Would rice varieties without root aerenchyma perform better in upland environments?

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Increasing rice production to feed the world in the 21st century remains a critical goal despite water scarcity and climate change. Upland rice requires less water and emits less methane. However, its yield potential has yet to be optimised from a market perspective, despite significant genetic advances. Recent researches have highlighted the importance of root aerenchyma, tissue cavities that transport gazes, in contrasted plant species. This study aimed to explore the potential of aerenchyma ratio as a valuable trait for upland rice breeding.

To test this hypothesis, we measured the percentage of aerenchyma volume in the root cortex (root porosity) and plant transpiration per leaf area (leaf transpiration) in ten rice varieties adapted to lowland, drought or upland environments, as well as fourteen CRISPR knockout lines with suppressed aerenchyma formation. Two cultivation methods were used: aerated hydroponics and substrate filled pots irrigated at field capacity. Differential treatments included aerated hydroponics versus anoxic hydroponics and flooded versus field capacity irrigation. At the 5-leaf stage, plant transpiration was measured, and root samples were collected to quantify porosity.

Our results showed that root porosity was significantly higher in lowland varieties compared to rainfed varieties, under anaerobic conditions compared to aerobic conditions, and closer to the root base than to the tip, regardless of the cultivation method. All CRISPR-edited lines had lower root porosity compared to their common parent. After one week of differential irrigation, leaf transpiration was lower under aerobic conditions compared to flooded conditions for most varieties and edited lines, while some upland or drought-tolerant varieties showed similar transpiration rates. In addition, a negative correlation was observed between leaf transpiration and root porosity under aerobic conditions.

This study is an important step toward utilizing root aerenchyma as a valuable trait in upland rice breeding, with the ultimate goal of ensuring food security and reducing the environmental footprint of rice crops. Our research is now focused on identifying key regulator genes of aerenchyma formation and developing efficient phenotyping techniques for aerenchyma traits.