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

Practice Abstract

Methods for measuring root traits in the field

Problem

Root systems, along with their interactions with soil conditions and micro-organisms, are crucial for crop performance, mainly through the efficient capture of water and nutrients. These root traits significantly enhance crop resilience against climate change. However, measuring root systems is more labor-intensive compared to the above-ground parts of plants.

Solution

Four methods – minirhizotron, soil pit, soil coring and shovelomics (figure 1) – were evaluated to assess their capacity to measure root traits in different crops and their accessibility (table 1).

Benefits

All four methods have advantages. The minirhizotron, soil pit, and soil coring methods can measure roots to depths of 1 m or more. Shovelomics, while limited to measuring surface roots in the top 20 cm, is a much faster method.

Applicability box

Theme: Root phenotyping toolbox

Geographical coverage: Unrestricted

Application time: Seedlings to grown plants

Required time: See Table 1 on second page.

Equipment: See Table 1 on second page.

Keywords: Root traits, minirhizotron, soil pit, soil coring, shovelomics

Figure 1: Root-phenotyping in the field

Minirhizotron

A rotating scanner is inserted into a transparent tube in the soil and takes pictures at different depths. Root traits are measured using modelling software.

Main root traits: root diameter, planar root length density (cm/cm^2)

Soil Pit

A soil pit is dug and the presence of roots on the vertical face of the soil in the pit is noted within each square of a grid.

Main root traits: presence/absence of roots and percentage of roots per unit of soil depth

Soil Coring

Involves sampling a core of soil, washing soil from roots, capturing a digital image of the washed roots and assessing root traits with software such as WinRhizo™.

Main root traits: specific root length, volumic root length density (cm/cm^3)

Shovelomics

Involves digging up whole plants with their surface root system using a spade, washing the roots and measuring root traits.

Main root traits: Cereals and legumes – root angle, maximum width and depth of root system, nodal root number, root dry weight, root length and diameter; Potato – stolon N°/length/weight, basal root, plantlet N°

Practical recommendations

See practice abstracts on root measurement methods for practical recommendations (link below).

Table 1: Root phenotyping toolbox for field measurements

Methods	Minirhizotron	Soil coring	Shovelomics	Soil pit
Depth	40-100 cm	0->100 cm	0-20 cm	0-150 cm
Time per sample	20 min	6 h	1-2 h (time differs between crops)	4 h
Material	Rotative scanner 22K € Tubes 40 € ARVALIS software	Hydrocare 36K € Root washer 500 € "WinRhizo" 7K €/open source	Spade 40 €	Grid mechanical excavator
Advantages	Non-destructive, dynamic measures	Deep rooting	Less laborious, no specialised quipment needed, 3D architecture	Wide and deep field of view
Disadvan-tages	Not available on the first 0-30 cm	Time consuming	Assess top 20 cm soil depth only	Very destructive and time consuming

Further information

- Beauchêne, K., et al. (2023). Root2Res D2.1 Phenotyping toolbox – architectural traits. Available at: root2res.eu/home/knowledge-center/.
- **Shovelomic:** York, L. M. et al. (2018). Wheat shovelomics I: A field phenotyping approach for characterising the structure and function of root systems in tillering species, BioRxiv. Available at: doi 10.1101/280875.
- **Soil coring:** White, C. A., et al. (2015). Root length densities of UK wheat and oilseed rape crops with implications for water capture and yield, Journal of Experimental Botany. Available at: doi 10.1093/jxb/erv077.
- **Soil pit:** Zarzyńska, K., Boguszewska-Mańkowska, D. and Nosalewicz, A. (2017). Differences in size and architecture of the potato cultivars root system and their tolerance to drought stress, Plant, Soil and Environment, 63(4), pp. 159–164. Available at: doi.org/10.17221/4/2017-PSE.
- **Minirhizotron:** Postic, F., Beauchêne, K., Gouache, D., Doussan, C., 2019. Scanner-Based Minirhizotrons Help to Highlight Relations between Deep Roots and Yield in Various Wheat Cultivars under Combined Water and Nitrogen Deficit Conditions, Agronomy 9, 297. Available at: doi.org/10.3390/agronomy9060297.
- **Practice abstracts on four root measurement methods** (in progress): https://zenodo.org/search?q=R2RPhenoToolbox-PA&l=list&p=1&s=10&sort=bestmatch
- WinRhizo. Image Analysis for Plant Science. Available at: https://www.regentinstruments.com/assets/winrhizo_software.html

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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