STATE-OF-THE-ART PHENOTYPING FOR ROOT MORPHOLOGY AND PHYSIOLOGY

Aims, methodologies, and research infrastructure

06.09.2018 I FABIO FIORANI

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Deutsches
Pflanzen
Phänotypisierungs-
Netzwerk
DPPN


Federal Ministry
of Education
and Research


European
Plant
Phenotyping
Network
EPPN

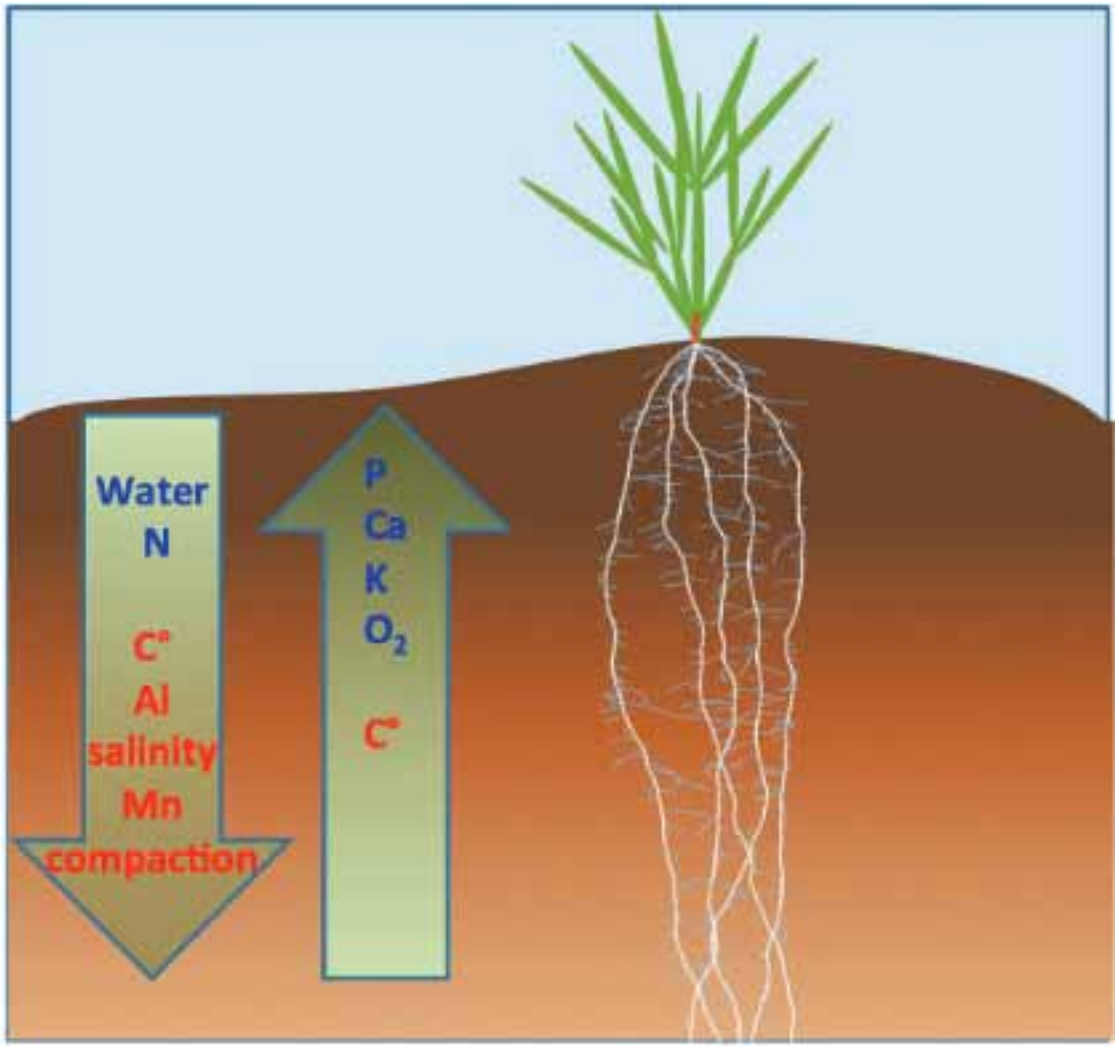

European
Plant Phenotyping
Network
EPPN 2020


cost


EMPHASIS

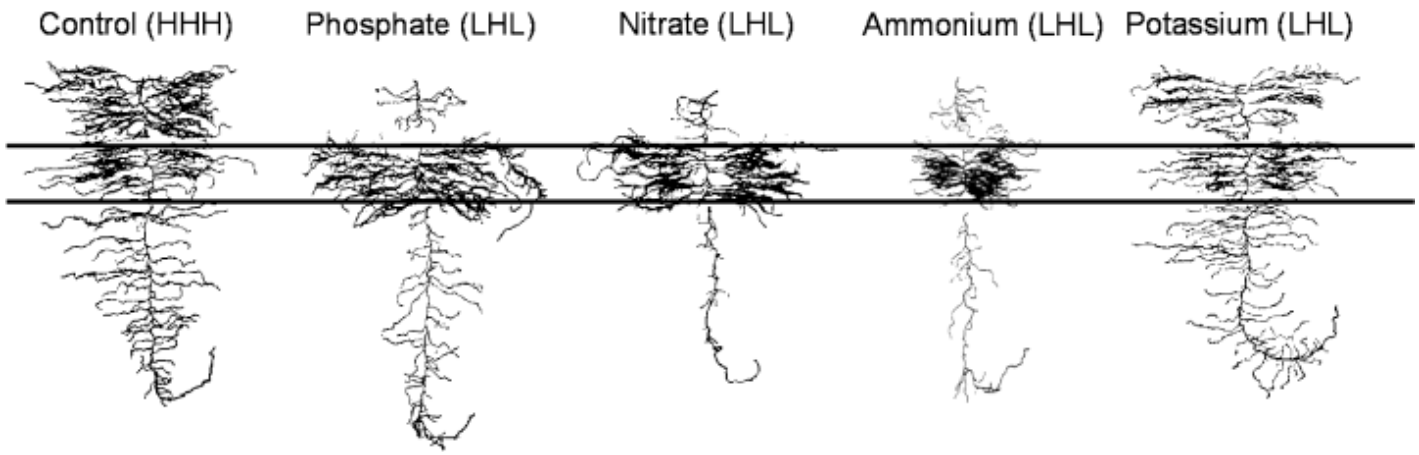

ESFRI

How efficient roots need to be?



Lynch & Wojciechowski, 2015

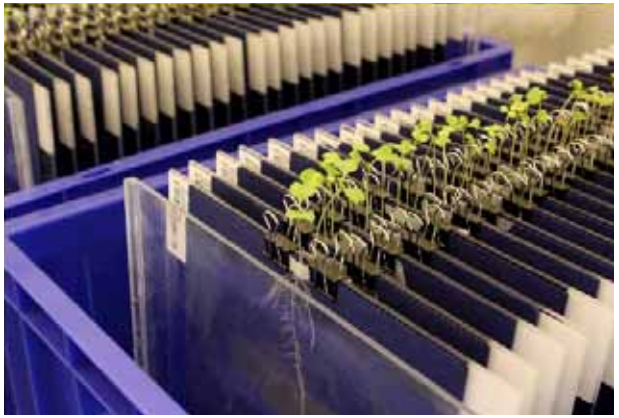
The plastic plant: root responses to heterogeneous supplies of nutrients



The plastic plant: root responses to heterogeneous supplies of nutrients, Volume: 162, Issue: 1, Pages: 9-24, First published: 03 February 2004, DOI: (10.1111/j.1469-8137.2004.01015.x)

There is considerable variation in size of root system

There is considerable variation in several root traits

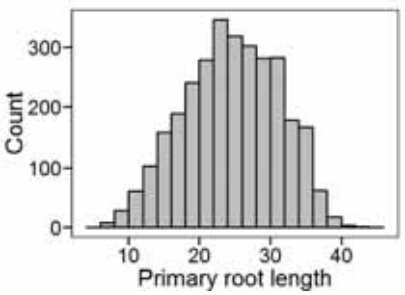


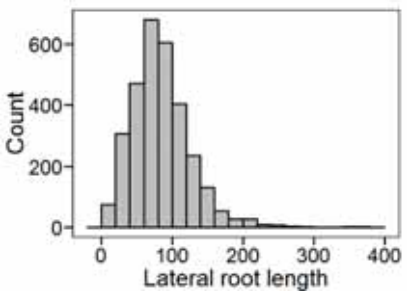
Experimental design:

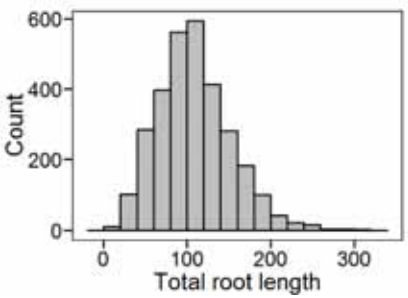
- 430 genotypes DH lines
- 8 replicates
- Randomized design
- Data generated from 7 experiments and 3360 single plants

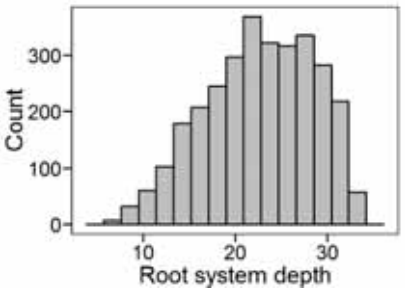
29 traits were recorded

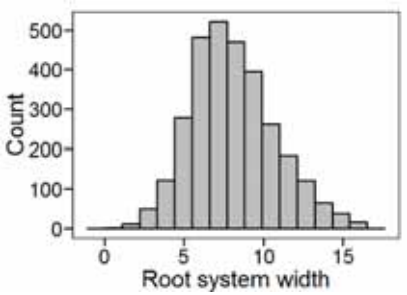
19 traits constantly showed significant genotypic variation

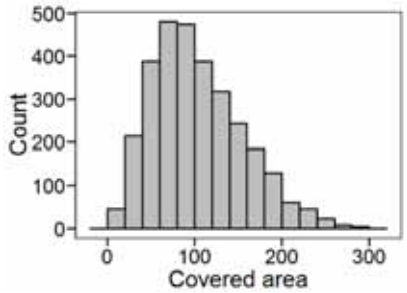


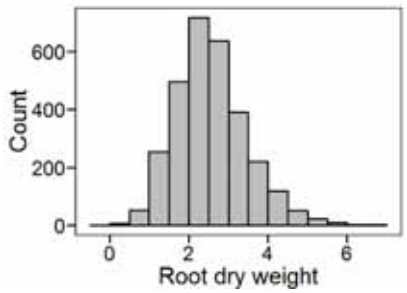


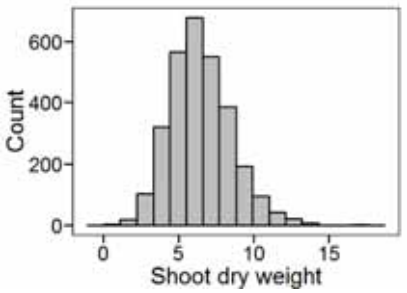


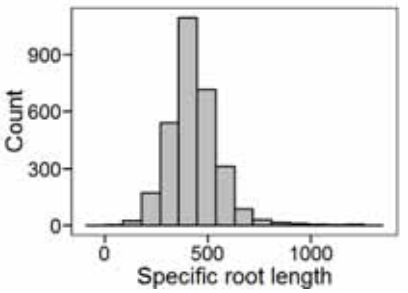








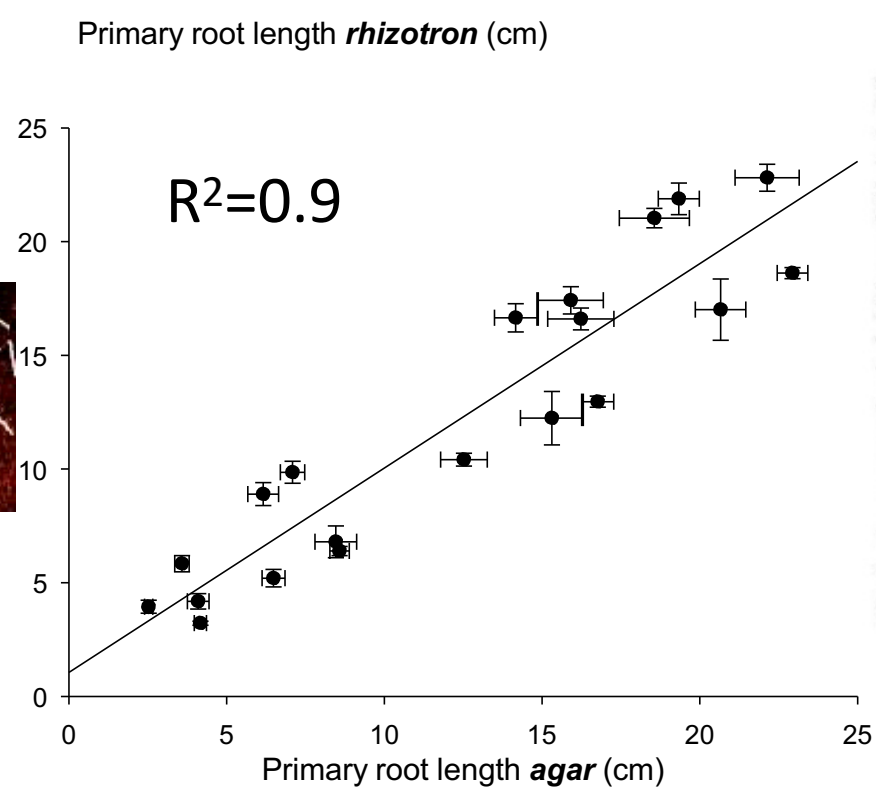


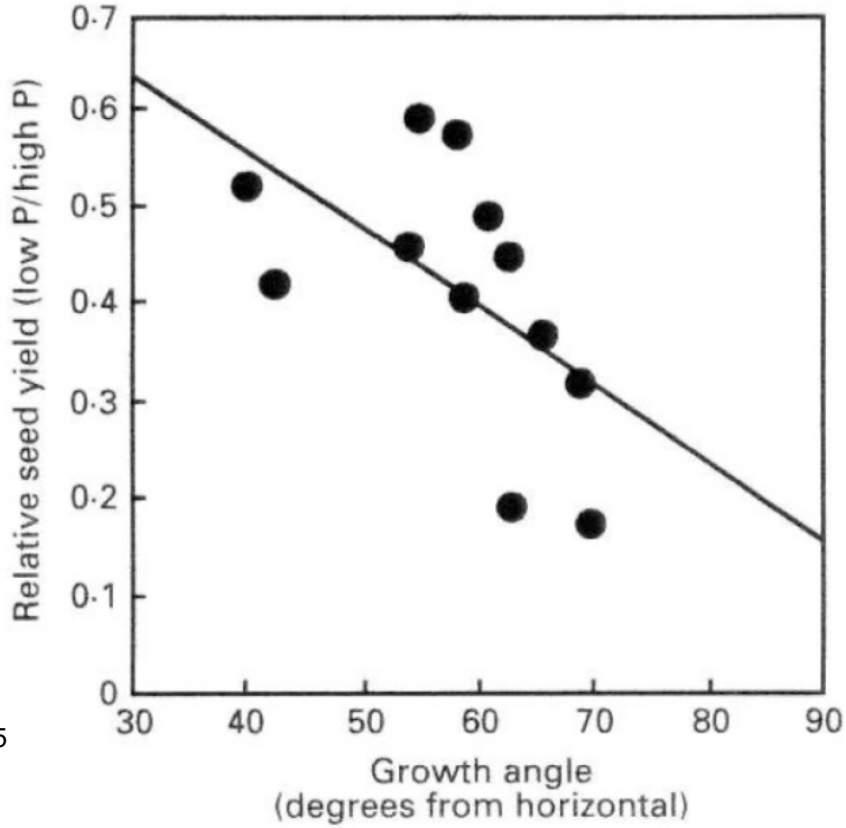


Variability in root architecture can, in some cases, be revealed in the field

Variation of tiller numbers and lateral root branching in a barley diversity panel

Results transferability





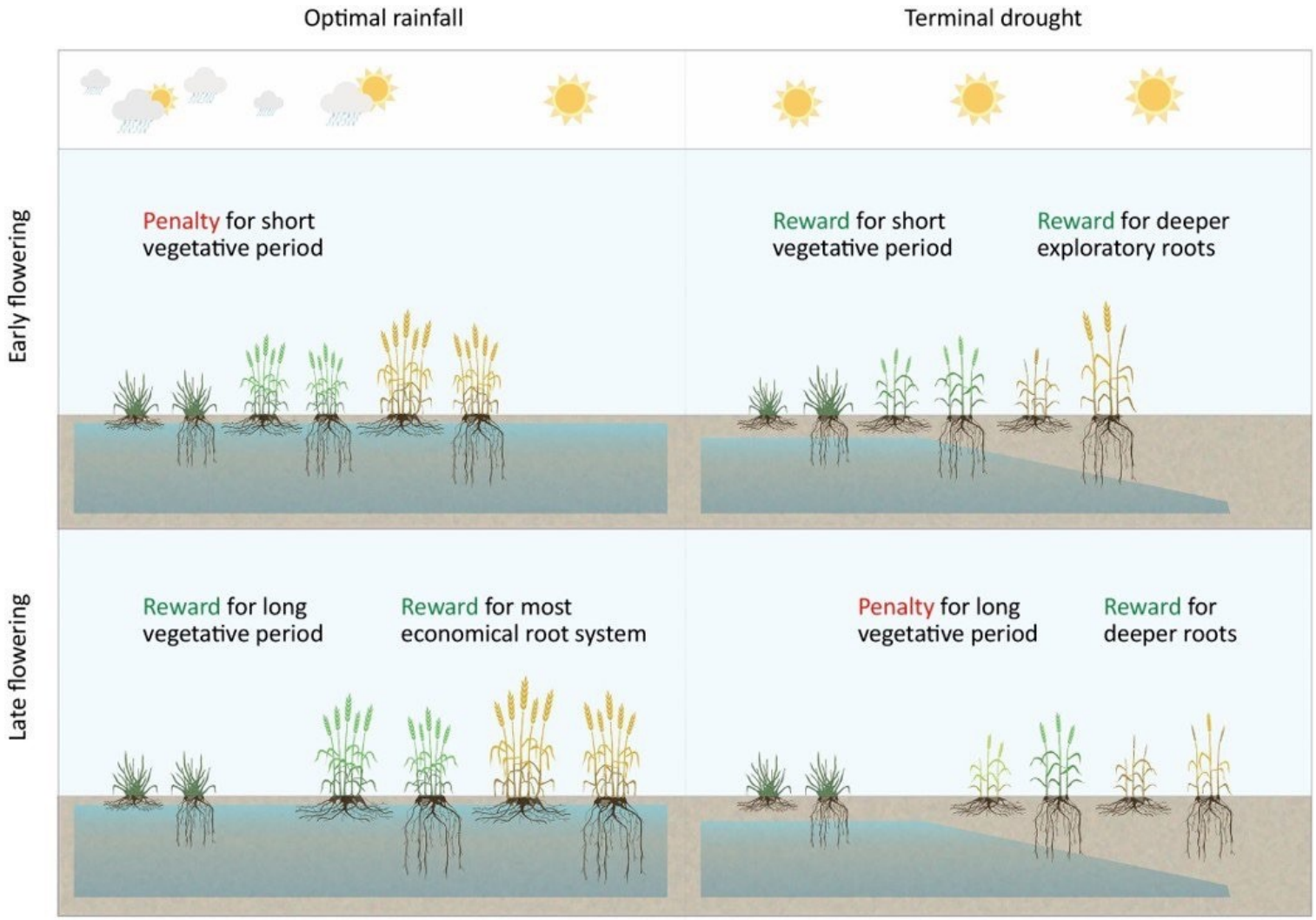
Bonser et al., 1996

Deeper rooting genotypes

Paddy rice cultivar Asia Negative regulation of auxin Upland cultivar Philippines

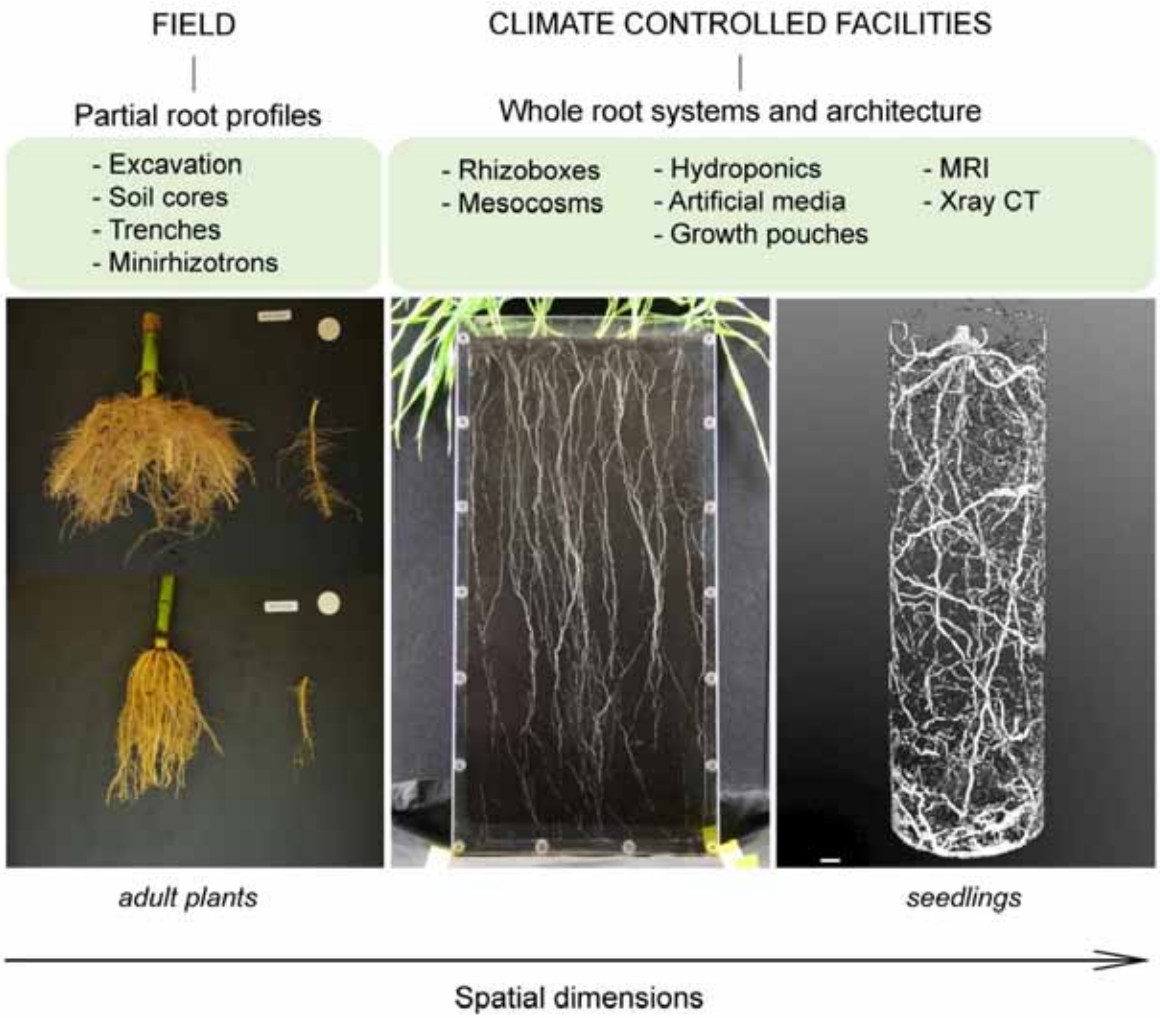
Uga et al., (2014), Nature Genetics

That simple?



Trends in Plant Science

Which methodologies?

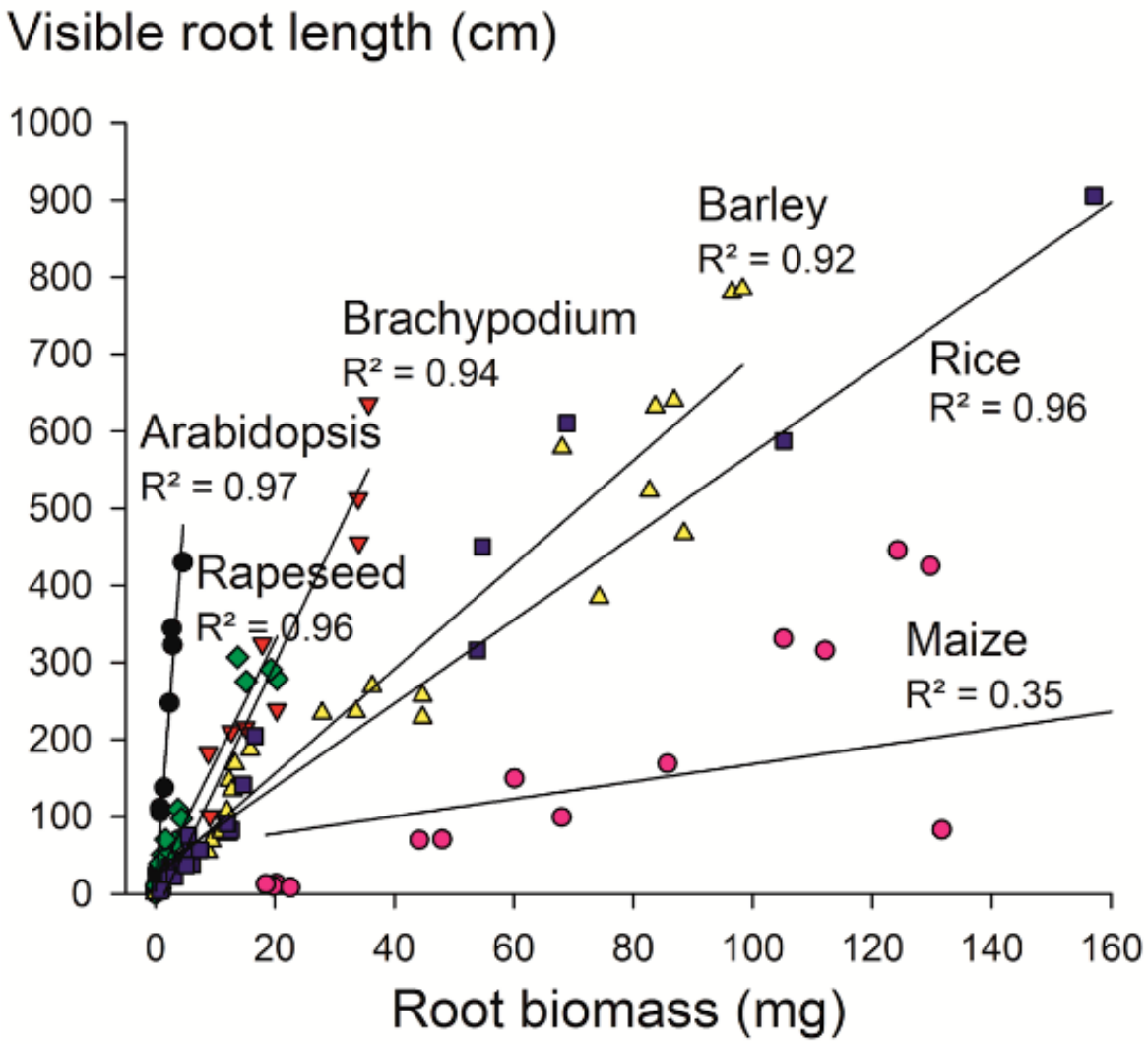


Postma et al., 2013

GROWSCREEN-RHIZO: an automated system for 2D imaging of roots and shoots

Nagel et al. 2012

Visible root length correlates with global root parameters



Nagel et al. 2012

Domestication and breeding effects on root architecture in relation to nitrogen availability

$$CV_A = \frac{\sqrt{V_A}}{\bar{X}}$$

Gioia et al (2015) Impact of domestication on the phenotypic architecture of durum wheat under contrasting nitrogen fertilization; J Exp Bot doi:10.1093/jxb/erv289

Dubcovsky/ Dvo

estication series
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physiological

(growth,

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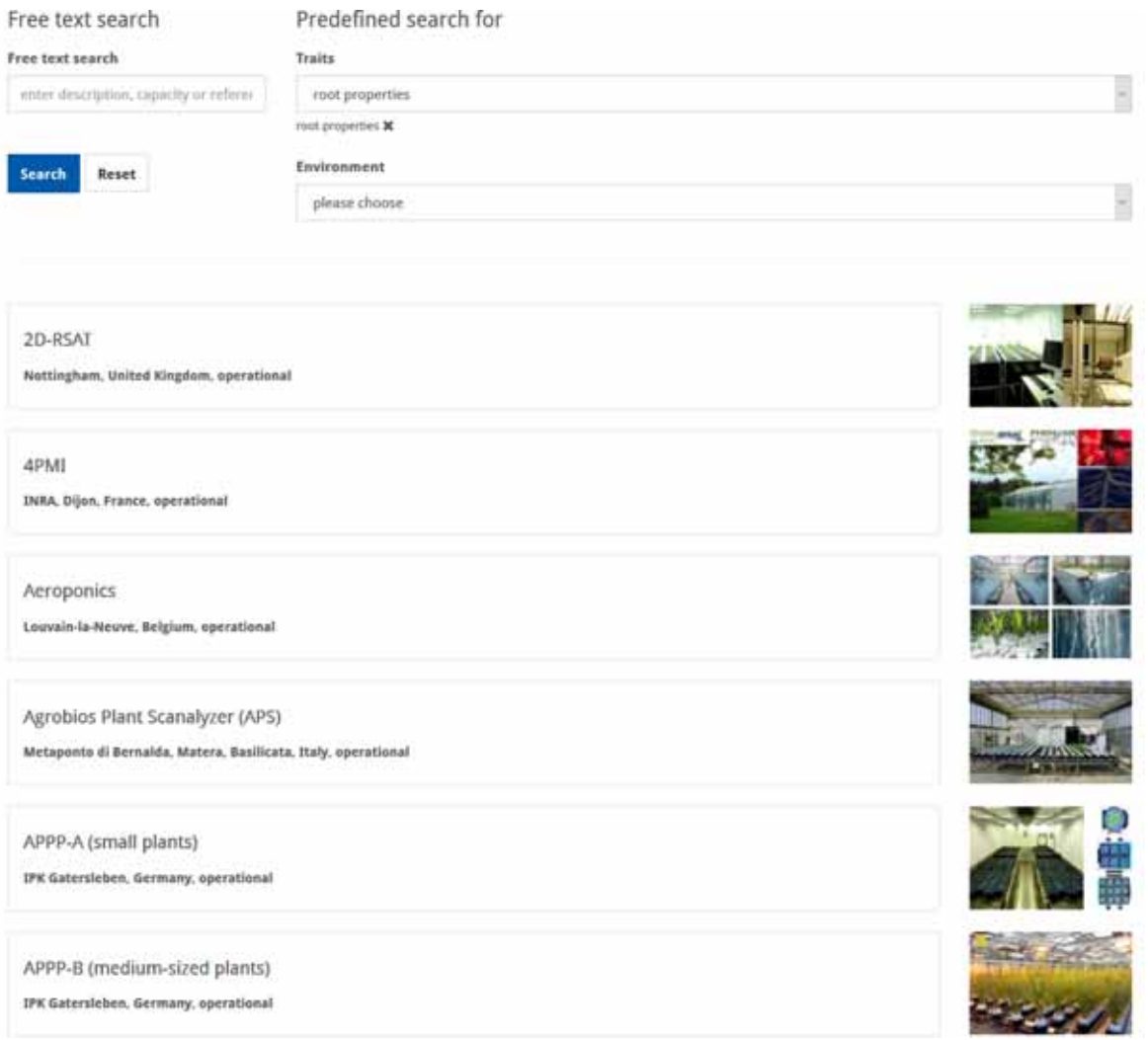
effects

Table 5. *Loss of phenotypic diversity for shoot- and root-related traits during the primary domestication (ΔCV_{Apd}) and secondary domestication (ΔCV_{Asd}) processes, under optimal nitrogen and nitrogen starvation treatments*

Treatment	Trait	ΔCV_A (%)	
		ΔCV_{Apd}	ΔCV_{Asd}
Optimal nitrogen	All	5	24[a]
	Shoot	−8	51[a]
	Root	−1	23[a]
Nitrogen starvation	All	−7	7
	Shoot	4	23[a]
	Root	5	1

[a]$P<0.05$ by Wilcoxon rank-sum test (two-sided alternative).

Many more platforms in our network



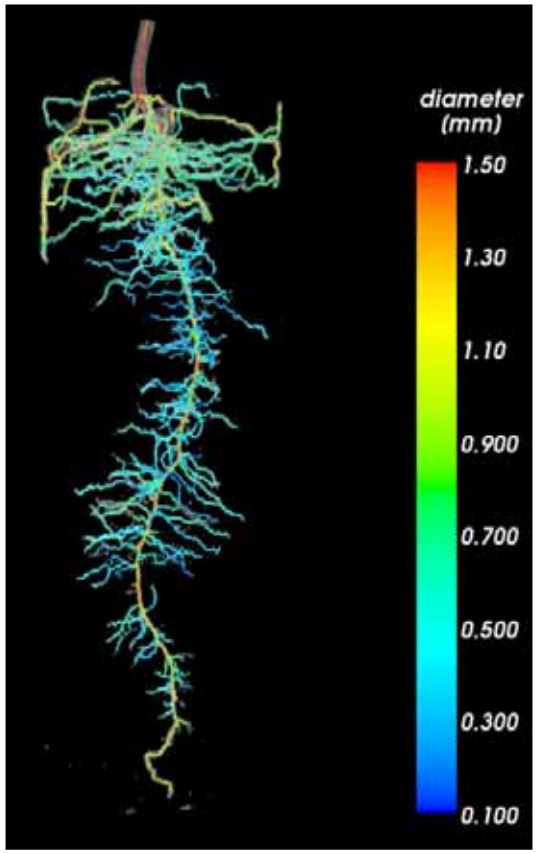
https://eppn2020.plant-phenotyping.eu/EPPN2020_installations#/

MRI: Magnetic Resonance Imaging:

making root growth visible in soil

4.7T MRI magnet

Automated plant handling

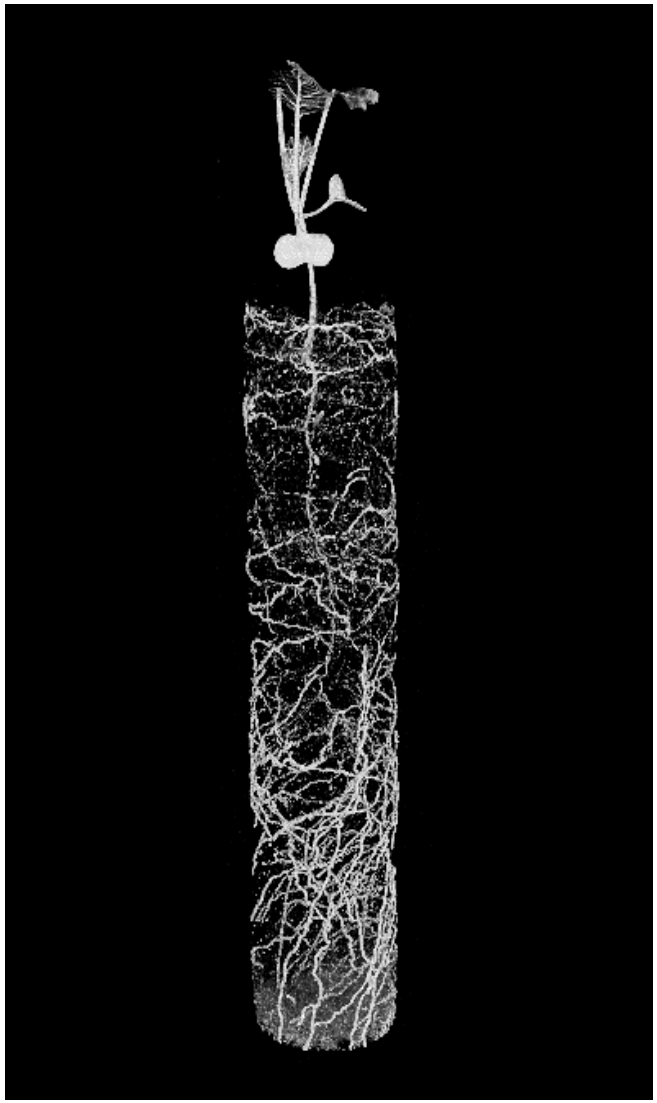


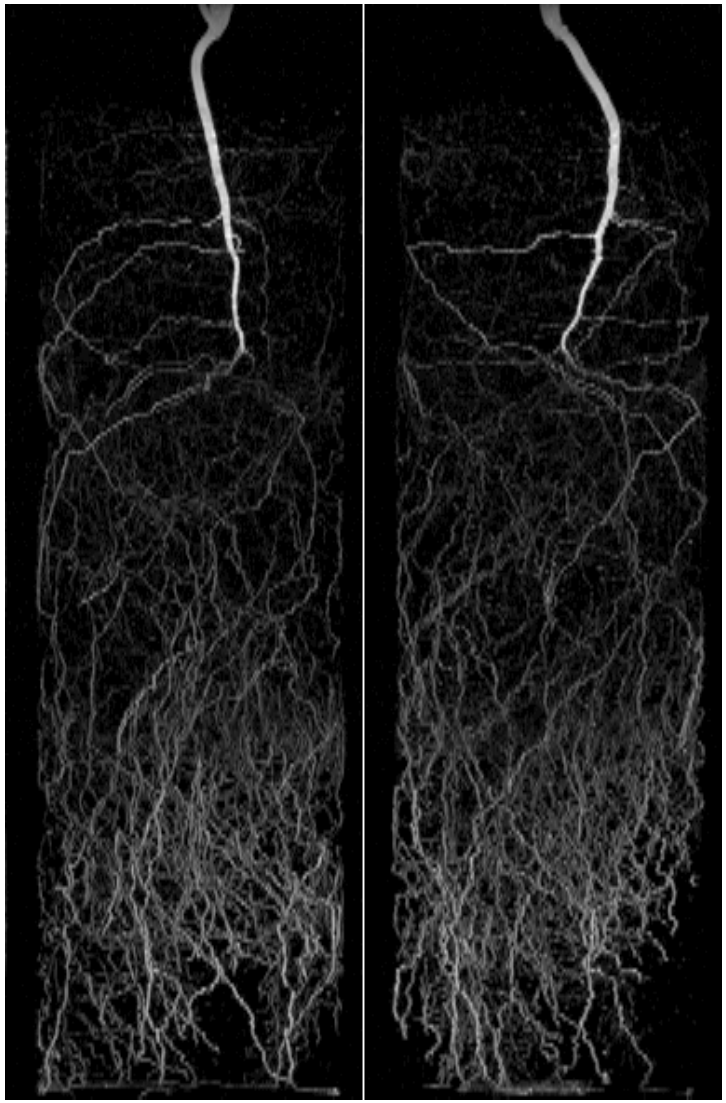
Software: '*NMRooting*'

van Dusschoten *et al.* 2016, *Plant Physiology*

Schmittgen et al. Journal of Experimental Botany 2015

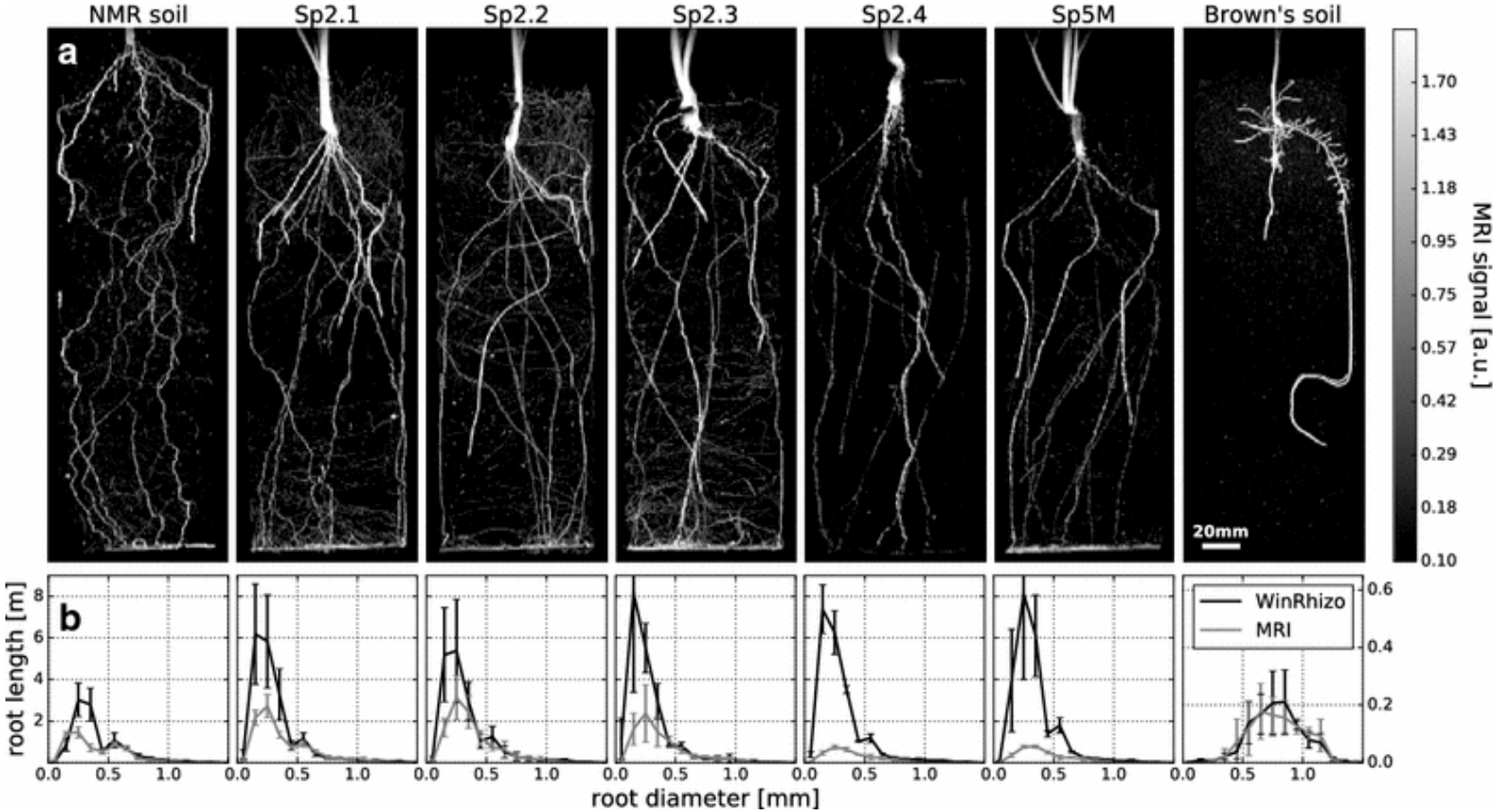
Visualizing rapeseed root by MRI





Mitglied der Helmholtz-Gemeinschaft

Understanding suitability of methods



Pflugfelder et al., Plant Methods, 2017

Some necessary points for future agenda

- Throughput and combination platforms for shoot/roots
- Include root respiration as a main physiological trait?
- Dedicated platforms for root-microbiome research
- Multi-year field experiments with relevant genetic material
- Which new methodologies for field?
- Modeling, also exploiting trait correlation networks


STILL
FZJ-100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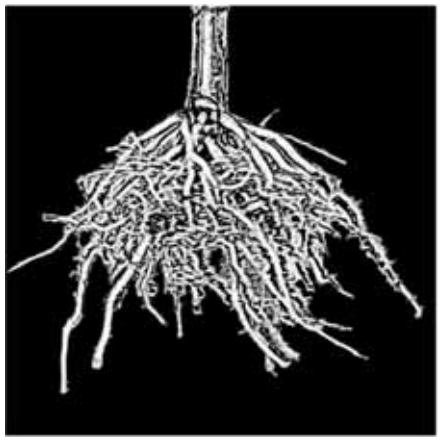
CASSAVASTORE

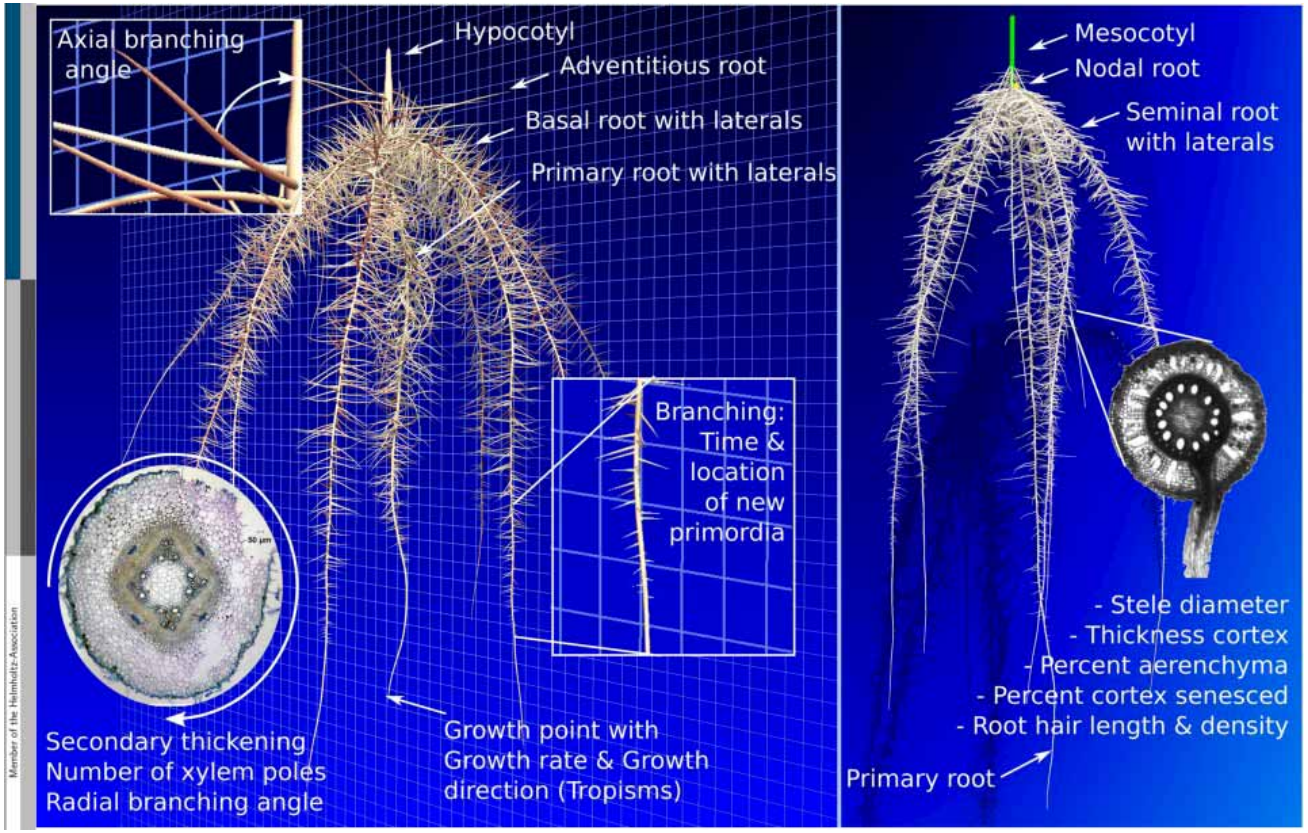
Mitglied der Helmholtz-Gemeinschaft

JÜLICH
Forschungszentrum

Max Width

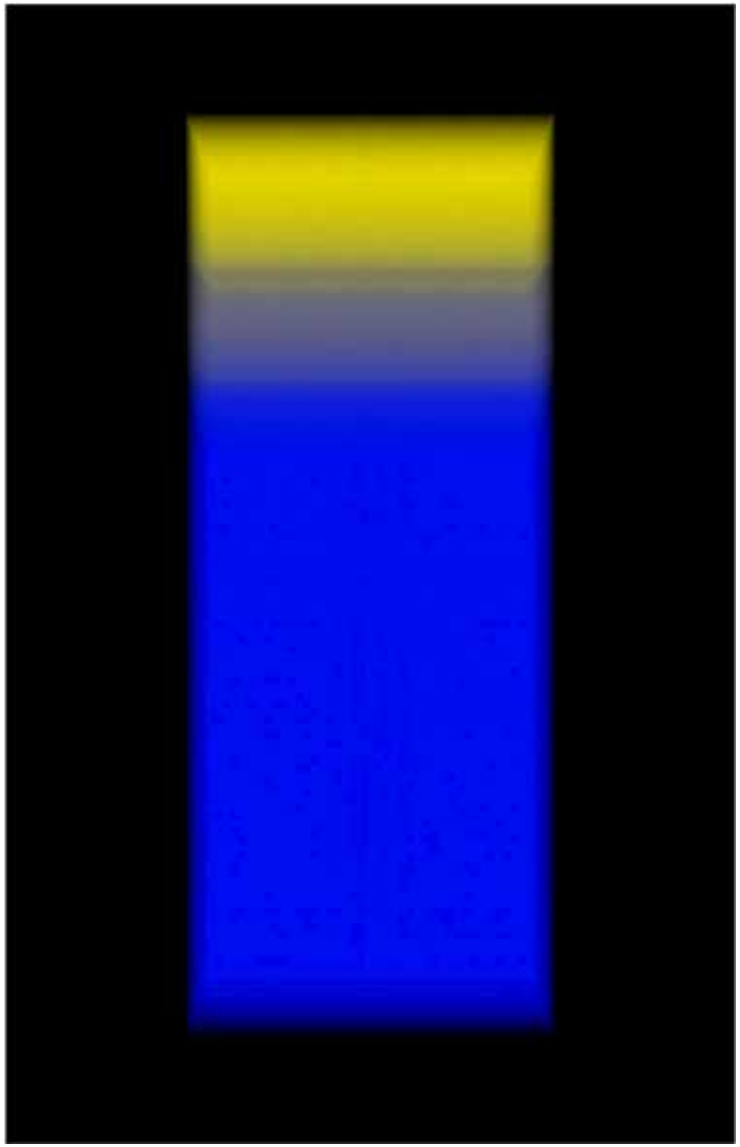
Min Width





OPENSIMROOT

Postma et al., New Phytologist, 2017



OpenSimRoot

Postma et al., New Phytologist, 2017

OUTLINE

- There is considerable variation in root traits (architecture)
- Can this variation be exploited (Tobias barley, bean paper angles, deeprooted rice)?
- Which methodologies have emerged (include very shortly other platforms in EPPN2020)?
- Modeling can be exploited
- What are the next developments?