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#### ► To cite this version:

Ikram Madani, Thanyakorn Rongsawat, Anne-Aliénor Véry, Hervé Sentenac, Jean-Benoît Peltier. Plasticity of root and root hair development in response to nutrient deficiency among wheat genotypes. EMBO workshop " Molecular responses of plants facing climate change ", Jun 2022, Montpellier, France. . hal-03812305

### HAL Id: hal-03812305 https://hal.science/hal-03812305

Submitted on 12 Oct 2022

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# Plasticity of root and root hair development in response to nutrient deficiency among wheat genotypes

# **I. Madani<sup>1</sup>,** T. Rongsawat<sup>1</sup>, A.A. Véry<sup>1</sup>, H. Sentenac<sup>1</sup>, J.B. Peltier<sup>1</sup>

<sup>1</sup>UMR B&PMP, CNRS-INRAE-Supagro-Univ Montpellier, 2 place Pierre Viala – 34060 Montpellier Cedex 2, France

<sup>2</sup>Montpellier Ressources Imagerie, BioCampus Montpellier, CNRS, INSERM, University of Montpellier

### Introduction

Reducing the ecological costs of conventional agriculture, including fertilization, is a major objective of research in plant science. High-throughput phenotyping of root traits as predictors of crop performance under limited water and nutrient available but these still often ignore root hairs (RHs), although these cells provide a major contribution to plant nutrient, water uptake and interactions with soil microbes. We developed a non-destructive procedure (based on a Rhizobox-type device) to phenotype wheat root hair development in whole root systems.

We used this system to phenotype the architectural traits of a landrace wheat variety *Triticum turgidum ssp. durum* cv. Oued Zenati and an ancestral wheat variety T. t. L. spp. dicoccum cv. Escandia and we performed an integrative analysis of the plasticity of root and root hair traits under low phosphorus availability

A rhizobox-type device providing high resolution images of root hairs (Rh) on intact root systems

1- Root hair phenotyping system (Rhizobox-like system)



2-Type of images obtained by the rhizobox





(1) Solid polyurethane foam board (2) Black polyester fabric (3) U-shape aluminium sliding bar. (4) Glassplate (5) Polystyrene board (C) Watering system. Pressurized air (0.6 bar) moves the nutrient solution from a reservoir bottle to the rhizobox via a symmetrical circuit

Roots are scanned through transpalent glassplate

# Vital staining of root hair cells indicating that most cells were alive

**3-** Root and root hair images vital staining



4 - Differences in rhizobox occupancy between wheat genotypes Rhizobox width: 21 cm central zone: 10 cm 120 100 80

Wheat seedling Oued Zenati grown for 14 days in a rhizobox and watered with complete hoagland solution.

Root and root hair image segmentation using the pixel-based trainable classifier llastik workflow.

# **Rhizobox for architectural traits phenotyping**

5 - Response to a physical constraint imposing vertical growth to seminal roots



(A) the FDA staining of RHs. (B) IP staining of RHs. (C) bright field image of RH. Pieces of fabric on which root regions harboring root hairs were present were carefully excised (without moving the root segment at the surface of the fabric to prevent root hair damages) and directly transferred into dual-labeling solution containing. Fluorescent di-acetate (FDA) and Propidium iodide (PI).Green staining is indicative of living cell. Red nuclei staining (white arrows) indicates dead cells.



(A) Procedure used to analyze rhizobox occupancy by the root system. The rhizobox area is vertically divided into a 10 cm wide "central" zone and 2 lateral zones (considered as a single zone of 11 cm width in total).

We introduced Plastic jumpers of different length in the rhizoboxes between the fabric and the glass plates to impose vertical growth for the seminal roots. (A) and (B) Representative images of the root system of a Oued and (C) and (D) of Escandia. (A) & (C) : control without plastic jumpers. (B) & (D): presence of plastic jumpers. Escandia showed a strong reorientation capacity toward a horizontal growth when the vertical constraint ceases.

Integrative analysis of the plasticity of root and root hair traits reveal differences between the 2 wheat accessions in low phosphorus condition



7 -Effects of low P on root hair elongation and density



# **Conclusion and perspectives**

The developed methodology allowed to differences between reveal root architectural traits the Of two accessions, and their responses to phosphorus starvation.



Pi shortage resulted in an increase in total root area (root skeleton) +RHs) mainly due to a large increase in RH area. The RH contribution to the increase in total root area upon Pi deficiency was especially significant in Escandia seedlings, the ratio of root hair area to total root area being increased by more than two times (from less than 15% to more than 30%) in this wheat accession upon Pi deficiency

Pi deficiency increased both root hair length and root hair density. the most prominent effect being on root hair length.



Representative images of root segment with root hairs in control condition (A) and Low P (B)

Such analyses pave the to way comparison of wheat genotypes that recapitulate wheat domestication in different abiotic conditions (nutrient availability) and in presence or absence of PGPR bacteria.

# **Acknowledgement:**

This work was supported by the Algerian Ministry of High Education and Scientific Research through the funding of the PhD of Ikram MADANI

