How plant roots sense and react to soil flooding

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Arabidopsis thaliana. Credit: Wikipedia.

While we already knew that plant roots were capable of sensing many individual soil characteristics (water, nutrients and oxygen availability),

we did not have any understanding of how they integrated these signals in order to respond in an appropriate way. Researchers from CNRS and INRA have just discovered a mechanism that allows a plant to adjust its water status and growth according to different soil flooding conditions. The results of this study, published on 15 September 2016 in the journal *Cell*, describe how roots sense and respond to soil oxygen and potassium levels jointly, so as to change their water uptake capacity. Aside from their scientific importance, these findings could make it possible to optimize crop flood tolerance.

Although hidden from view, roots are essential for plant growth and survival. Their growth and branching in the soil allows the plant to take up the water and nutrients it needs. This underground activity requires energy and, therefore, a high respiration rate in the roots, which uses the oxygen present in soil pores. If the soil becomes waterlogged, an oxygen deficit can develop because oxygen diffuses poorly in water, putting a severe stress on the roots and the plant as a whole. This reduces root water permeability in many plants. Plants growing in flooded soil can therefore suffer from reduced water content and their leaves wilt – a paradox agronomists are familiar with.

By using different lines of model plant Arabidopsis thaliana, researchers from the Biochimie et physiologie moléculaire des plantes laboratory (CNRS/INRA/Université Montpellier/Montpellier SupAgro) and Institut Jean-Pierre Bourgin (INRA/AgroParisTech/CNRS) identified a gene that controls root water permeability and which is influenced jointly by soil oxygen and potassium levels. Named HCR1, this gene reduces water entry into the roots when there's a lack of oxygen, but only when the soil is also rich in potassium, a mineral salt essential for plant growth. In fact, such conditions favor better plant recovery after flood conditions have ceased. The HCR1 gene actually also sets off a whole series of metabolic "survival" reactions that contribute to plant resilience. Once the soil is reoxygenated, the plant rehydrates its leaves and will grow more than if

it had previously been deprived of potassium.

These findings are not only important from a fundamental scientific point of view, but also open new avenues for agronomy. Plant water use and root performance are key targets for plant breeders. In nature, however, plants are never exposed to only one stress at a time, so breeders have also taken an interest in the plants' capacity to resist multiple environmental stresses. The identification of this mechanism linking oxygen availability, mineral levels and root water permeability is thus an important step forward for agronomy. This mechanism is a promising target for future plant improvement.

More information: A potassium-dependent oxygen sensing pathway regulates plant root hydraulics, Zaigham Shahzad, Matthieu Canut, Colette Tournaire-Roux, Alexandre Martinière, Yann Boursiac, Olivier Loudet, Christophe Maurel. *Cell*, 15 September 2016. DOI: 10.1016/j.cell.2016.08.068

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