Root2Res
Root phenotyping and genetic improvement for rotational crops resilient to environmental change

Practice Abstract

Root ideotype for a low phosphorus environment

Problem

Phosphorus (P) is a key nutritional element for crop productivity, critical for plant root formation, energy transfer and DNA synthesis. However, P is an immobile nutrient and binds to soil particles, making it less available to plant roots. P is also a finite resource which needs to be used more efficiently within agricultural systems.

Solution

Root traits with evidence for improving P capture and uptake were developed into a single root ideotype (a model of an ideal root system), with priority root traits indicated where more evidence was available. Ideotypes have been developed for cereal, faba bean and potato crop species.

Benefits

Through breeding and managing these crop species to exhibit these ideal root traits, crop P capture will be improved, enhancing crop yield in low to medium P available soils and increasing the crop use efficiency of P nutrient inputs.

Applicability box

Theme: Root traits to improve crop phosphorus capture

Keywords: Ideotype, phosphorus, P, root length density, root hairs, phosphate solubilising bacteria

Context: Low phosphorus soils and improving P uptake in cropping systems

Period of impact: Medium to long term, dependent on finding genetic markers for identified traits that can be transferred into modern varieties

Best in: Plant breeding; all soils where there is a crop P requirement, more impactful in low to medium P level soils.

Practical recommendations

The two key elements to improve crop P capture are to:

- increase **root surface area** and
- increase the amount of **P in plant available** form.

High priority root traits identified in all crop species that have supportive evidence to improve and enhance crop P capture include:

- increased **root length density** and **surface area** in the **topsoil** where P is more abundant,
- greater **root hair density** and **longer root hairs** to increase root scavenging ability,
- greater **abundance** and association with **phosphate solubilising bacteria**, and
- more **mycorrhizal associations** to increase the soil surface area crops can access.

Other lower priority and related traits include **early root vigour**, greater **adventitious root porosity** to aid greater **root densities** and **root exudates** including organic acids to solubilize soil P.

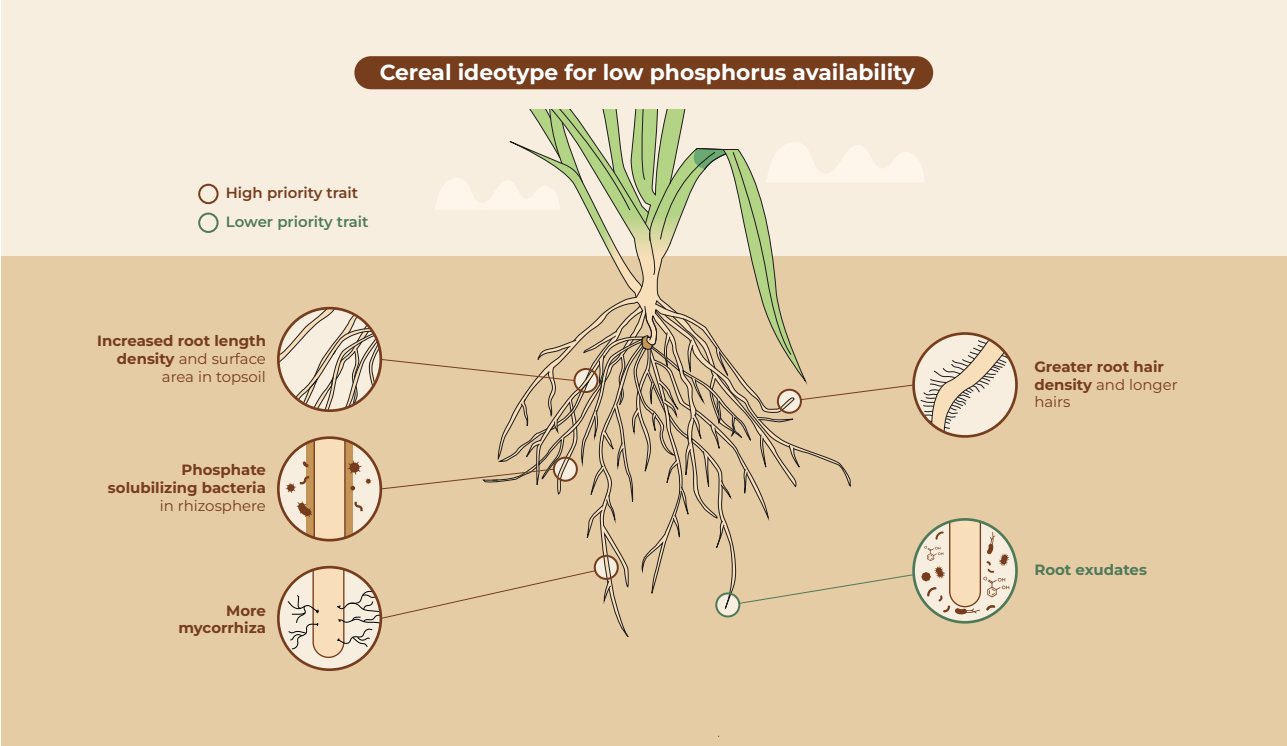

Figure 1: Example of a cereal root ideotype for a low phosphorus environment. The highlighted root traits are consistent for faba beans and potatoes. The full set of example ideotypes can be found in deliverable 1.2.

Further information

- Root2Res Deliverable 1.2 Define target ideotypes. https://zenodo.org/records/19564381
- Root2Res Practice Abstract: Root ideotype for water stress environments. https://zenodo.org/re/19564449
- Root2Res Podcast Episode: Exploring Root Ideotypes and Plasticity: Strategies for Resilient Agriculture. https://www.youtube.com/watch?v=_VlmB0sq8Ds
- Lynch, J.P. (2013) Steep, cheap and deep: an ideotype to optimize water and N acquisition by maize root systems. Annals of Botany. 112, 347–357. doi: 10.1093/aob/mcs293.
- Schmidt, J.E. and Gaudin, A.C.M. (2017). Toward an Integrated Root Ideotype for Irrigated Systems. Trends in Plant Science. Vol. 22, No. 5, 433-443. doi: 10.1016/j.tplants.2017.02.001.
- Berry, P.M., Sylvester-Bradley, R. and Berry, S. (2007). Ideotype design for lodging-proof wheat. Euphytica. 154, 165-179. doi: 10.1007/s10681-006-9284-3

About this practice abstract and Root2Resilience

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Root2Resilience: The project is running from September 2022 to August 2027. The overall goal of Root2Resilience – Root phenotyping and genetic improvement for rotational crops resilient to environmental change – is to develop root phenotyping, genetic and modelling tools and use them to define and test innovative genotype ideotypes able to enhance the tolerance to abiotic stress and carbon sequestration in soils

Project website: root2res.eu

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