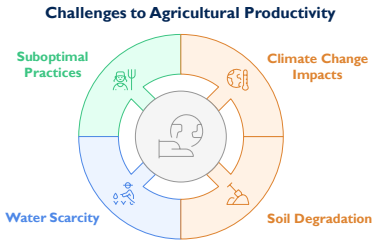
Impact of extracellular polymeric substances (EPS), biochar, and microbial inoculants on maize growth and irrigation needs

Alexandra Overall[1], Helena Moreira[1,2,3], Ana Sofia Sousa[1], Philipp Wilfert[4,5], Mark van Loosdrecht[4], Paula M. L. Castro[1], Sofia I.A. Pereira[1]*

*sapereira@ucp.pt

[1]Universidade Católica Portuguesa, CBQF - Centro de Biotecnologia e Química Fina – Laboratório Associado, Escola Superior de Biotecnologia, Porto, Portugal; [2]CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Campus de Vairão, Universidade do Porto, Portugal; [3]BIOPOLIS Program in Genomics, Biodiversity and Land Planning, CIBIO, Campus de Vairão, Portugal; [4]Department of Biotechnology, Faculty of Applied Sciences, Delft University of Technology, Delft, The Netherlands; [5]Present/Permanent address: University of Applied Sciences Lübeck, Urban Water management, Lübeck, Germany

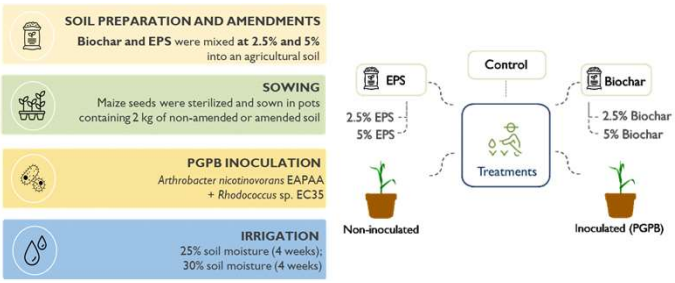
Aims and Scope



The combined use of soil microorganisms, namely plant growth-promoting bacteria (PGPB) and arbuscular mycorrhizal fungi (AMF), together with soil amendments (*e.g.* biochar) can improve essential soil functions and soil microbial biodiversity.

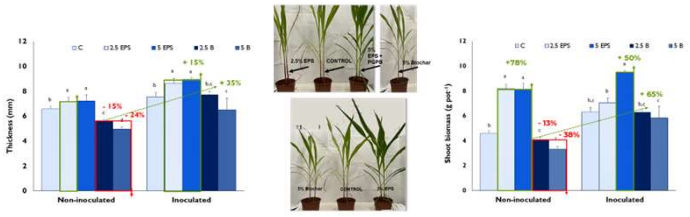
This work aimed to investigate the effects of combining plant growth-promoting bacteria (PGPB) with different doses of soil amendments - biochar and extracellular polymeric substances (EPS) - on maize growth and water irrigation requirements

Experimental Design



Results

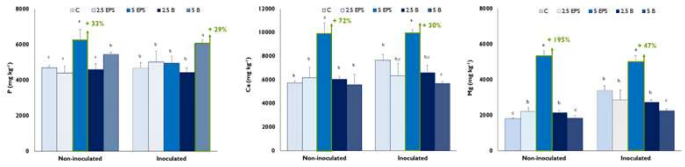
Plant Growth



- EPS addition increased stem thickness, shoot elongation and biomass
- Biochar reduced maize growth suggesting a detrimental effect on plant growth
- PGPB inoculation enhanced maize growth and mitigated the negative effects of biochar

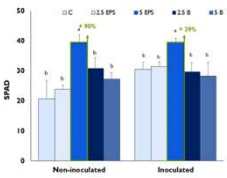
Results

Nutrient content



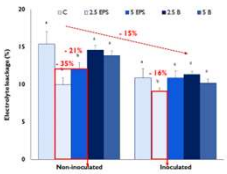
- Plants amended with **5% EPS** showed higher accumulation of P, Mg and Ca in shoots
- Bionoculation had a marginal effect on plant nutrition

Chlorophyll content

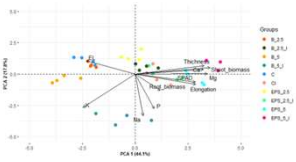


- SPAD readings were higher in plants grown with **5% EPS**
- Biochar - no significant diferences were observed

Electrolyte leakage

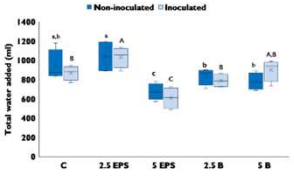


- Biochar-treated plants showed higher electrolyte leakage, suggesting a stress response likely responsible for the reduced growth observed in these plants
- **EPS** and **PGPB inoculation** decreased electrolyte leakage → protective effect to plants



- The enhanced nutrient concentration in shoots was associated with improved plant growth parameters in 5% EPS-amended soils
- Mg and Ca showed a strong correlation with shoot elongation, stem thickness, and biomass, highlighting their essential role in plant development
- A strong correlation was also observed between SPAD and Mg content

Irrigation needs



- **Biochar** reduced the irrigation needs by **9%**
- **5% EPS** reduced the irrigation needs by **30%**
- Inoculation did not significantly affect maize irrigation requirements

Conclusions

- EPS and PGPB inoculation increased shoot biomass, stem thickness, and chlorophyll content, suggesting improved nutrient availability and photosynthetic efficiency, while reducing irrigation needs. In contrast, biochar slightly reduced irrigation needs but induced plant stress, limiting growth.
- These results underscore the potential of combining EPS and microbial inoculants as a sustainable strategy to enhance maize production in water-limited conditions by improving soil water retention and nutrient uptake.

Acknowledgements

This study was financially supported by project ReCROP — Bioinocula and CROPping systems: an integrated biotechnological approach for improving crop yield, biodiversit and REsilience of Mediterranean agro-ecosystems, funded by Fundação para a Ciência e Tecnologia (PRIMA/0002/2020) under the framework of the Program for Research and Innovation solutions in the Mediterranean region (PRIMA). The authors also thank the CBQF scientific collaboration under the FCT project UIDB/50016/2020. The Kaumera was extracted within the European Union Horizon 2020 project WATER-MINING (Grant Agreement No 869474). PW and MvL were financially supported by this program. The authors also acknowledge COST Action Root-Benefit CA22142, supported by COST (European Cooperation in Science and Technology).