DOCTORAT ECOLOGIE
BRETAGNE GEOSCIENCES
LOIRE AGRONOMIE ALIMENTATION

PhD PROPOSAL FOR THE DOCTORAL SCHOOL « Ecologie, Géosciences, Agronomie, ALimentation »

GENERAL INFORMATION

Thesis title: Correlative mappings to elucidate structure-property relationships of plant cuticle
Acronym: COPLAnAR
Disciplinary field 1: Agronomy **Disciplinary field 2:** Ecology
Three keywords: plant-polymer, cutin polysaccharides, phenolics
Research unit : UR Biopolymères Interactions Assemblages- INRAE Nantes
Name of the thesis director: Bénédicte Bakan **Email address of the thesis director : benedicte.bakan@inrae.fr** **Name of the thesis co-director (if applicable):** Marc Lahaye **Email address of the thesis co-director: marc.lahaye@inrae.fr** **Name of the thesis co-supervisor:** Angelina D'orlando **Email address of the thesis co-supervisor :** Angelina D'orlando <angelina.dorlando@inrae.fr>
Thesis grant (funding origin and amount): ANR
Contact(s) (mailing address and E-mail): INRAE La Geraudière 44316 Nantes cedex 03
Recruitment process: Recruitment process depends on thesis funding. To select the corresponding recruitment process, please visit the EGAAL website here. This information is needed for proposal publication. ☐ **Doctoral school contest** ☒ **Interview** ☐ **Other (indicate) :**

All sections must be filled. Once filled, please save the proposal form in pdf format using the following naming: Supervisor Name_Unit_Subject Acronym_EN.pdf

DOCTORAT ECOLOGIE
BRETAGNE GEOSCIENCES
LOIRE AGRONOMIE ALIMENTATION

SCIENTIFIC DESCRIPTION OF THE PhD PROJECT

Socio-economic and scientific context

The Biopolymers-Interactions-Assemblies (BIA) Unit develops research on the sustainable transformation of agricultural resources and plant biomass.

Among these polymers, the cuticle covers all the aerial parts of the plant organs. The cuticle is a supramolecular structure combining lipid polymers, polysaccharides and phenolic compounds.

The biological functions (resistance to biotic and abiotic stresses) and technological properties (post-harvest fruit preservation, fractionation and industrial processing) of cuticular bases are closely associated with their architecture. Currently, these structure-property relationships of cuticular bases are a major issue for tomorrow's agriculture (plants grown with environmental stresses, less input) as well as for the definition of new bioinspired materials.

Assumptions and questions

Plant cuticles are complex hydrophobic edifices of lipidic (cutin, a polyester of hydroxylated fatty acids) and polysaccharide (pectin, hemicellulose, cellulose) polymers. They are involved in the development of plants and their resistance to environmental stresses, and are now a prime target for the selection of plants adapted to climate change. The relationships between the architecture of these polymer assemblies and their functional properties are still lacking. The objective of COPLANAR is to decipher the macromolecular architecture of this natural biocomposite by correlative biochemical and spectrophotometric approaches associated with data and image analysis, in relation with mechanical properties at different scales.

Using tomato as a model, this approach will benefit from original mutants affected in the structure of lipid and polysaccharide polymers.

The main steps of the thesis and scientific procedure

The model plant used for this thesis will be the tomato fruit whose cuticle size is compatible with the targeted structural analyses and on which the laboratory and the partners of the COPLAnAR project have acquired an expertise.

In a preliminary stage prior to the beginning of the thesis (ongoing stage), fruits affected in the biosynthesis of the cuticle will be generated by two partners of the project (INRAE Bordeaux, Cornell University). The cuticles of these fruits will be extracted and their structure will be characterized macroscopically (in particular their composition and mechanical properties) by the PhD student.

In addition, mapping approaches using different spectral microscopy approaches on the same anatomical regions will be developed and applied to these different cuticle variants.

In a third step, the integration of structural data of these assemblies and their mechanical properties will allow to establish the structure/property relationships.

Methodological and technical approaches considered

The structural characterization methods of cuticular bases and associated polysaccharides are available in the BIA laboratory in the ELIPS and PVPP teams, respectively. In addition, the BIA laboratory has the capacity to characterize the mechanical properties of these cuticles (MC2 team). These methods can be applied before and after enzymatic treatment and will allow to characterize the hydrolysis products (GC-MS, MALDI-TOF-MS, LC-MS) but also the structural modifications of the composite.

The mapping approaches will be performed at BIA (BIBS platform), in the PANTHER unit (APEX platform) and at ICP (Orsay University).

DOCTORAT ECOLOGIE
BRETAGNE GEOSCIENCES
LOIRE AGRONOMIE ALIMENTATION

Scientific and technical skills required by the candidate

The thesis project is multidisciplinary. The candidate will have a Master 2 or equivalent, and will have skills in plant biology and plant biochemistry including analytical chemistry (GC-MS, LC-MS, FT-IR, RAMAN, enzyme biochemistry, MALDI-TOF-MS). Knowledge in chemometrics and statistical analysis (R) will be highly appreciated.

Ability to synthesize and communicate scientifically in English.

Rigor and organization, listening skills, ability to work in a team and interact with teams of different scientific cultures (multidisciplinary) and to integrate quickly into a research group.

THESIS SUPERVISION[1]

Unit name:	**Team name:**
INRAE UR Biopolymer Interactions Assembly	ELIPS
Unit director name:	**Team director name:**
Bernard CATHALA	Bénédicte BAKAN
Mailing address of the unit director:	**Mailing address of the team director:**
Bernard.cathala@inrae.fr	Benedicte.bakan@inrae.fr

Thesis director

Surname, first name: BAKAN Bénédicte

Position: Research Director

Obtained date of the HDR (Habilitation thesis to supervise research): 2015

Employer: INRAE

Doctoral school affiliation: EGAAL

Rate of thesis supervision in the present project (%): 40

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 50

Number of current thesis supervisions/co-supervisions: 1

Thesis co-supervisor 1 (if applicable)

Surname, first name: LAHAYE Marc

Position: DR

Habilitation thesis to supervise research ☒ yes ☐ no If yes, date diploma received: 1995

Employer: INRAE

Doctoral school affiliation: EGAAL

Rate of thesis supervision in the present project (%): 30

[1] **In EGAAL Doctoral School, if only one scientist in thesis supervision = 100% of supervision rate; if 2 people involved in thesis supervision = from 50% to 70% of supervision rate for the director; if 3 people involved in thesis supervision = 40% / 30% / 30% of supervision rate distribution among supervisors.**

DOCTORAT ECOLOGIE
BRETAGNE GEOSCIENCES
LOIRE AGRONOMIE ALIMENTATION

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 100

Number of current thesis supervisions/co-supervisions: 2

Thesis co-supervisor 2 (if applicable)

Surname, first name: D'Orlando Angelina

Position: IR

Habilitation thesis to supervise research ☐ yes ☒ no If yes, date diploma received:

Employer: INRAE

Doctoral school affiliation: EGAAL

Rate of thesis supervision in the present project (%): 30

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 0

Number of current thesis supervisions/co-supervisions: 0

Professional status of previous PhD students supervised by both director and co-supervisors (from 5 years)

Please provide the following information for each PhD students supervised

Surname, first name: **PHILIPPE, Glenn**

Date of PhD beginning and PhD defence: **2014-2017**

Thesis supervision: **D Marion, B Bakan**

Professional status and location: **Université de Cornell (USA)**

Contract profile (post-doc, fixed-term, permanent): **post doc**

List of publications from the thesis work:

Philippe, G., C. Gaillard, J. Petit, N. Geneix, M. Dalgalarrondo, C. Bres, J. P. Mauxion, *et al.* "Ester Cross-Link Profiling of the Cutin Polymer of Wild-Type and Cutin Synthase Tomato Mutants Highlights Different Mechanisms of Polymerization." [In eng]. *Plant Physiology* 170, no. 2 (Feb 2016): 807-20. https://doi.org/10.1104/pp.15.01620. http://www.ncbi.nlm.nih.gov/pubmed/26676255.

Philippe, G., N. Geneix, J. Petit, F. Guillon, C. Sandt, C. Rothan, M. Lahaye, D. Marion, and B. Bakan. "Assembly of Tomato Fruit Cuticles: A Cross-Talk between the Cutin Polyester and Cell Wall Polysaccharides." *New Phytol* 226, no. 3 (May 2020): 809-22. https://doi.org/10.1111/nph.16402. https://www.ncbi.nlm.nih.gov/pubmed/31883116.

Velickovic, D., H. Herdier, G. Philippe, D. Marion, H. Rogniaux, and B. Bakan. "Matrix-Assisted Laser Desorption/Ionization Mass Spectrometry Imaging: A Powerful Tool for Probing the Molecular Topology of Plant Cutin Polymer." [In eng]. *Plant J* 80, no. 5 (Dec 2014): 926-35. https://doi.org/10.1111/tpj.12689. http://www.ncbi.nlm.nih.gov/pubmed/25280021.

Five main recent publications of the supervisors on thesis subject:

Bakan, Benedicte, and Didier Marion. "Assembly of the Cutin Polyester: From Cells to Extracellular Cell Walls." *Plants* 6, no. 4 (2017): 57. http://www.mdpi.com/2223-7747/6/4/57.

Lahaye, Marc, Wafae Tabi, Lucie Le Bot, Mickael Delaire, Mathilde Orsel, José Antonio Campoy, José Quero Garcia, and Sophie Le Gall. "Comparison of Cell Wall Chemical Evolution During the Development of Fruits of Two Contrasting Quality from Two Members of the Rosaceae Family: Apple and Sweet Cherry." *Plant Physiology and Biochemistry* 168 (2021/11/01/ 2021): 93-104. https://doi.org/https://doi.org/10.1016/j.plaphy.2021.10.002. https://www.sciencedirect.com/science/article/pii/S098194282100512X.

Philippe, G., C. Gaillard, J. Petit, N. Geneix, M. Dalgalarrondo, C. Bres, J. P. Mauxion, *et al.* "Ester Cross-Link Profiling of the Cutin Polymer of Wild-Type and Cutin Synthase Tomato Mutants Highlights Different Mechanisms of Polymerization." [In eng]. *Plant Physiology* 170, no. 2 (Feb 2016): 807-20. https://doi.org/10.1104/pp.15.01620. http://www.ncbi.nlm.nih.gov/pubmed/26676255.

Philippe, G., N. Geneix, J. Petit, F. Guillon, C. Sandt, C. Rothan, M. Lahaye, D. Marion, and B. Bakan. "Assembly of Tomato Fruit Cuticles: A Cross-Talk between the Cutin Polyester and Cell Wall Polysaccharides." *New Phytol* 226, no. 3 (May 2020): 809-22. https://doi.org/10.1111/nph.16402. https://www.ncbi.nlm.nih.gov/pubmed/31883116.

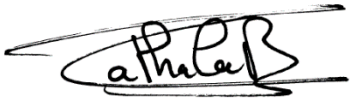
Reynoud, N., J. Petit, C. Bres, M. Lahaye, C. Rothan, D. Marion, and B. Bakan. "The Complex Architecture of Plant Cuticles and Its Relation to Multiple Biological Functions." *Front Plant Sci* 12 (2021): 782773. https://doi.org/https://doi.org/10.3389/fpls.2021.782773. https://www.ncbi.nlm.nih.gov/pubmed/34956280.

THESIS FUNDING

Origin(s) of the thesis funding: ANR
Gross monthly salary: 1975 €
Thesis funding state : Acquired
Funding beginning date/Funding ending date: oct-nov 2022

Date: 21th March 2022

Name, signature of unit director: Bernard CATHALA



Name, signature of team director: Bénédicte BAKAN

DOCTORAT ECOLOGIE
BRETAGNE GEOSCIENCES
LOIRE AGRONOMIE ALIMENTATION

Name, signature of thesis project director: Bénédicte BAKAN