

PhD thesis offer

Study of coumarin uptake by roots, a key mechanism for plant iron nutrition.

Contact: Christian DUBOS (IPSiM, Équipe FeROS, Montpellier, France)

✉ christian.dubos@inrae.fr

🌐 <https://www1.montpellier.inra.fr/wp-inra/bpmp/recherche/les-equipes/feros/>

Summary. Iron (Fe) is an essential micronutrient for plant productivity and the quality of their derived products. However, Fe is generally poorly available to plants because it is mainly present in the soil in the form of insoluble oxides/hydroxides. This is for instance the case in soils with neutral to alkaline pH, which account for about one third of the world's cultivated land. We have recently identified a new mechanism that enables plants (excluding grasses) to take up the iron present in these soils. This mechanism is based on the secretion of Fe mobilizing coumarins (specialized metabolites from the phenylpropanoid pathway), such as fraxetin. We have demonstrated that once secreted these coumarins form Fe³⁺-complexes that are then taken up by the plant root, thereby improving plant Fe nutrition. Once in the root, coumarins are stored in the vacuoles of different cell types (epidermis, cortex and endodermis). The next challenge to improve our understanding of this original mechanism is to characterize the transport dynamics of these coumarins from their removal from the soil to their storage in vacuoles, and to identify the molecular players involved. This is an essential issue if one aims at improving food crop production as well as providing better food for the growing population, without the use of exogenous fertilizers, which might be questioned in terms of sustainability in modern agriculture.

Research program:

1 - Molecular and physiological characterization of mutant lines affected in the uptake and/or intra- and/or intercellular partitioning of coumarins. The aim will be to characterize potential candidates identified following large-scale expression analysis experiments (i.e. RNA-seq and quantitative proteomics). In addition, candidate lines previously isolated following a genetic screen will be analyzed.

2 - Characterization of coumarin uptake dynamics. We have already conducted a first description of the accumulation profile of coumarins after their uptake into the root system. The aim here is to pursue the investigation by precisely analyzing the accumulation profile of coumarins along the root axes, and in the different cell types, of the selected mutants. To this end, we will be using an original approach, the spectral imaging, based on the fluorescence properties of coumarins.

3 - Integrated analysis of the dynamics of coumarin uptake and trafficking. This part of the thesis will involve a comparative study between the new players identified and the known genes involved in the biosynthesis and transport of coumarins, focusing on the location and abundance of the various proteins involved.

General information. The proposed 3-year thesis program is jointly funded by the INRAE's BAP Department and the ANR DYNAFER project. The thesis will be carried out in the FeROS team at IPSiM (Institut for Plant Sciences of Montpellier) under the supervision of Christian DUBOS. IPSiM is an institute whose research is focused on the study of the fundamental mechanisms governing the hydromineral nutrition of plants. The institute has several cutting-edge technical platforms (elemental quantification, imaging, proteomics) and a wide range of facilities dedicated to plant cultivation. Start date: September 2, 2023 (but can be postponed until January 2, 2025).

References:

- Robe K, et al. 2021. The Coumarins: Secondary Metabolites Playing a Primary Role in Plant Nutrition and Health. *Trends Plant Sci.* 26:248-259. doi: 10.1016/j.tplants.2020.10.008.
- Robe K, et al. 2021. Coumarin accumulation and trafficking in *Arabidopsis thaliana*: a complex and dynamic process. *New Phytol.* 229:2062-2079. doi: 10.1111/nph.17090.