

## PhD PROPOSAL FOR THE DOCTORAL SCHOOL « Végétal, Animal, Aliment, Mer, Environnement »

### GENERAL INFORMATION

<p><b>Thesis title:</b> Metabolic response and priming after electromagnetic pulses in tomato (<i>Solanum Lycopersicon</i>).</p>
<p><b>Acronym of the project:</b> PULSEPRIME</p>
<p><b>Disciplinary field 1:</b> plant and animal biology and physiology <b>Disciplinary field 2:</b> agronomy</p>
<p><b>Three keywords:</b> electromagnetic pulses– metabolic responses - priming</p>
<p><b>Registration establishment:</b> université d'Angers</p>
<p><b>Research unit:</b> UMR 1345 IRHS</p>
<p><b>Name of the thesis director HDR (Accreditation to supervise research) required:</b> Vian, Alain <b>Email address of the thesis director:</b> alain.vian@univ-angers.fr <b>Name of the thesis co-director (if applicable): HDR (Accreditation to supervise research) required:</b> Bonnet, Pierre <b>Email address of the thesis co-director (if applicable):</b> pierre.bonnet@uca.fr <b>Name of the thesis co-supervisor 1 (if applicable):</b> <b>Email address of the thesis co-supervisor 1 (if applicable):</b> <b>Name of the thesis co-supervisor 2 (if applicable):</b> <b>Email address of the thesis co-supervisor 2 (if applicable):</b></p>
<p><b>Contact(s) (mailing address and E-mail):</b> UMR 1345 IRHS – 42 rue G. Morel – 49070 Beaucouzé Alain.vian@univ-angers.fr</p>
<p><input checked="" type="checkbox"/> <b>Doctoral school contest</b></p> <p><input type="checkbox"/> <b>Interview</b></p> <p><input type="checkbox"/> <b>Other (specify):</b></p>

## SCIENTIFIC DESCRIPTION OF THE PhD PROJECT

### Socio-economic and scientific context: (10 lines)

In recent years, climate warming has subjected vegetation to increasingly frequent episodes of water stress. The ability of plants subjected to a first stress to "store" this event in order to react more effectively when a second stress occurs at a later date (conditioning or priming phenomenon) is the subject of a great deal of research. Several studies have shown that exposing seeds to a static magnetic field or a cold plasma flow subsequently increases plant vigor and their ability to respond to salt stress. The PULSEPRIME project aims to use electromagnetic pulses to condition tomato germinations or seedlings in order to subsequently improve their resistance to water stress and study the underlying molecular mechanisms, which are currently poorly documented. This project is part of the " Mechanisms of plant response and adaptation to the biotic and abiotic environment " axis of the IRHS.

### Assumptions and questions (8 lines)

Can exposure to electromagnetic pulses condition a plant and thus improve its tolerance to subsequent water stress? The hypothesis is that this exposure induces biochemical, genome expression and epigenetic changes constituting events capable of being recorded ("memorized") by the plant, which would thus be conditioned. This would enable the plant to respond more effectively to future environmental stress. Our aim is therefore to characterize the biochemical and molecular changes that occur after the application of electromagnetic pulses, and to determine whether they can be associated with an improvement in the plant's tolerance to water stress.

### The main steps of the thesis and scientific procedure (10-12 lines)

Experiments will be carried out on tomato (*Solanum lycopersicon* cv MoneyMaker) sprouts or young seedlings, using high-amplitude electromagnetic pulses delivered by a dedicated applicator. The first phase will involve determining the optimum exposure conditions for inducing metabolic changes in the plant, which we will characterize using biochemical and molecular approaches (RNA-sequencing and epigenome studies). These exposure conditions will also be modeled by an electrical equivalent of the plant to improve understanding of the interface between electromagnetic pulses and biological responses. The ultimate aim is to understand the biochemical and molecular responses of the plant and increase its tolerance to water stress. Adaptation to water stress will be assessed through phenotypic analysis (morphological monitoring of plant development) and physiological analysis (measurements of water potential, transpiration, stomatal opening, photosynthetic activity).

### Methodological and technical approaches considered (4-6 lines)

Exposure of tomato (radicle emergence stage and/or young seedlings) to electromagnetic pulses (3-5 kV - a few nanoseconds) using dedicated applicators. Creation of an electrical equivalence model of the plant to describe the propagation of electromagnetic pulses in plant tissues. Study of the behavior of plants treated in this way through morphological (growth measurements, branching, root development), physiological (transpiration, water potential), biochemical (enzymatic activities, photosynthetic activity, ROS metabolism) and molecular (RNA extraction, qPCR gene expression analysis, RNAsequencing, epigenome) analyses.

### Scientific and technical skills required by the candidate

The candidate must have a good knowledge of plant physiology, molecular biology and biochemistry. Knowledge of techniques such as enzymatic activity or genome expression measurements by qPCR would be an asset. No particular expertise in radiation physics is required.

## THESIS SUPERVISION

<b>Unit name:</b> UMR 1345 IRHS	<b>Team name:</b> STREMHO
<b>Unit director name:</b> Marie-Agnès Jacques	<b>Team director name:</b> Nathalie Leduc
<b>Mailing address of the unit director:</b> marie-agnes.jacques@inrae.fr	<b>Mailing address of the team director:</b> nathalie.leduc@univ-angers.fr
<p><b>Thesis director</b></p> <p>Surname, first name: VIAN, Alain</p> <p>Position: Professor</p> <p>Obtained date of the HDR (Accreditation to supervise research): 29/11/2007</p> <p>Employer: université d'Angers</p> <p>Doctoral school affiliation: VAAME</p> <p>Rate of thesis supervision in the present project (%): 70%</p> <p>Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 0%</p> <p>Number of current thesis supervisions/co-supervisions: 0</p>	
<p><b>Thesis co-director</b></p> <p>Surname, first name: Bonnet, Pierre</p> <p>Position: Professor</p> <p>Obtained date of the HDR (Accreditation to supervise research): 19/06/2008</p> <p>Employer: université Clermont-Auvergne</p> <p>Doctoral school affiliation: Sciences Pour l'Ingénieur (ED No 70)</p> <p>Rate of thesis supervision in the present project (%): 30%</p> <p>Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 60%</p> <p>Number of current thesis supervisions/co-supervisions: 1</p>	
<p><b>Professional status of previous PhD students supervised by both director and co-supervisors (from 5 years)</b></p> <p><i>Please provide the following information for <u>each</u> PhD students supervised</i></p>	

*Under the supervision of Alain VIAN*

Surname, first name: PORCHER, Alexis

Date of PhD beginning and PhD defence: 1/10/1997 – 10/12/2020

Thesis supervision: Alain VIAN

Professional status and location: Post-doc, university of Helsinki, Finland

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

List of publications from the thesis work:

Porcher A, Guérin V, Montrichard F, Lebrec A, Lothier J, **Vian A**. Ascorbate glutathione-dependent H<sub>2</sub>O<sub>2</sub> scavenging is an important process in axillary bud outgrowth in rosebush. *Annals of Botany* 126:1049–1062 (2020) IF : 4,00

Porcher A, Guérin V, Lebrec A, Leduc N, Lothier J, **Vian A**. Glutathione synthesis and AsA-GSH pathway, mediated by cytokinins, manage H<sub>2</sub>O<sub>2</sub> level in bud burst photocontrol. *Plant Physiology* 186: 910–928 (2021). IF : 8,34. IF : 8,34.

Porcher A, Guérin V, Macherel D, Lebrec A, Satour P, Lothier J, **Vian A**. High expression of ALTERNATIVE OXIDASE 2 in latent axillary buds suggests its key role in quiescence maintenance in rosebush. *Plant & Cell Physiology* 64( 2): 165–175 (2023). IF: 4,92

*Under the supervision of Pierre Bonnet*

Surname, first name: MASSAOUDI Imane

Date of PhD beginning and PhD defence: 01/10/2020-19/12/2023

Thesis supervision: P. Bonnet

Professional status and location: research scientist (Altran company)

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

List of publications from the thesis work:

I. MASSAOUDI, P. BONNET, "A Domain Decomposition Approach for Cost Effective Transmission Lines Time Domain Stochastic Simulations," in *IEEE Transactions on Electromagnetic Compatibility*, Early Access 10 Jan. 2024, [10.1109/TEMC.2023.3342275](https://doi.org/10.1109/TEMC.2023.3342275)

Surname, first name: AL IBRAHIM, Ali

Date of PhD beginning and PhD defence: 01/10/2017-28/01/2021

Thesis supervision: P. Bonnet

Professional status and location: research scientist (EDF Energie Marine)

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

List of publications from the thesis work:

A AL IBRAHIM, C. CHAUVIERE, P. BONNET, "Experimental Validations of Time-Domain Voltage/Current Control: Electrical Correction of Faulty Transmission-Line Networks," in *IEEE Transactions on Instrumentation and Measurement*, vol. 72, pp. 1-10, 2023, [10.1109/TIM.2023.3304680](https://doi.org/10.1109/TIM.2023.3304680)

V. MAZIERES, A AL IBRAHIM, C. CHAUVIERE, **P. BONNET**, R. PASCAUD, R. CLERGEREAUX, S. DAP, L LIARD, O. PASCAL, *Transient Electric Field Shaping With the Linear Combination of Configuration Field Method for Enhanced Spatial Control of Microwave Plasmas*, in IEEE Access, vol. 8, pp. 177084-177091, 2020, doi: [10.1109/ACCESS.2020.3025366](https://doi.org/10.1109/ACCESS.2020.3025366)

A AL IBRAHIM, C. CHAUVIERE, **P. BONNET**, *Active Electromagnetic Interference Control in Time Domain: Application to Software Correction of Defective Lossy Transmission-Line Networks*, in IEEE Transactions on Electromagnetic Compatibility, vol. 62, no. 2, pp. 355-363, April 2020, [10.1109/TEMC.2019.2911035](https://doi.org/10.1109/TEMC.2019.2911035)

Surname, first name: GAYRARD Emeline

Date of PhD beginning and PhD defence: 17/10/2016-14/11/2019

Thesis supervision: P. Bonnet & H. Djellout

Professional status and location: research scientist in “Big data” science in bank service

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

List of publications from the thesis work:

E. GAYRARD, C. CHAUVIERE, H. DJELLOUT, **P. BONNET**, *Modeling experimental data with polynomials chaos*. Probability in the Engineering and Informational Sciences, Vol. 34, Issue 1, Jan. 2020 pp.14-26. DOI: <https://doi.org/10.1017/S026996481800030X>

E. GAYRARD, C. CHAUVIERE, H. DJELLOUT, **P. BONNET**, D.-P. ZAPPA, *Global sensitivity analysis for stochastic processes with independent increments*, Probabilistic Engineering Mechanics, Vol. 62, 2020, <https://doi.org/10.1016/j.probengmech.2020.103098>

E. GAYRARD, C. CHAUVIERE, H. DJELLOUT, **P. BONNET**, *Modeling experimental data with Polynomials Chaos*, Journal of Probability in the Engineering and Informational Sciences, Vol. 34, Issue 1, pp. 14-26, Jan. 2020.

Surname, first name: OSMAN Ousama

Date of PhD beginning and PhD defence: 01/10/2017-07/12/2020

Thesis supervision: P. Bonnet & F. Paladian

Professional status and location: researcher-engineer

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

List of publications from the thesis work:

O. OSMAN, S. SALLEM, L. SOMMERVOGEL, M. OLIVAS CARRION, **P. BONNET**, and F. PALADIAN, *Sensor Communication Implementation Using Multicarrier Reflectometry for Distributed Diagnosis in Complex Wired Networks*, in IEEE Transactions on Electromagnetic Compatibility, vol. 63, no. 3, pp. 902-911, June 2021, doi: [10.1109/TEMC.2020.3034175](https://doi.org/10.1109/TEMC.2020.3034175)

O. OSMAN, S. SALLEM, L. SOMMERVOGEL, M. OLIVAS CARRION, **P. BONNET**, and F. PALADIAN, *Distributed Sensor Diagnosis in Twisted Pair Networks for Soft Fault Identification Using Reflectometry and Neural Network*, Progress In Electromagnetics Research C, Vol. 100, 83-93, January 2020. [10.2528/PIERC19122402](https://doi.org/10.2528/PIERC19122402)

O. OSMAN, S. SALLEM, L. SOMMERVOGEL, M. OLIVAS CARRION, **P. BONNET**, and F. PALADIAN, *Distributed Reflectometry for Soft Fault Identification in Wired Networks Using Neural Network and*

*Genetic Algorithm*, IEEE Sensors Journal, Vol. 20, no. 9, pp. 4850-4858, May 2020.  
[10.1109/JSEN.2020.2965287](https://doi.org/10.1109/JSEN.2020.2965287)

O. OSMAN, S. SALLEM, L. SOMMERVOGEL, M. OLIVAS CARRION, **P. BONNET**, and F. PALADIAN, *Method to improve fault location accuracy against cables dispersion effect*, Progress In Electromagnetics Letters, vol. 83, 29-35, January 2019. [10.2528/PIERL19021907](https://doi.org/10.2528/PIERL19021907)

Surname, first name: RABAT Amélie

Date of PhD beginning and PhD defence: 01/10/2015-16/12/2019

Thesis supervision: P. Bonnet & K. El Kamlichi

Professional status and location: unknown

Contract profile (post-doc, fixed-term, permanent): N/A

List of publications from the thesis work:

A. RABAT, **P. BONNET**, K. EL KHAMLICHI, S. GIRARD, "An Analytical Evaluation of the Shielding Effectiveness of Enclosures Containing Complex Apertures," in IEEE Access, vol. 9, pp. 147191-147200, 2021, doi: [10.1109/ACCESS.2021.3123441](https://doi.org/10.1109/ACCESS.2021.3123441)

#### Five main recent publications of the supervisors on thesis subject:

Kaur St, **Vian A**†, Pal Singh H, Chandel S, Batish DR, Sharma VP, Kohli RK. Radio Frequency Electromagnetic Field Radiations: Insights into Plant Sensitivity and Mechanisms. Environmental pollution. Reviews in Environmental Science and Bio/Technology 20: 55–74 (2021). **IF : 14,3 – † : contribution égale des auteurs.**

Czerwinski M, **Vian A**, Woodcock BA, Golinski P, Recuero Virto L, Januszkiewicz L. Do electromagnetic fields used in telecommunications affect wild plant species? A control impact study conducted in the field. Biological indicators 150 : 110267 (2023). **IF : 6,26.**

Porcher A, Girard S, Bonnet P, Rouveure R, Guérin V, Paladian F, **Vian A**. Non thermal 2.45 GHz electromagnetic exposure causes rapid changes in Arabidopsis thaliana metabolism. Journal of Plant Physiology 286 : 153999 (2023). **IF : 3,69.**

Porcher A, Wilmot N, Bonnet P, Procaccio V, **Vian A**. Changes in Gene Expression After Exposing Arabidopsis thaliana Plants to Nanosecond High Amplitude Electromagnetic Field Pulses. Bioelectromagnetics 45:4--15 (2024). **IF : 1,9.**

Handa AP, **Vian A**, Singh HP, Kohli RK, Kaur S, Batish DR. Effect of 2850 MHz electromagnetic field radiation on the early growth, antioxidant activity, and secondary metabolite profile of red and green cabbage (Brassica oleracea L.). Environmental Science and Pollution Research (*in press*) doi.org/10.1007/s11356-023-31434-3. **IF : 5,8.**

## THESIS FUNDING

<b>Origin(s) of the thesis funding:</b> doctoral contract from university of Angers
<b>Gross monthly salary:</b> 2100€
<b>Thesis funding state:</b> Non acquired
<b>Funding beginning date/duration of the thesis funding:</b> 10/1/2024 – 36 months

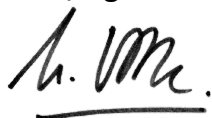
**Date:** 27/02/2024

**Name, signature of unit director:**

Marie-Agnès Jacques



**Name, signature of team director:**



Pr N LEDUC

**Name, signature of thesis project director:**

Professor Alain VIAN



**All sections must be filled in. Once completed, please save the proposal form in PDF format using the following naming: Supervisor Name\_Unit\_Subject Acronym\_EN.pdf**  
**Please also send a Word version to make it easier to change the layout if necessary.**

**Documents to be send to:** [ed-vaame@doctorat-paysdelaloire.fr](mailto:ed-vaame@doctorat-paysdelaloire.fr)