French Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes one of the PhD subjects proposed by the French Polytech network. The network is composed of 15 engineering schools/universities. The document also provides information about the supervisor. Please contact the PhD supervisor by email for further information regarding your application.

Supervisor information	
Family name	ROCHE and LAROCHE
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Web reference	Cliquez ou appuyez ici pour entrer du texte.
Lab name	Genetics, Diversity and Ecophysiology of Cereals Pascal Institute
Lab web site	https://eng-umr1095.clermont.hub.inrae.fr/ http://www.institutpascal.uca.fr/index.php/en/
Polytech name	Polytech Clermont
University name	Clermont INP, UCA
Country	France

PhD information	
Title	Development of innovative bioformulations of biostimulants based on microalgae polysaccharides

Main topics regards to CSC list (3 topics at maximum)	Green chemistry, Ecological agriculture
Required skills in science and engineering	Biotechnology, microbiology, plant biology

Subject description (two pages maximum including biblio)

Facing with global warming and the massive use of pesticides and chemical inputs, one of the planet's main challenges is to ensure food security for a growing world population, in a context of sustainable ecoproduction that moderates the use of water resources and chemical inputs. Water is currently one of the limiting factors for agriculture in arid and semi-arid regions. By 2030, it is estimated that global demand for water will be 50% higher, leading to water scarcity, especially as the agricultural sector accounts for 70% of global freshwater consumption. Models proposed by the IPCC (Intergovernmental Panel on Climate Change) predict a rise in average temperature of 2 to 4°C by 2050, accompanied by a reduction in the amount of water available for field crops (IPCC, 2014) and frequent episodes of severe drought. The dramatic consequences of these changes are manifold, with in particular a reduction in global production of field crops, such as wheat or rice, with losses estimated at 5% for 1°C of warming (Truong et al., 2017). On the other hand, the agriculture of the future is facing with the excessive use of synthetic inputs to meet ever-increasing production needs. In the long term, these can have alarming effects on human health and the environment (air pollution, soil toxicity, degradation of agroecosystems, accumulation of residues, resistance of pests and pathogens) (Sellare et al., 2020; Rani et al., 2021).

Over the past decade, plant biostimulants have been increasingly used in agriculture as environmentally friendly tools that improve the sustainability and resilience of plant production systems under conditions of environmental stress. Agriculture is one of the sectors most sensitive to water scarcity and drought due to global warming (Mancosu et al., 2015). Biostimulants are defined as molecules designed to enhance plant growth through mechanisms naturally present in plants without having harmful effects. They are seen as future alternatives to polluted mineral fertilizers. They are natural and/or biosourced materials that meet the requirements of the current agricultural transition in this difficult context. Among the various sources of biostimulants, polysaccharides represent an inexhaustible and diverse reserve, depending on their structure, composition and origin. Algae produce polysaccharides, in particular microalgae, which have the particularity of excreting them into the environment, making them more readily available.

Recent studies evaluated the microalgal EPS potentiality for agricultural applications as a plant growth biostimulant and as a protector against adverse conditions. The application of EPS from Dunaliella salina on tomato plants (Solanum lycopersicum) attenuated the salt stress caused by the presence of NaCl (El Arroussi et al., 2018). This reduction was observed by the lower content of salt stress indicators, such as

antioxidant enzymes, phenolic compounds, and proline. In addition, the treatment increased the root dry weight and the shoot length and dry weight.

Drira et al. (2021) evaluated the effect of pretreatment with EPS from P. sordidum in mitigating the damage caused by the fungus Fusarium oxysporum on the leaves of Arabidopsis thaliana. Foliar spraying with a solution containing EPS reduced the development of necrotic lesions and the disease severity caused by F. oxysporum. The application of EPS stimulates defense responses such as the production of hydrogen peroxyde (H2O2), accumulation of the enzyme phenylalanine ammonia-lyase (PAL), and upregulation of defense-related marker genes. All these indicators suggest that plants are capable of reacting to the application of these EPS, perceived as a signal molecule, enabling them to adapt to increasingly stressful environments.

In this thesis project, we plan to create innovative active bioformulations composed of EPS and to test their biostimulant power.

Initially, based on previous works in the 2 laboratories (Borjas et al. 2022; Bouissil et al. 2022), the aim of the project will be to cultivate in photobioreactors several strains of microalgae selected and to characterize the EPS produced under the supervision of Céline Laroche. The second stage will involve testing the biostimulant power of EPS derived from the selected strains under the supervision of Jane Roche. The third objective will be to formulate microalgae for soil application or foliar spraying on wheat or rice plants under the supervision of both the thesis directors.

The thesis will be carried out in 2 laboratories of national and international renown located on the Cézeaux campus: the GDEC laboratory (Genetics, Diversity and Ecophysiology of Cereals) and the Pascal Institute. The Pascal Institute has a very rich strain library of red and green microalgae, which could be explored during the thesis; and numerous photobioreactors. The GDEC has 2 important platforms: a phenotyping platform (Pheno3C, corresponding to super-equipped field microplots with sensors for measuring plant development and growth) and a genotyping platform (Gentyane, enabling sequencing of microalgae strains and transcriptomic analyses).

Several techniques will be employed:

- At the Pascal Institute: microalgae culture in photobioreactors, extraction, structural characterization and depolymerization of polysaccharides by chemical or enzymatic activities.
- At the GDEC: in vitro (wheat and rice) and platform plant cultivation, gene expression analysis techniques, sequencing and metabolomics.

References

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Sellare J. et al. (2020). Fairtrade, agrochemical input use and effects on human health and the environment. Ecological Economics 176,106718. https://doi.org/10.1016/j.ecolecon.2020.106718.

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Drira, M., Elleuch, J., Hlima, H.Ben, Hentati, F., Gardarin, C., Rihouey, C., Cerf, D.Le, Michaud, P., Abdelkafi, S., Fendri, I., 2021. Optimization of exopolysaccharides production by Porphyridium sordidum and their potential to induce defense responses in Arabidopsis thaliana against Fusarium oxysporum. Biomolecules 11, 1–18. doi: 10.3390/biom11020282.

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Borjas Esqueda A, Gardarin C, Laroche C. Exploring the Diversity of Red Microalgae for Exopolysaccharide Production. Mar Drugs. 2022 Mar 31;20(4):246. doi: 10.3390/md20040246.