The role of soil bacteria in plant drought resistance: the relationship between tomato, soil thermophilic bacteria and plant growth promoting rhizobacteria

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Plant Soil Ecology

Ciências ULisboa

centre for ecology, evolution and environmental changes

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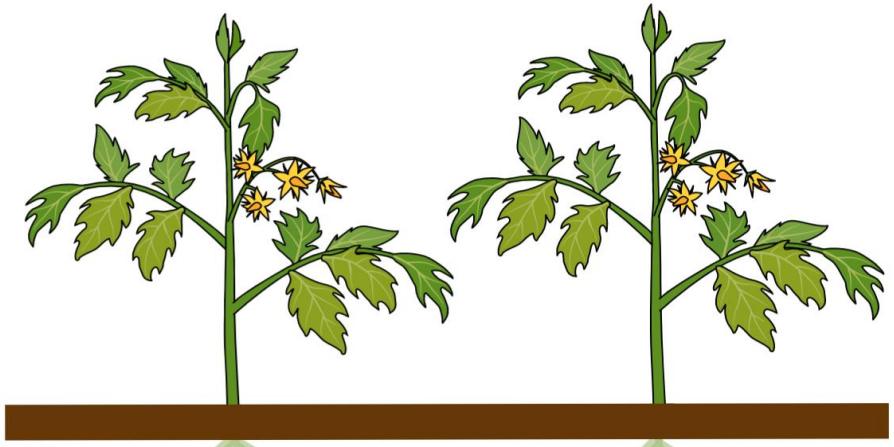
Background: Tomato is an importante crop for agroecomony

Sugal Group

Tomato is:

- Important horticultural product
- Used as model plant and genome sequenced: the genome of cultivar Heinz 1706 (H1706) comprises 12 chromosome pairs with a size of 950 Mb, and a total of 35,000 genes (Sant'Ana&Lefsrud, 2018)

Background: Plant Growth Promoting Rhizobacteria and Tomato



ACC deaminase-producing PGPR withdraw ACC-the precursor of ethylene- and hydrolyze it into ammonia and α-ketobutyrate for nitrogen and energy supply.

Lowering the levels of plant stress hormone ethylene

Secretion of osmolytes to maintain cell turgor

Act synergistically with plant-synthesized osmolytes to prevent water loss

Phytohormone production, e.g., IAA, cytokinins

Alteration of the activity of antioxidant enzymes, i.e., SOD, CAT, APX, and glutathione reductase

Enhanced formation of lateral roots and root hairs, increasing water and nutrient uptake

EPS production

EPS increase aggregate stability and RAS/RT (root-adhering soil/root tissue) ratio, leading to increased soil moisture and uptake of water and nutrients

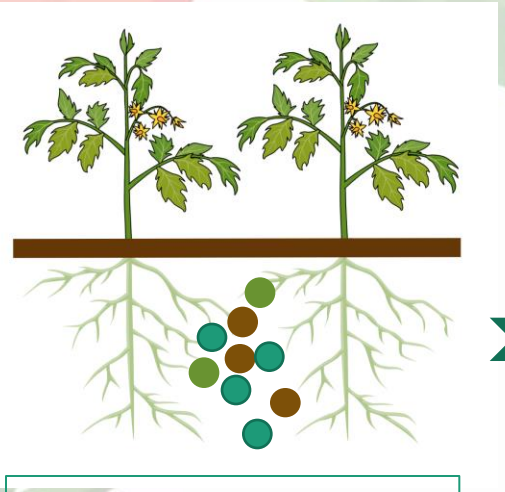
Production of VOCs, e.g., dimethyl disulfide, 2,3-butanediol

Increased stomatal closure, reducing water loss, through SA signaling pathway

Improvement of plant iron and sulfur nutrition

Rosa *et al.*, 2023 (https://doi.org/10.3390/agronomy13010183)

Work plan:

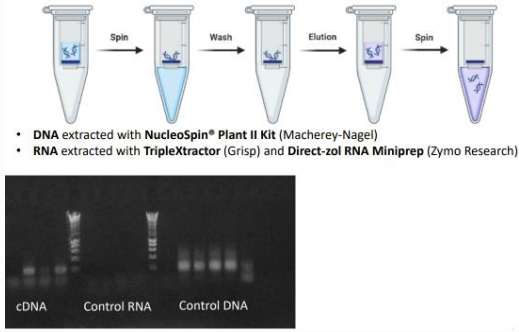


- Plants grown under control and stress conditions
- 20 plants per treatment
- Stress treatment imposed for 37 days

Composite sample of rhizospheric soil from 3 pots

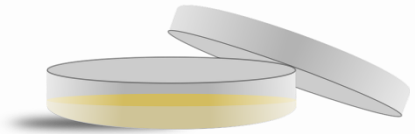
Metabolite profilling (aminoacids) → UHPLC-PDA → Samples **in analysis**

Metagenomic and transcriptomic analisys → **Optimization** in nucleic acid preparation → RNA and DNA **extracted for analysis**



Isolation and screening of PGPR

- Biochemical tests to screen PGPR traits done
- Screening done with the results from the omic analysis



Plant inoculation with PGPR isolates and consortiums with soil thermophiles:
- Soil thermophiles characterization
- Study the effect of PGPR isolated or in consortium on tomato growth under hydric stress

Results: Early identification of drought stress responses

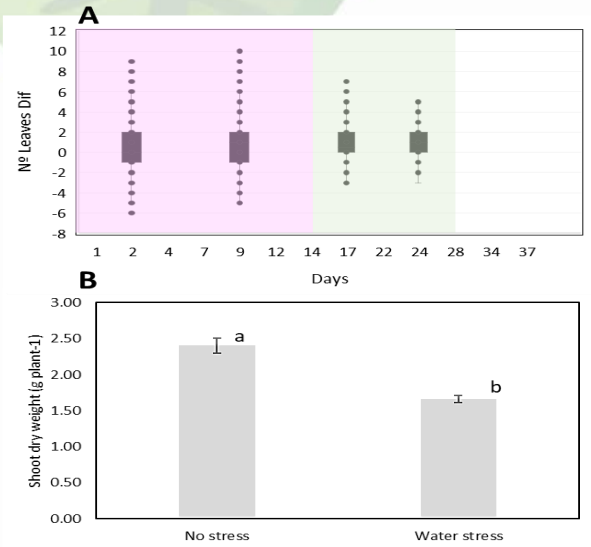


Figure 1. Differences between morphological parameters - nº of leaves (**A**) measured in treatments with watering to 80% and 40% field capacity, along the 37 days of the experiment, in box and whiskers graphics. The "box" includes differences between the 1st and the 3rd quartile. (**B**) Tomato shoot´s dry biomass obtained at the end of the experiment for both treatments. Values shown are means and error bars represent the standard error of the mean. The different letters above the bars indicate means that differ significantly ($p < 0.001$).

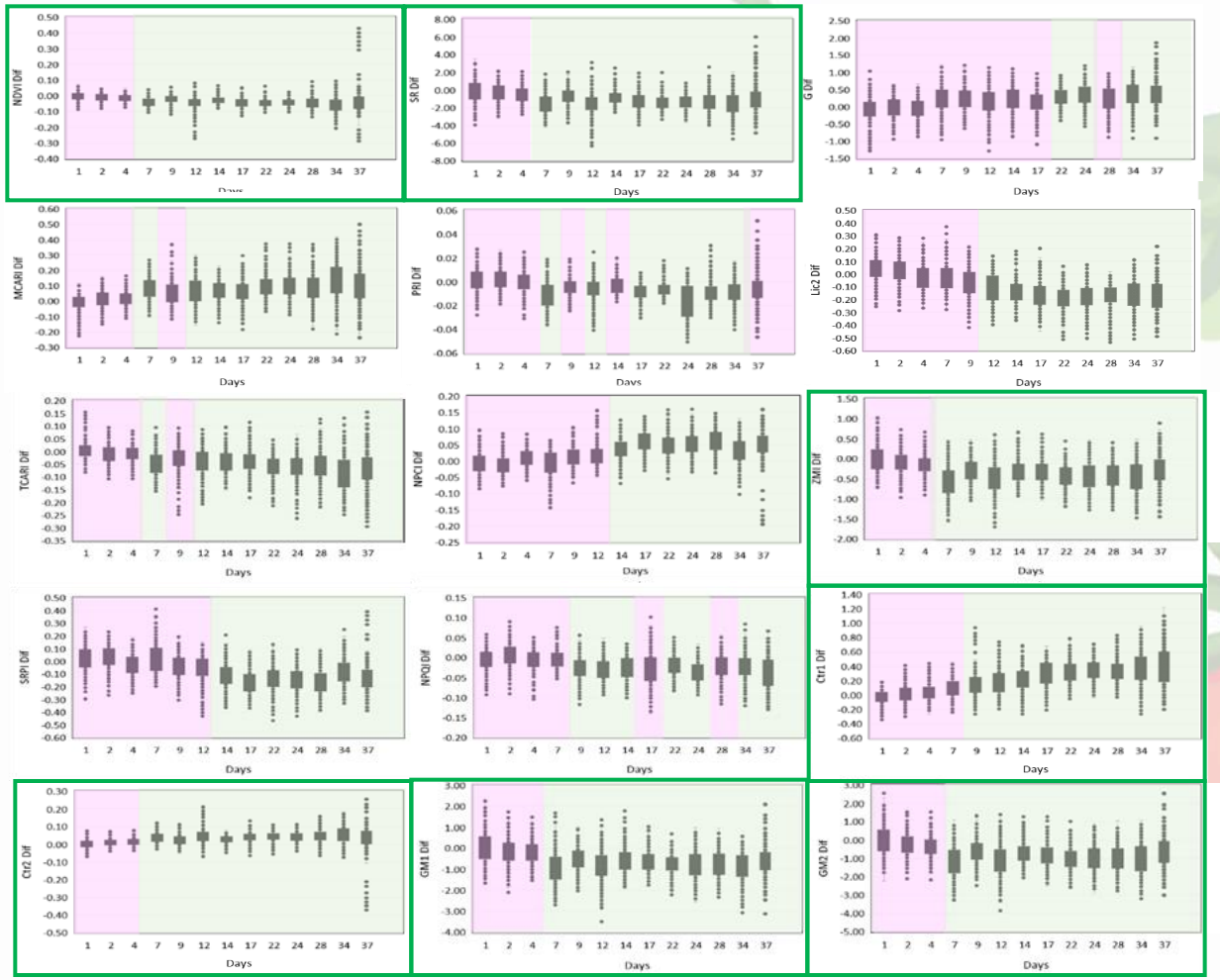


Figure 2. Differences between the significant vegetation index values determined in treatments with watering to 80% and 40% field capacity, along the 37 days of the experiment, in box and whiskers graphics. The "box" includes differences between the 1st and the 3rd quartile.

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Results: Early identification of drought stress responses

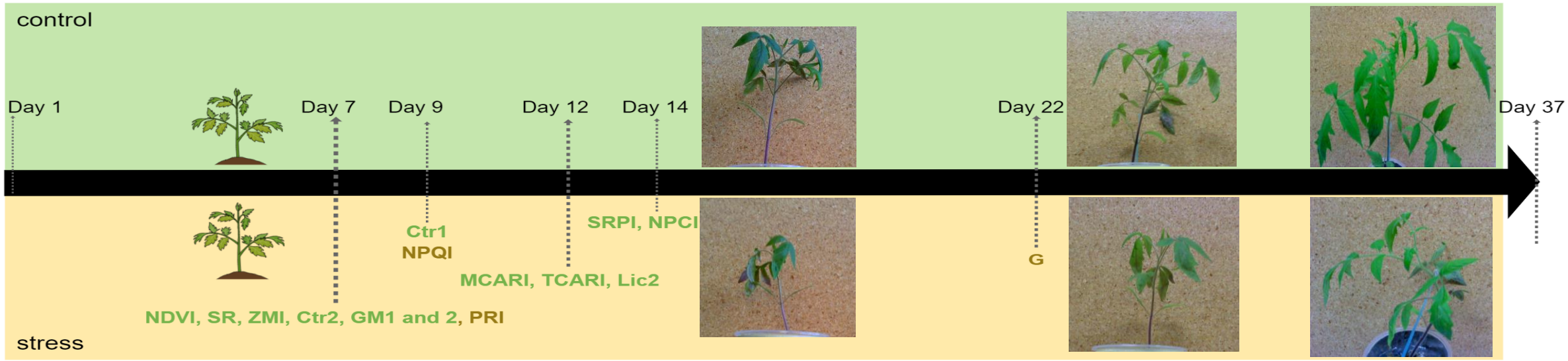

Figure 3. Timeline of the tomato plant experiment, showing when the indices became significant different between the two treatments (watering to 80% and 40% of soil field capacity). "Green" indices indicate significance from that day on, while "gold" indices indicate that although they became significant between treatments, the significance is not consistent until day 37.

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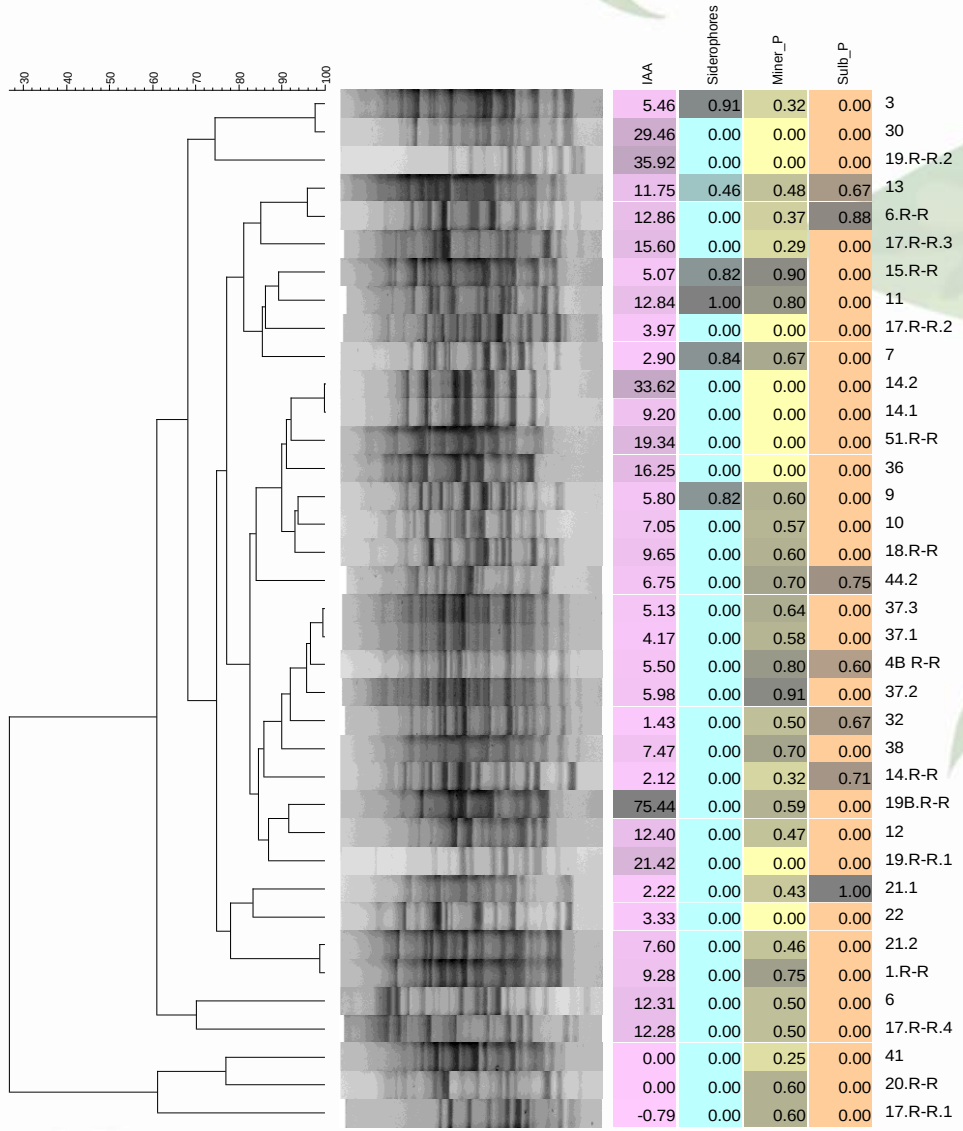
Results: Early identification of drought stress responses

Soil isolates:

- 37 isolates studied
- All different morphologically
- 33 with different fingerprint (M13) profiles
- All show one or more PGPR traits
- At least 7 have three or more PGPR traits and are capable of growing at 50°C



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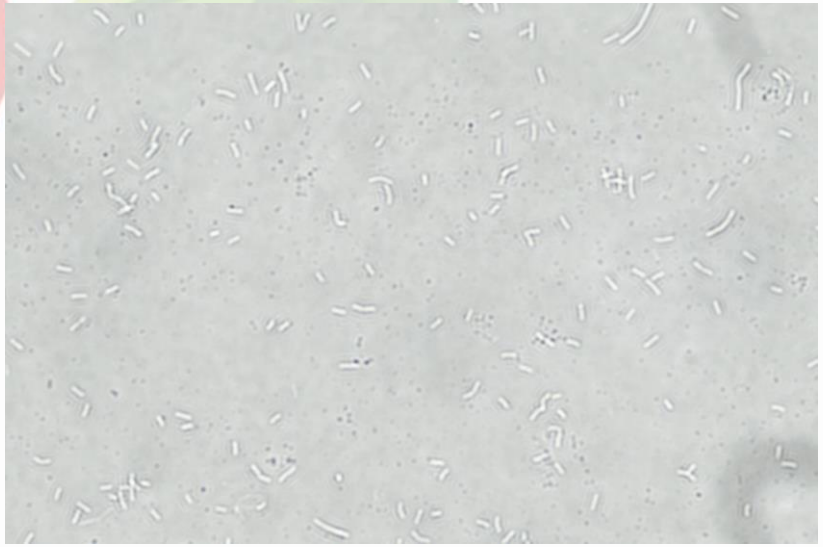
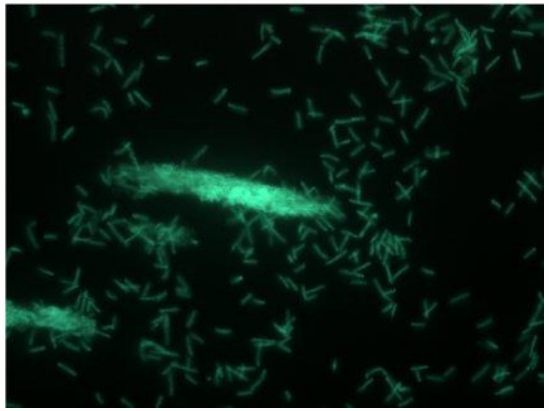
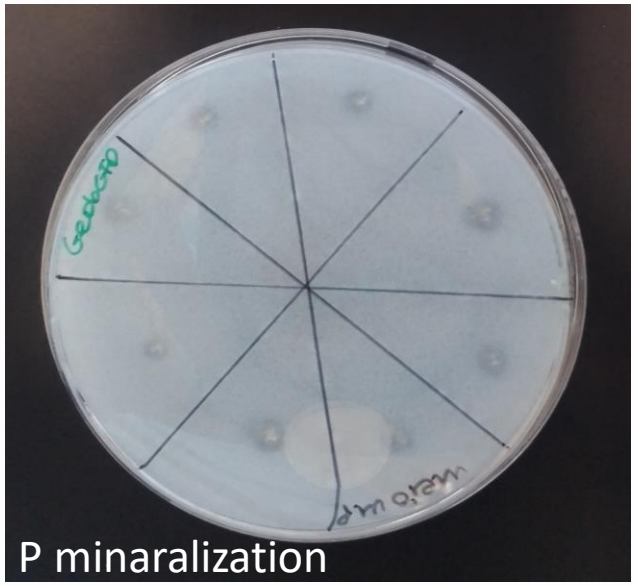
Results: Tomato and *P. thermoglucosidasius* CECT 9160 interaction





Micrograph of *Parageobacillus thermoglucosidasius* C56-YS93 cells showing individual cells and clumps of cells (*from:* Brumm *et al.*, 2015)

P mineralization and solubilization:

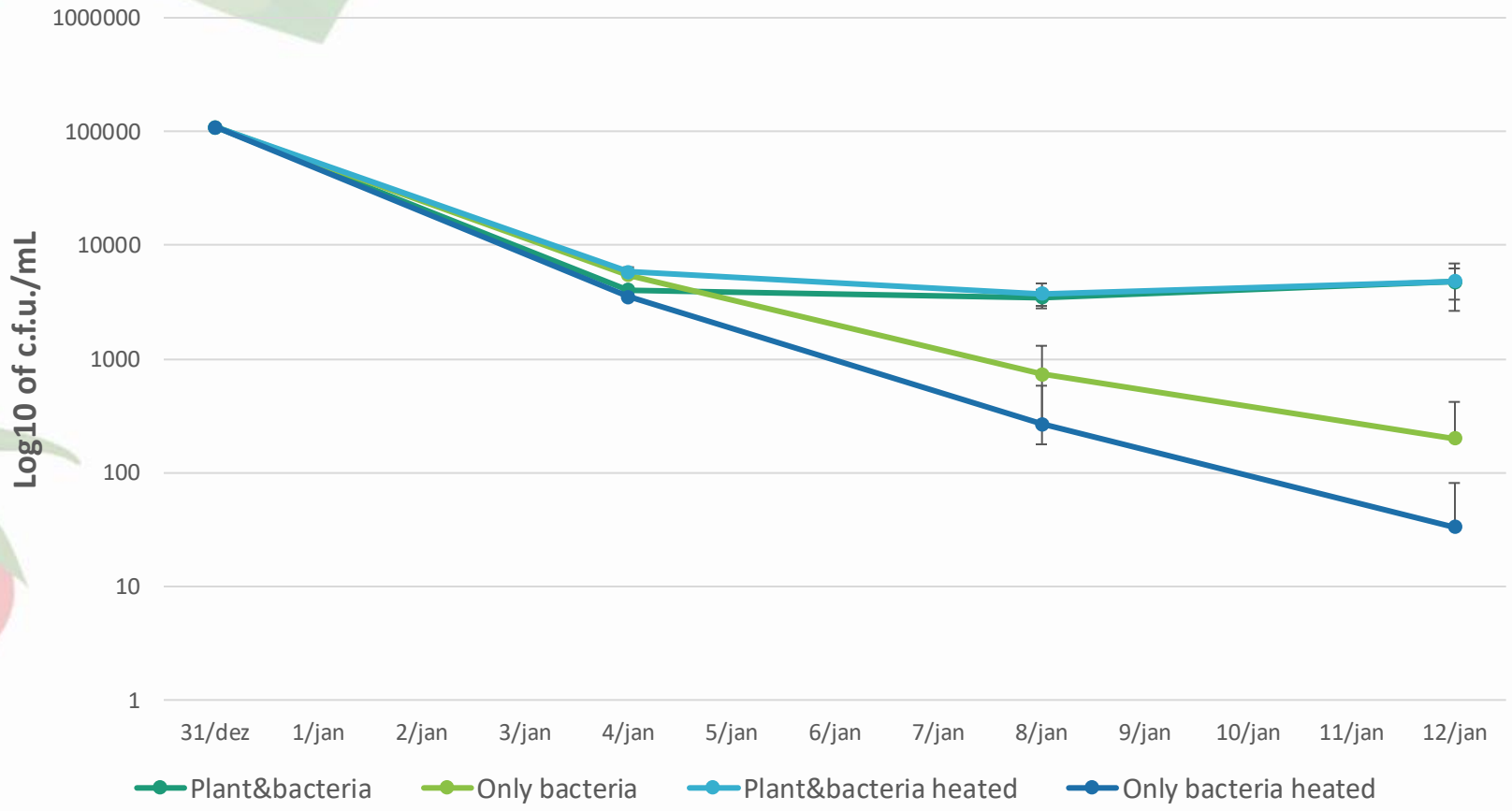


IAA production:

5 to 20 µg/mL IAA

Results: Tomato and *P. thermoglucosidasius* CECT 9160 interaction

Comparison of *P. thermoglucosidasius* survival with and without tomato in Hoagland solution



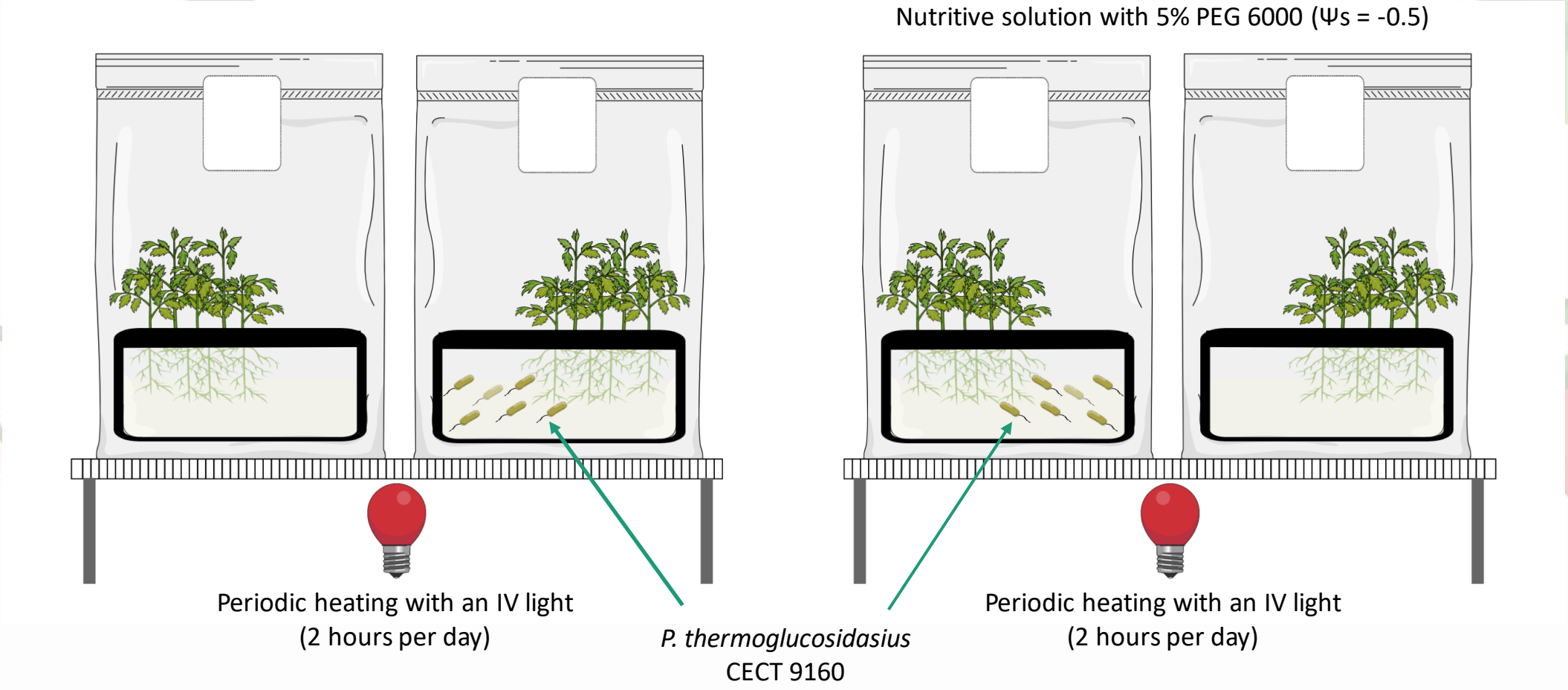
- ↑ survival with plant
- Probably adherent to the roots

Tomato root before sonication:

Tomato root after sonication:

Results: Tomato and *P. thermoglucosidasius* CECT 9160 interaction

Effect on tomato growth in Hoagland solution vs Hoagland solution without sulphate



Results: Tomato and *P. thermoglucosidasius* CECT 9160 interaction

Effect on tomato growth in Hoagland solution vs Hoagland solution without sulphate

Hoagland ¼

Hoagland ¼ + 5% PEG 6000

Hoagland ¼ + *Parageobacillus* cT

Hoagland ¼ + 5% PEG 6000 + *Parageobacillus* cT

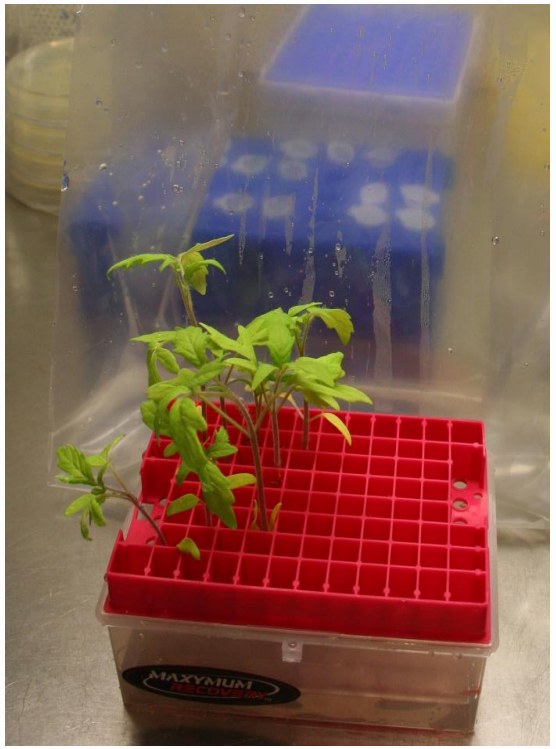
Results: Tomato and *P. thermoglucosidasius* CECT 9160 interaction

Effect on tomato growth in Hoagland solution vs Hoagland solution without sulphate

Hoagland sem S

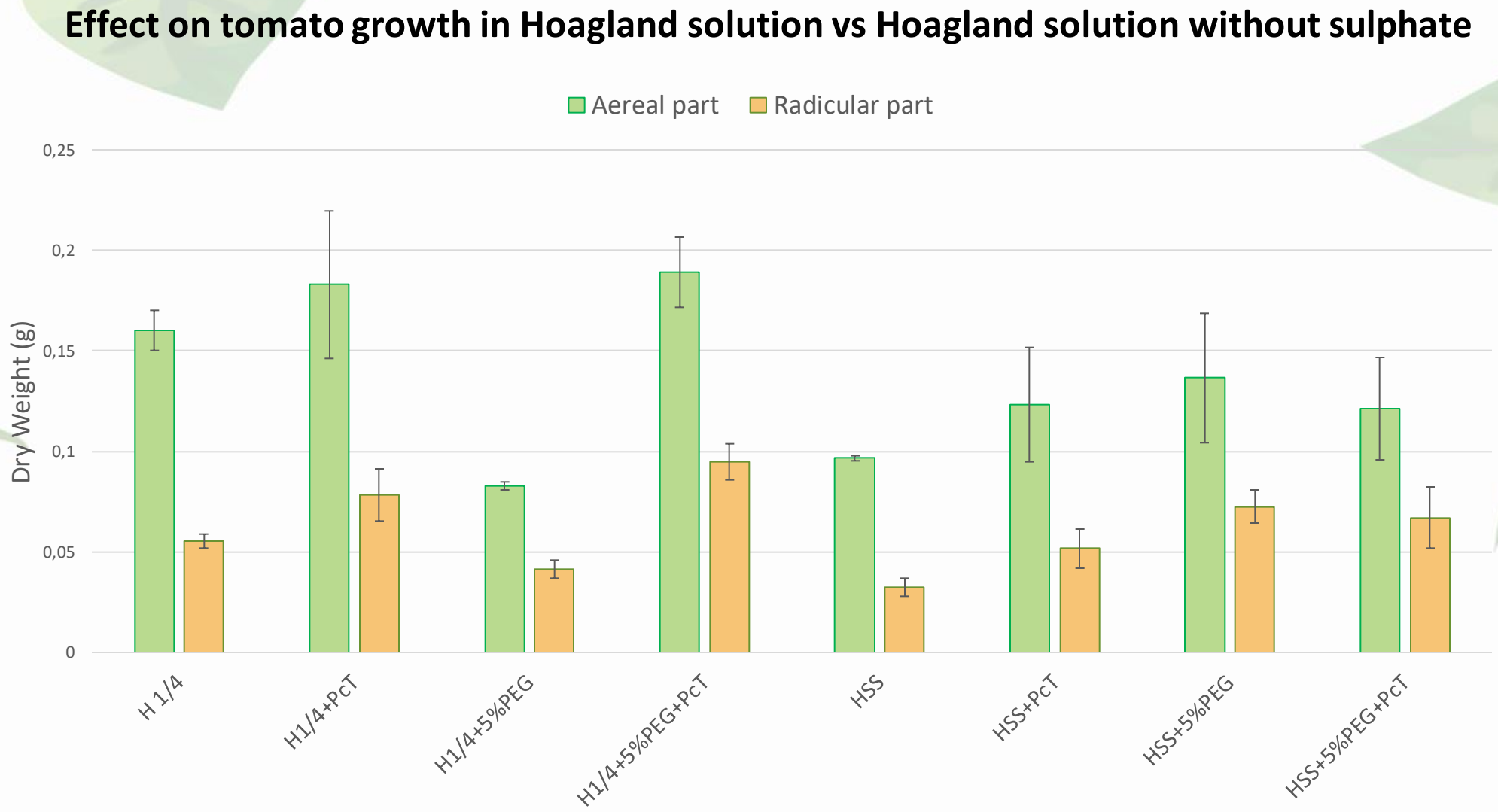
Hoagland sem S + 5% PEG 6000

Hoagland sem S + *Parageobacillus* cT



Hoagland sem S + 5% PEG 6000 + *Parageobacillus* cT

Results: Tomato and *P. thermoglucosidasius* CECT 9160 interaction



Conclusions:

- Tomato's bull hearts variety responds to moderate hydric stress with an increase in chlorophyl content and a different metabolic flux (activation of cyclic electron flow around photosystem I)

- A set of seven indices - **NDVI, SR, ZMI, Ctr2, GM1, GM2 and Ctr1** - can be used as promising proxies for early detection of hydric stress "invisible" responses

- *Parageobacillus thermoglucosidasius* CECT 9160 has **PGPR traits**

- *P. thermoglucosidasius* has the potential to be directly used as a PGPR promoting **tomato growth under hydric/osmotic and thermic stress**

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