results found in other species
- In the long term, this change in nutrition for the different compounds could help us to increase the resistance of soybeans under individual or combined heat and water stress.
- Towards a consideration and integration of other omics data !!!



Is it possible to integrate all the data sets together?





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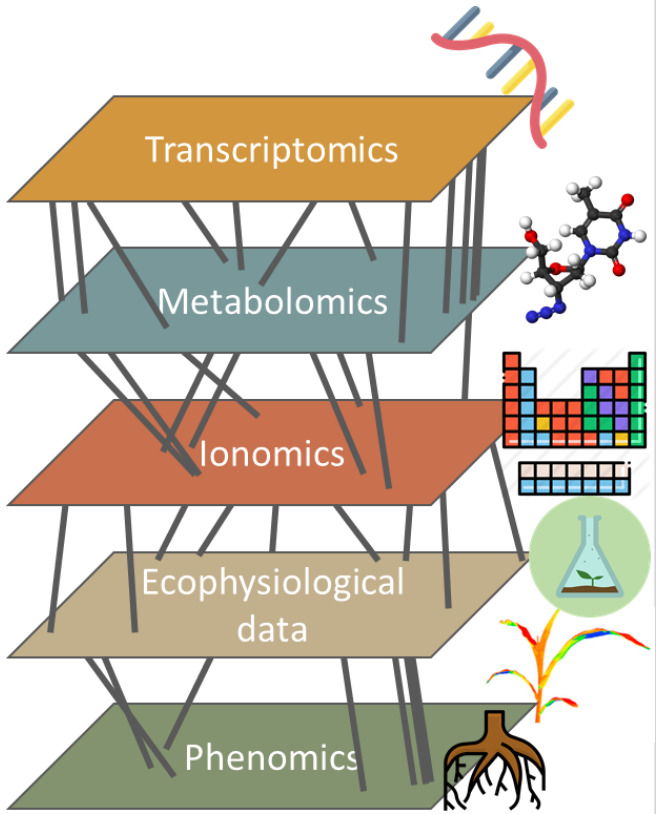

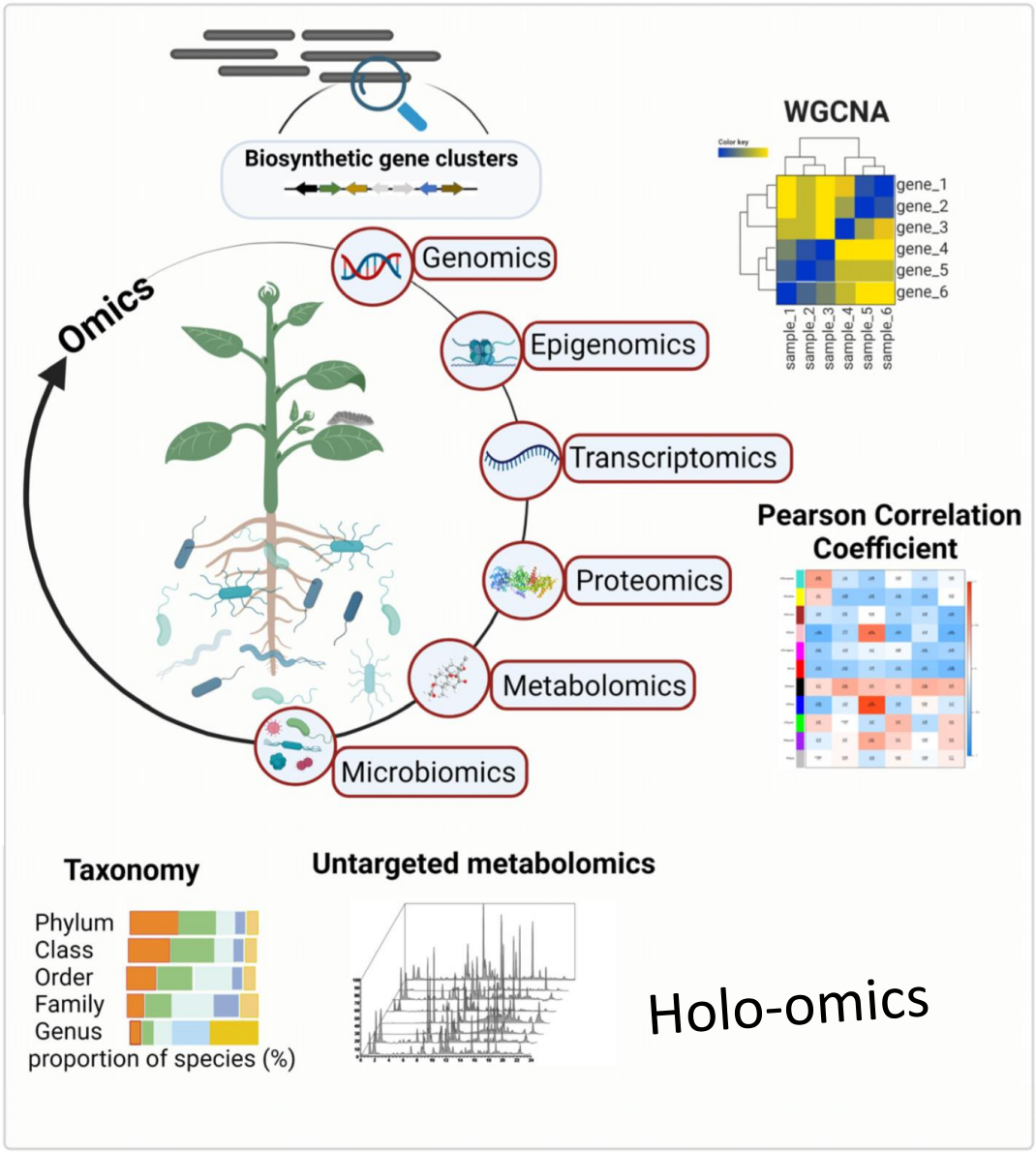

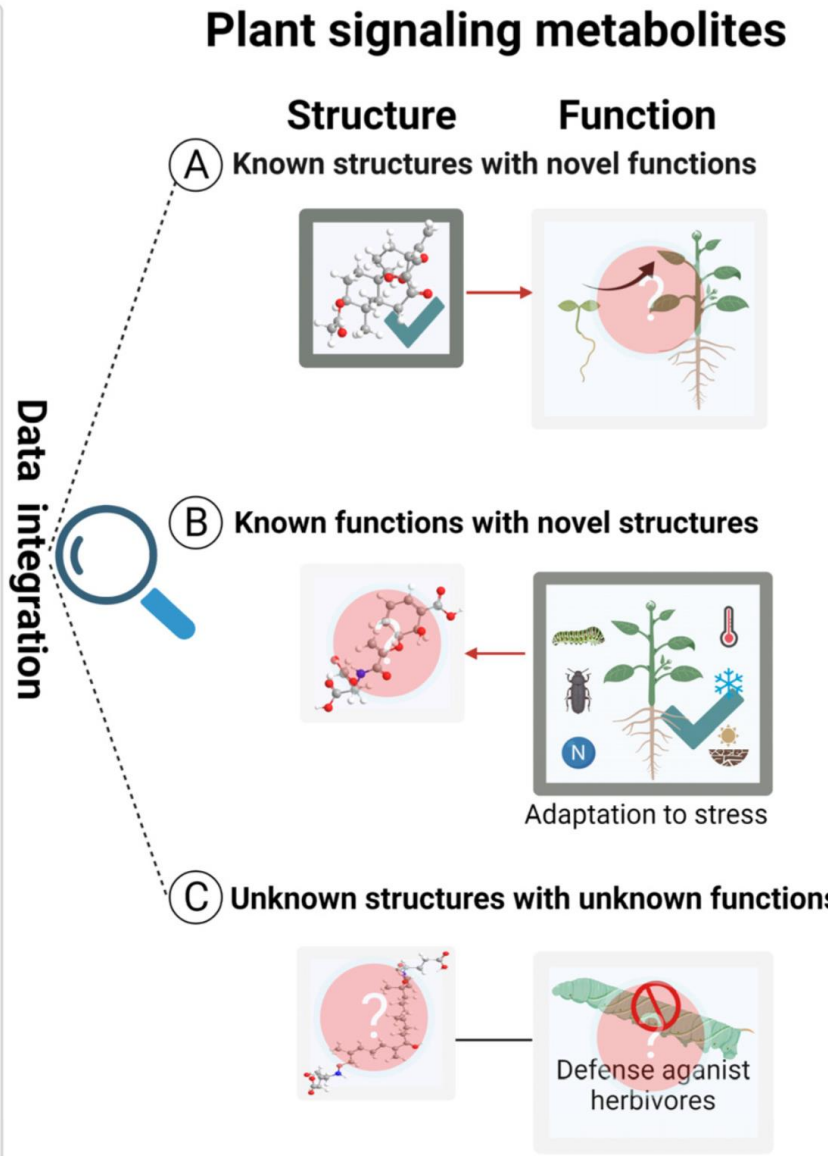

Conclusion

Thank you for your attention, Merci pour votre attention

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