PhD position opportunity

Phenotyping of resilience to lodging and identification of its determinants in wheat (*Triticum aestivum*)

Host team :

UMR PIAF (INRAe - Université Clermont-Auvergne) (Integrative Physics and Physiology of Trees in Fluctuating Environments), FRANCE

MECA team (Trees BioMECAnics)

Cézeaux University Campus, Aubière, France

Supervisors : Mélanie Decourteix et Bruno Moulia

Contract details :

Stipend acquired

Contract (36 months) **to be started in September 2026**.

Employer : Clermont-Auvergne University

Description of the PhD project :

While encountering the dual challenges of gravity and wind, plants can only remain upright by actively controlling their posture. In cereals, lodging is the cause of significant yield losses. Since the Green Revolution, the risk of lodging has been reduced by improving variety resistance, shortening stem height through the introgression of *rht* dwarfing genes (semi-dwarf varieties), and the use of chemical growth regulators.

Since these two approaches are now reaching their limits, we believe it would be worthwhile to explore the possibility of a paradigm shift. We therefore propose to study the **mechanisms underlying resilience to lodging (through active stem recovery following root lodging)**, which, compared to resistance traits, have been studied very little.

The research proposed in this thesis project aims to address this current challenge by laying the groundwork for a better understanding of genotype × environment × management interactions in the context of lodging, and by providing new insights for defining ideotypes capable of effectively restoring an upright posture following adverse events.

All terrestrial plants with an erect growth habit have developed mechanisms for recovering from lodging, which fall under the category of posture control. Our research has shown that three processes must be taken into account to study posture control : stimulus perception, response control, and the motor actuation of recovery. The mechanisms underlying these three processes have been studied primarily in dicotyledons, and very little in cereals. In cereals, they involve specialized structures, the pulvini, which carry out all three processes jointly. The collenchyma fibers of the pulvini, organized into large clusters and capable of differentially elongating between two faces of the same pulvinus, are thought to be crucial for actuation. Regarding stimulus perception, we have shown that postural control does not result solely from the perception of inclination (graviperception); plants must also perceive their own curvature. The identification of these proprioceptive capabilities is recent in plant species and has only

just been demonstrated in wheat. Furthermore, our previous work has shown that, in dicots, the speed of convergence and the final stem posture are determined by the balance of these two perceptions, which can be measured by the Balance Number B.

Objectives of the project

- Identify the traits that are important for effective resilience to lodging in wheat (*Triticum aestivum*)
- Identify a potential association between these traits and genetic variability,

Achieving these objectives will first require determining whether the Balance Number B is a proxy for the genetic variability of resilience capabilities in wheat varieties and whether the collenchyma fibers of the pulvini are responsible for both proprioceptive sensitivity and actuation in lodging resilience.

Research program

Task 1: Determination of graviperceptive and proprioceptive sensitivities and of the Balance number B under controlled conditions

This first phase of the project will involve to collect data on the curving and decurving kinetics of wheat shoots using an automated imaging system. These data will be analyzed using image analysis procedures developed in the laboratory for the model plant Arabidopsis and for poplar, which will be adapted to the segmented stem (articulated by pulvinus nodes) of cereals. Determining graviperceptive and proprioceptive sensitivities through this model-assisted phenotyping approach will then allow us to compare genotypes.

Task 2: Characterization of the sensory and motor properties of collenchyma fibers

The selected student will characterize the cellular elongation of collenchyma fibers between the faces of the pulvini during the curving and decurving phases. They will conduct experiments aiming at advancing our understanding of this phenomenon by analyzing the physiological (hormonal gradients and water movements), cellular (actin network organization), and molecular (gene expression) mechanisms that integrate gravi- and proprioceptive responses.

Task 3: Modeling the postural control of wheat stalks and sensitivity analysis

The selected student will participate in the conceptualization of a biophysical model to be implemented in collaboration with the team's biophysicists. A sensitivity analysis of all model parameters will be conducted to determine which traits most strongly influence postural control. The model's validity will be tested by comparing its outputs with the experimental data from Task 1.

Task 4: Study of genetic variability in the field

A campaign to measure the genetic variability of resilience to lodging will be conducted in collaboration with the UMR GDEC (Genetics, Diversity, and Ecophysiology of Cereals).

Desired Profile

Two types of candidates will be considered for this thesis:

- Either a Master's 2 student in biology with expertise in plant physiology as well as data analysis and statistics.
- Or a Master's 2 student in physics or biophysics with an interest in plant biology.

In both cases, the candidate must demonstrate motivation and an interest in plant biology and interdisciplinary research. Additionally, prior experience in conducting plant experiments is preferred.

The thesis will include a visit (several months) to a laboratory abroad. Mobility and fluency in scientific English are therefore essential.

Application Process

Application Deadline: June 25, 2026

Applications should be sent to melanie.decourteix@uca.fr

The best candidates will be shortlisted for an audition (early July—date to be determined).

Please submit the following documents **in a single PDF file**:

- a detailed resume
- a cover letter
- detailed transcripts for your first and second years of the master's program
- a letter of recommendation from each of your internship supervisors (particularly for your M1 and M2 internships)
- your Master's 2 thesis