Phenotypic variation of root architectural, morphological and anatomical traits of Thai rice (*Oryza sativa*)

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**Abstract**

Drought and suboptimal nutrient availability significantly reduce crop production worldwide. A number of experiments have demonstrated that the phenotypes, measured as architectural, morphological, and anatomical crop root traits, influence the performance of water and nutrient uptake. Hence, quantifying the phenotypic variation of root traits supports breeders in their efforts to produce efficient varieties under resource limiting conditions. Rice (*Oryza sativa*) is one of the most important crop targets to relate observed phenotypes to the already sequenced genome. In this study we evaluated phenotypic variation of root traits in several Thai rice cultivars using roll-up and semi-hydroponic systems. Root architectural traits including root growth angle, post-embryonic crown root branching, and crown root number were evaluated using a modified high-throughput root phenotyping technique "Shovelomics" and DIRT software. Root morphological traits including root hair length and density were evaluated by microscopic techniques, and ImageJ software. Root anatomical traits including diameter of root cross-section, diameter of stele, and size and number of xylem vessels were evaluated by hand-section and RootScan software. We found a large natural variation in root traits including 3.4 fold difference in crown root number, 2 and 3 fold difference in root hair length and density, respectively. Root cortex of all cultivars is mainly occupied by air space but the stele consists of a wide range of number of xylem vessels. Our results support national rice breeding campaigns in Thailand that aim at rice varieties with improved water and nutrient acquisition properties.

**Results and discussions**

**Root Architectural traits:**

- Root architectural traits such as crown root number and root growth angle influence root distribution and resource acquisition (Saengwilai et al., 2014). Experiments are being carried out to examine physiological utility of these traits for nitrogen acquisition of rice in low N soils (Research of Methanon Sangachart).

**Root Morphological traits:**

- Long and dense root hairs are known for their role in enhancing acquisition of immobile resources particularly phosphorus. At present we are investigating physiological utility of these traits for the acquisition of potassium, another essential immobile resource, among several Thai rice cultivars (Research of Ayuwat Wannaro).

**Root anatomical traits:**

- Root anatomical traits influence water and nutrient transport, root metabolic costs, and mechanical strength. In this study, we found that the root cortex of all rice cultivars is predominantly composed of aerenchyma, a tissue containing air spaces. In contrast, the stele consists of a large extend of xylem and phloem vessels. Variation in size and number of xylem vessels influence root hydraulic conductivity, which affects plant water use efficiency. We are currently investigating xylem vessel traits conferring drought tolerance in rice (Research of Siwaporn Satarn).

**Materials and Methods**

**Part 1: Studying Root architectural traits**

- Rice cultivars were grown in a semi hydroponic system
- Shovelomics and DIRT software
- Measurements including root growth angle, crown root number and branching and root depth

**Part 2: Studying root hair length and density**

- Rice cultivars were grown in a roll-up system
- Toluidine blue staining and observed using macro zoom imaging system
- ImageJ software

**Part 3: Studying root anatomy**

- Rice cultivars were grown in a roll-up system
- hand-section and observed using macro zoom imaging system
- Root anatomical trait measurements by RootScan software

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**References**