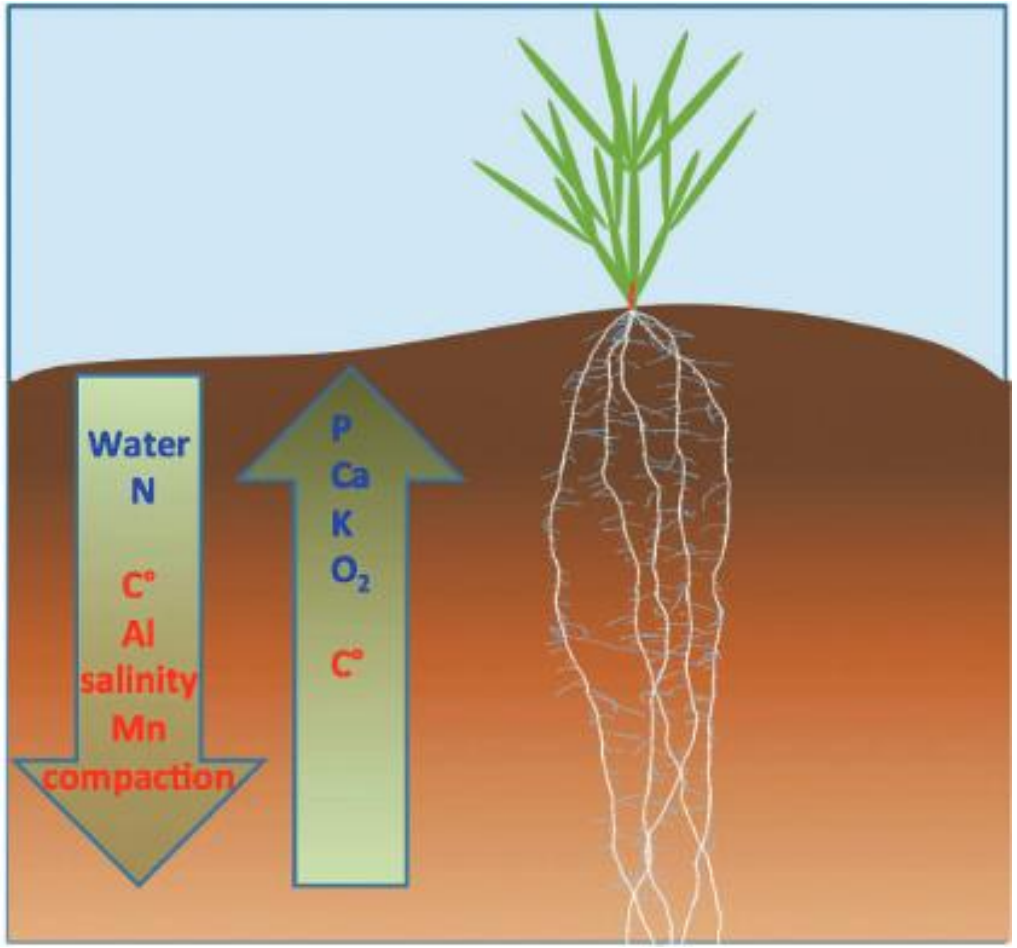



# PERSPECTIVES OF ROOT PHENOTYPING AND TOOLS

## NAC 2023 18th NSTDA Annual Conference

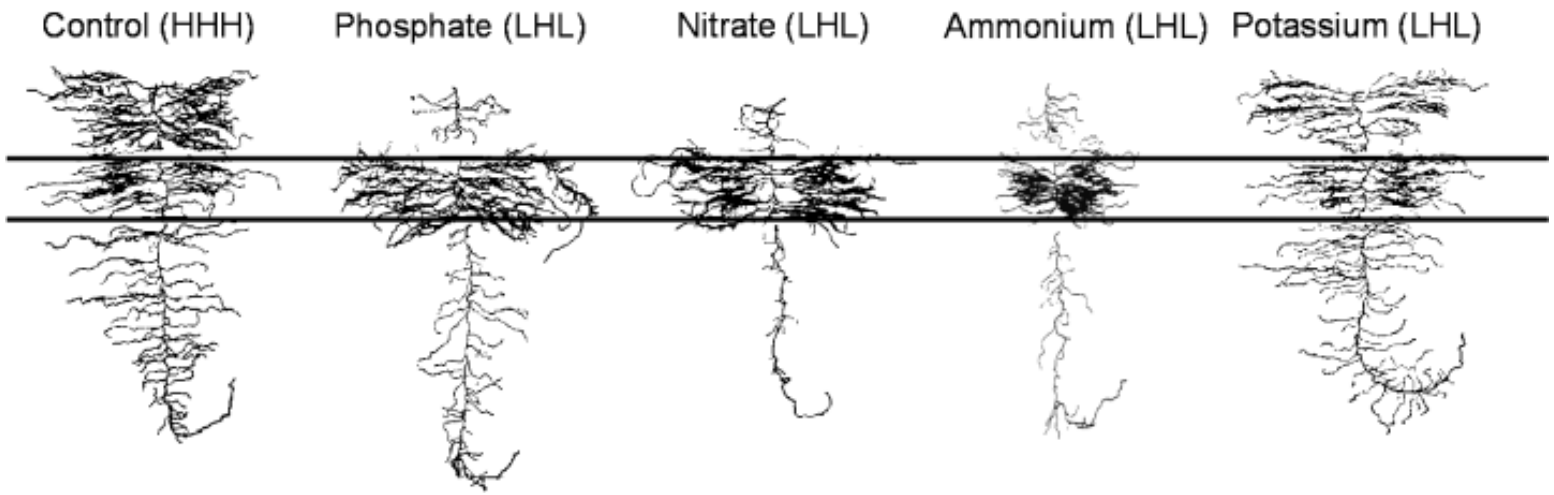
29.03.2023 I FABIO FIORANI

# HOW EFFICIENT ROOTS NEED TO BE?



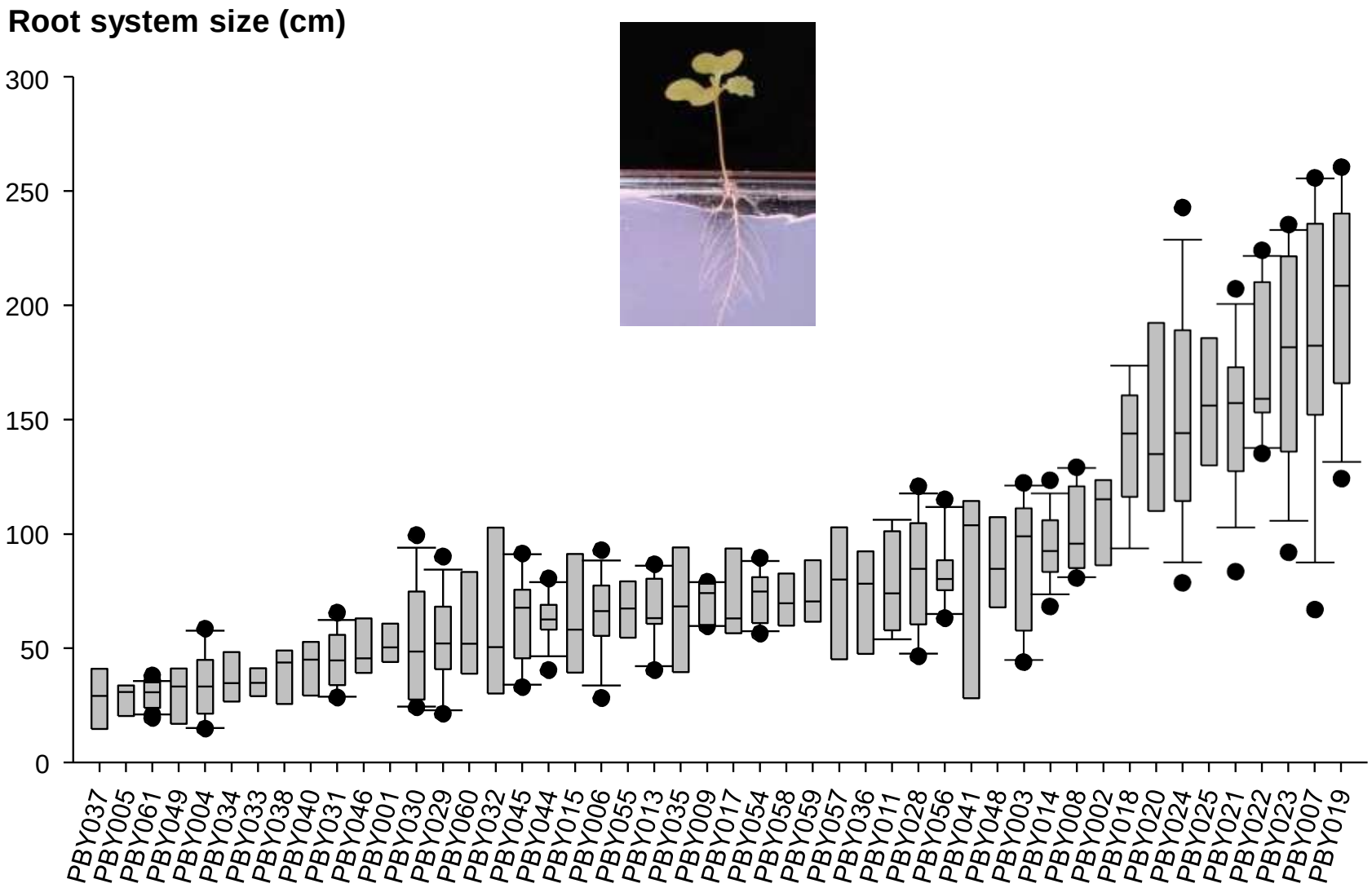

Lynch & Wojciechowski, 2015

# ROOTS SHOW PLASTIC RESPONSES




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 ROOT SIZE




*Nagel et al., unpublished*

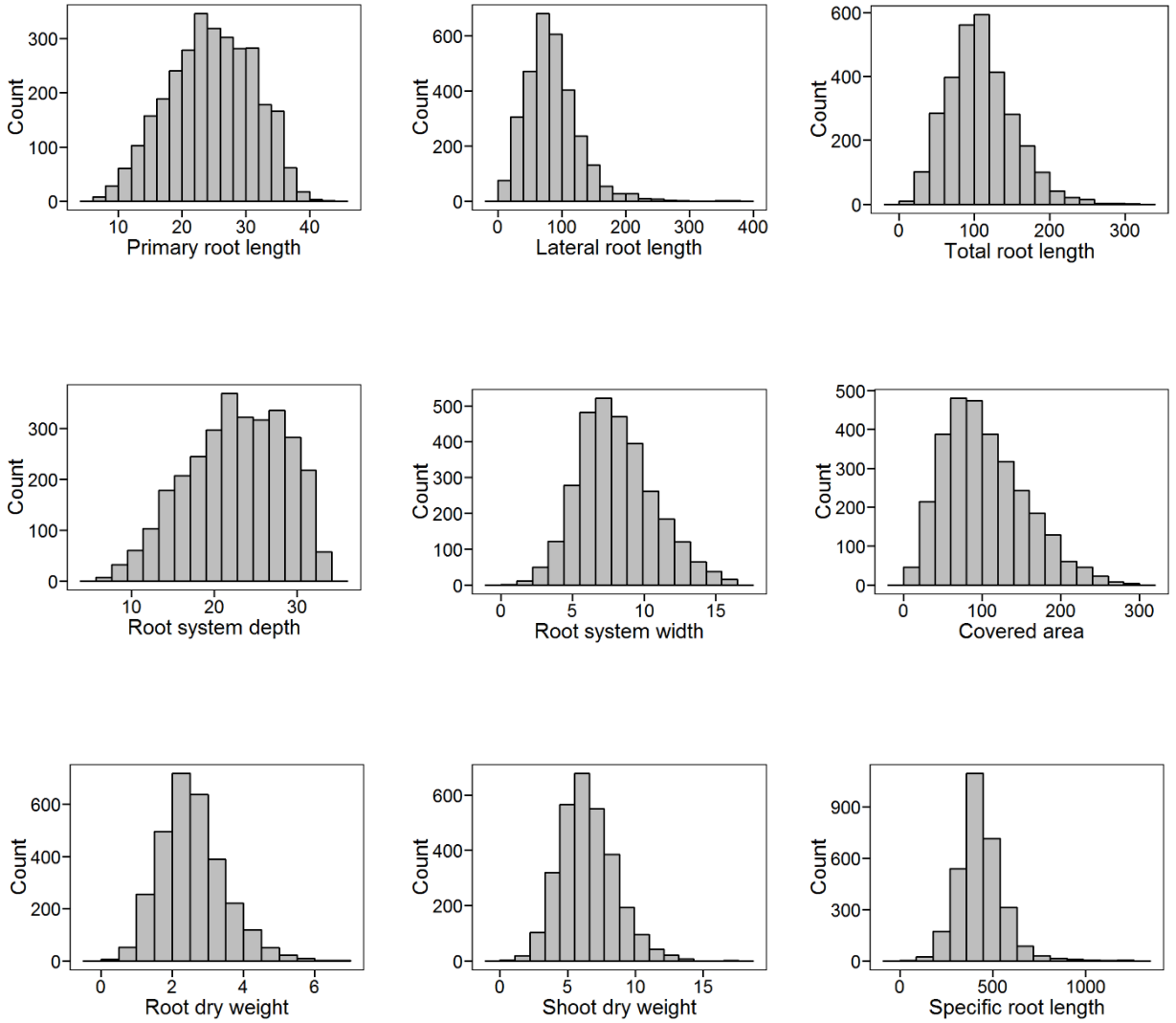
# THERE IS CONSIDERABLE VARIATION IN SEVERAL ROOT TRAITS

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




*Nagel et al., unpublished*

# VARIABILITY IN ROOT ARCHITECTURE CAN BE REVEALED IN THE FIELD

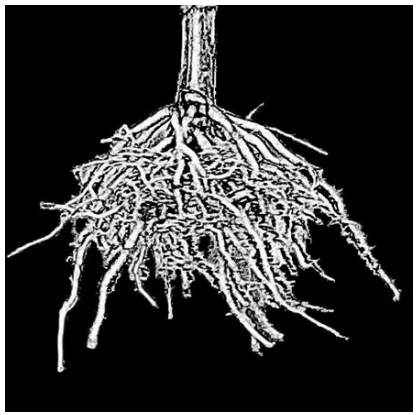
CASSAVASTORE


*Courtesy of T. Wojciechowski*

CASSAVASTORE

Max Width

Min Width

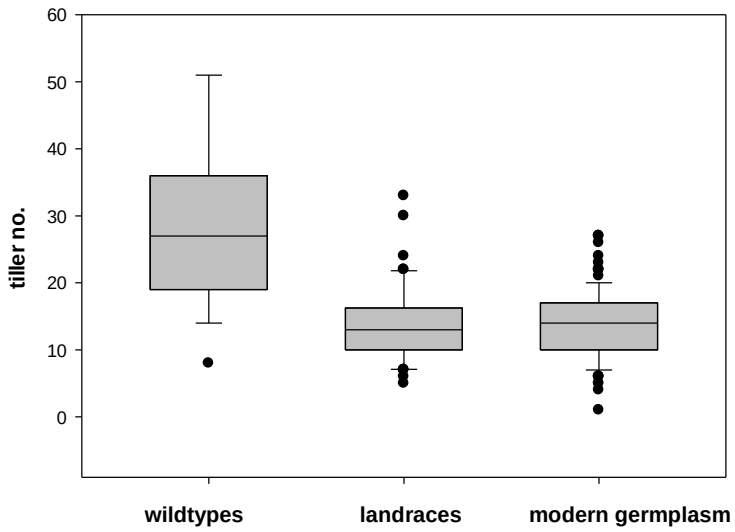


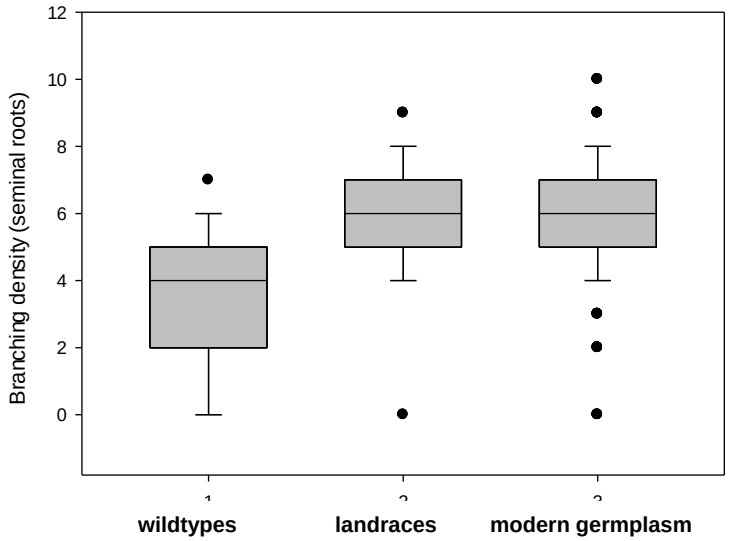
*Courtesy of T. Wojciechowski*

*Courtesy of M. Muller-linow*

CASSAVASTORE

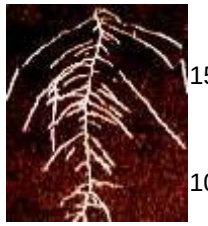
# THERE ARE RELATIONSHIPS BETWEEN SHOOT AND ROOT ARCHITECTURE

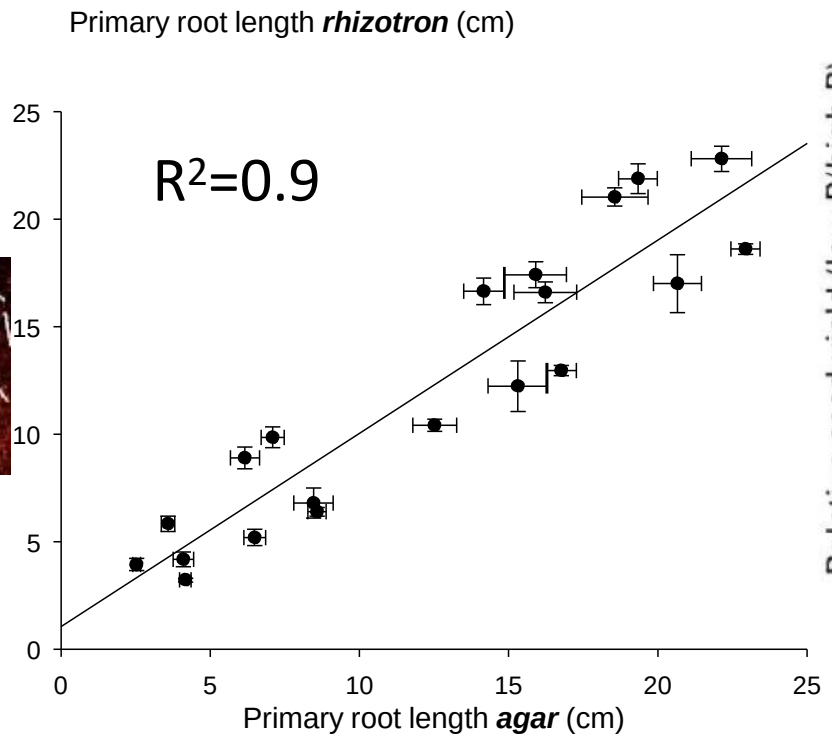


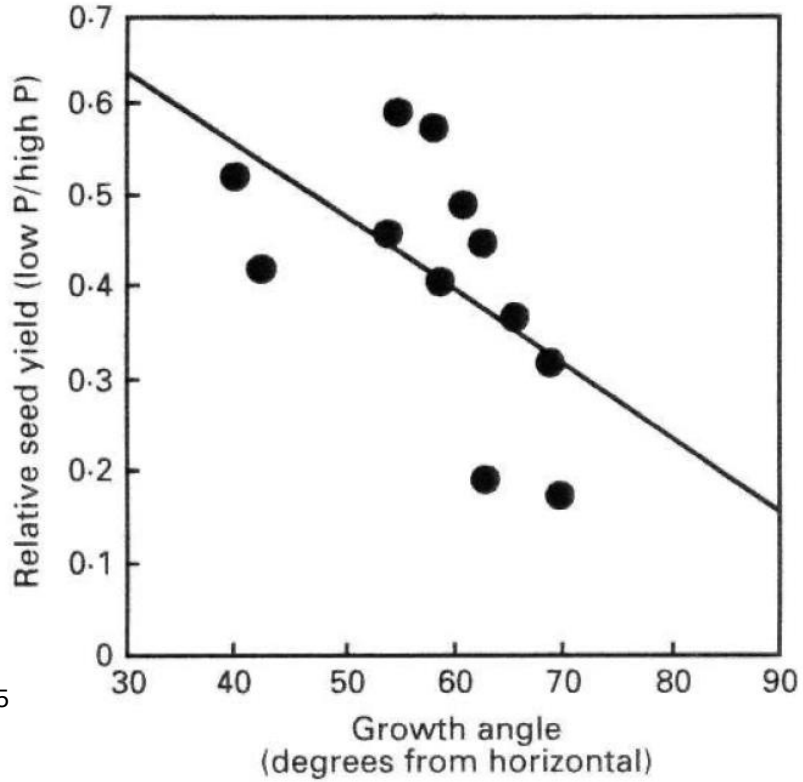




*Courtesy of T. Wojciechowski*

# TRANSFERABILITY CONTROLLED ENVIRONMENT AND FIELD






Bonser et al., 1996

# TRANSFERABILITY CONTROLLED ENVIRONMENT AND FIELD

| Phosphorus placement | Genotype | NAM screening* | Clear pot (seedling) | Rhizobox (late-tillering) | Lysimeter (anthesis) |
|---|---|---|---|---|---|
| | | ° | ° | ° | ° |
| Control | Narrow | 41 | 51 | 83 | 76 |
| | Wide | 82 | 70 | 71 | 80 |
| P-band | Narrow | | | 80 | 85 |
| | Wide | | | 79 | 79 |
| Topsoil-P | Narrow | | | 87 | 76 |
| | Wide | | | 76 | 79 |
| Mixed | Narrow | | | 76 | 71 |
| | Wide | | | 81 | 79 |
| *P*-value | G | 0.001 | 0.012 | n.s | n.s |
| | F | | | n.s | n.s |
| | G × F | | | n.s | n.s |
| Std.error | | | 7 | 8 | 8 |

*G* genotype, *F* fertiliser placement

*Data from the original NAM screening was collected by Alahmad et al. 2019 and used potting mix as a growth medium. All other experiments were conducted in the experimental soil

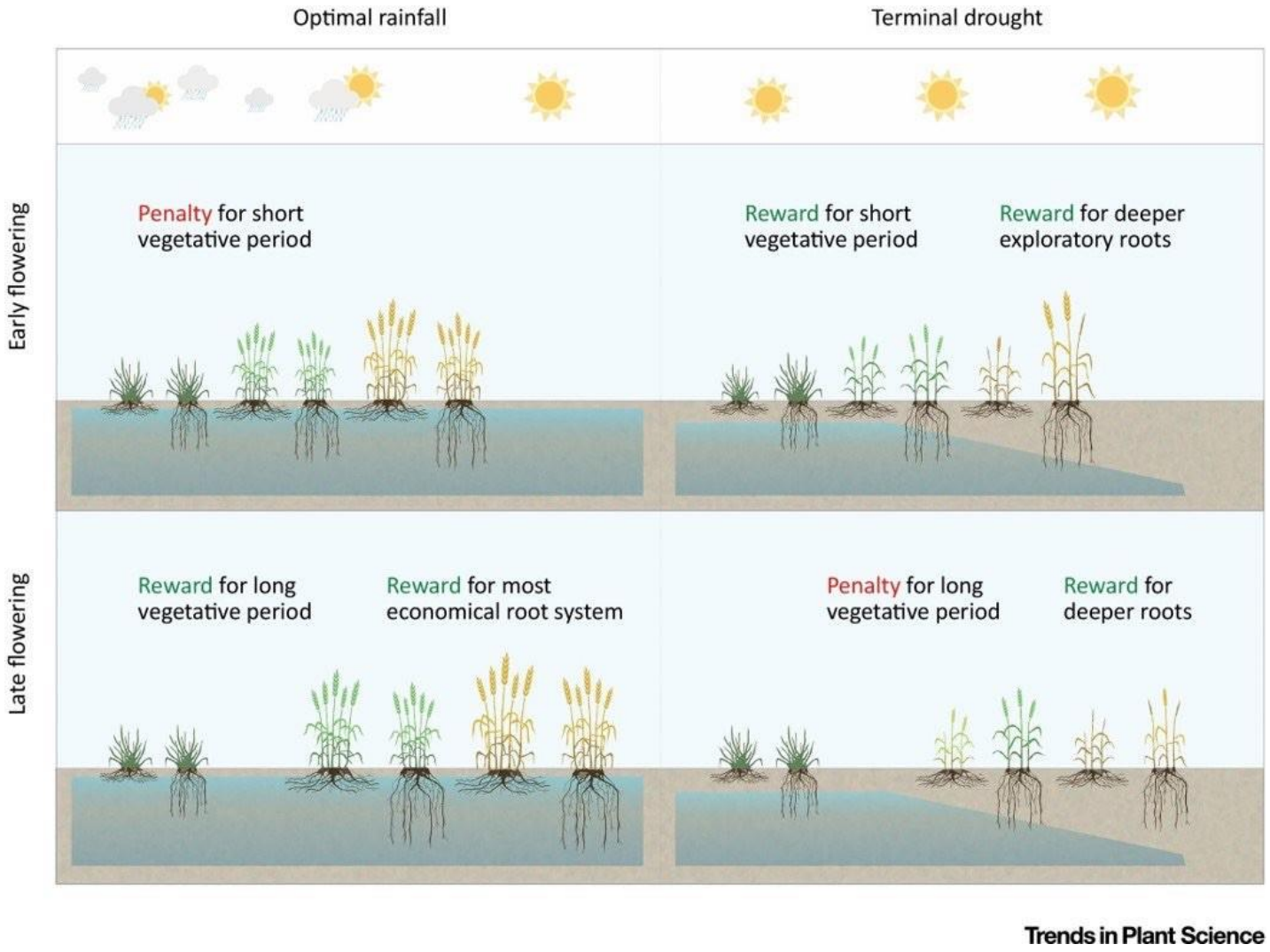
*Van der Bom et al., 2023*

# DEEP ROOTING GENOTYPES

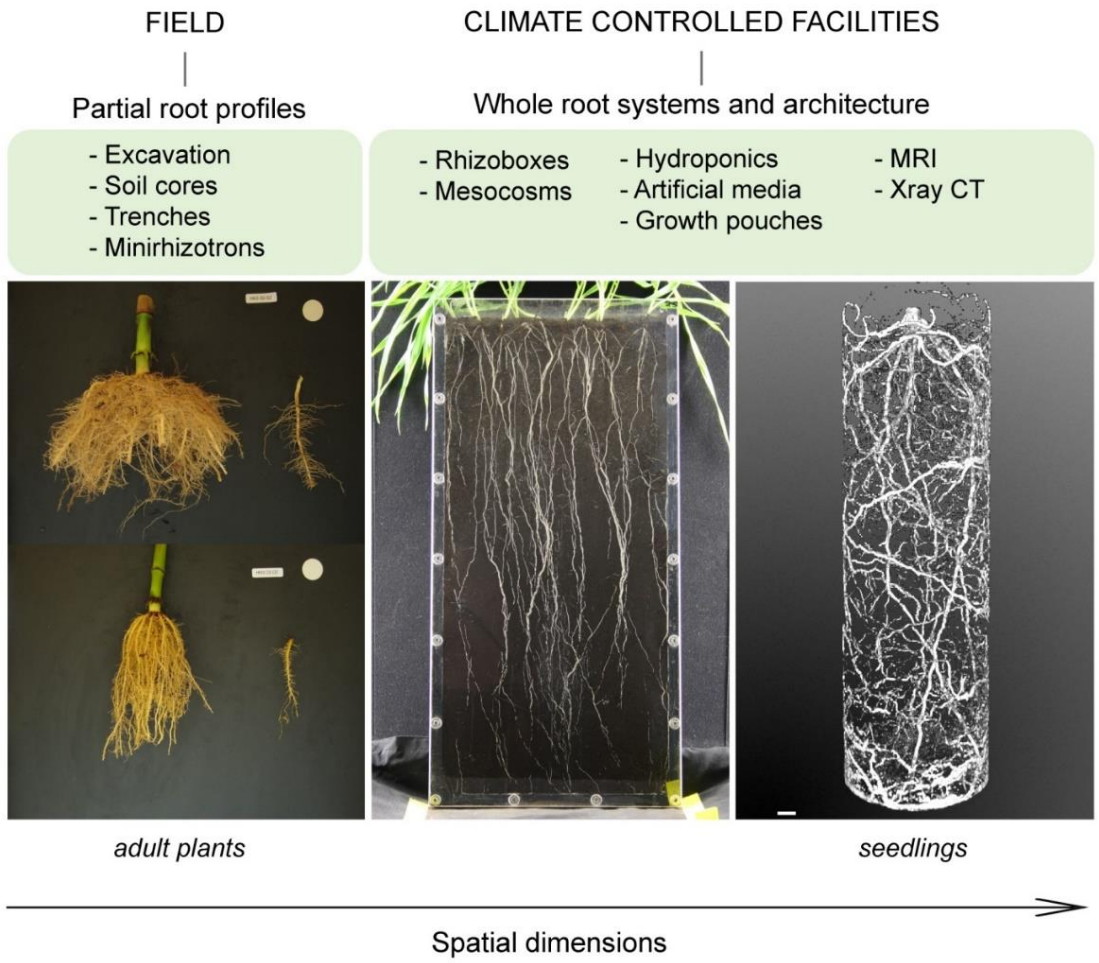
Paddy rice cultivar Asia  Negative regulation of auxin  Upland cultivar Philippines


*Uga et al., (2014), Nature Genetics*

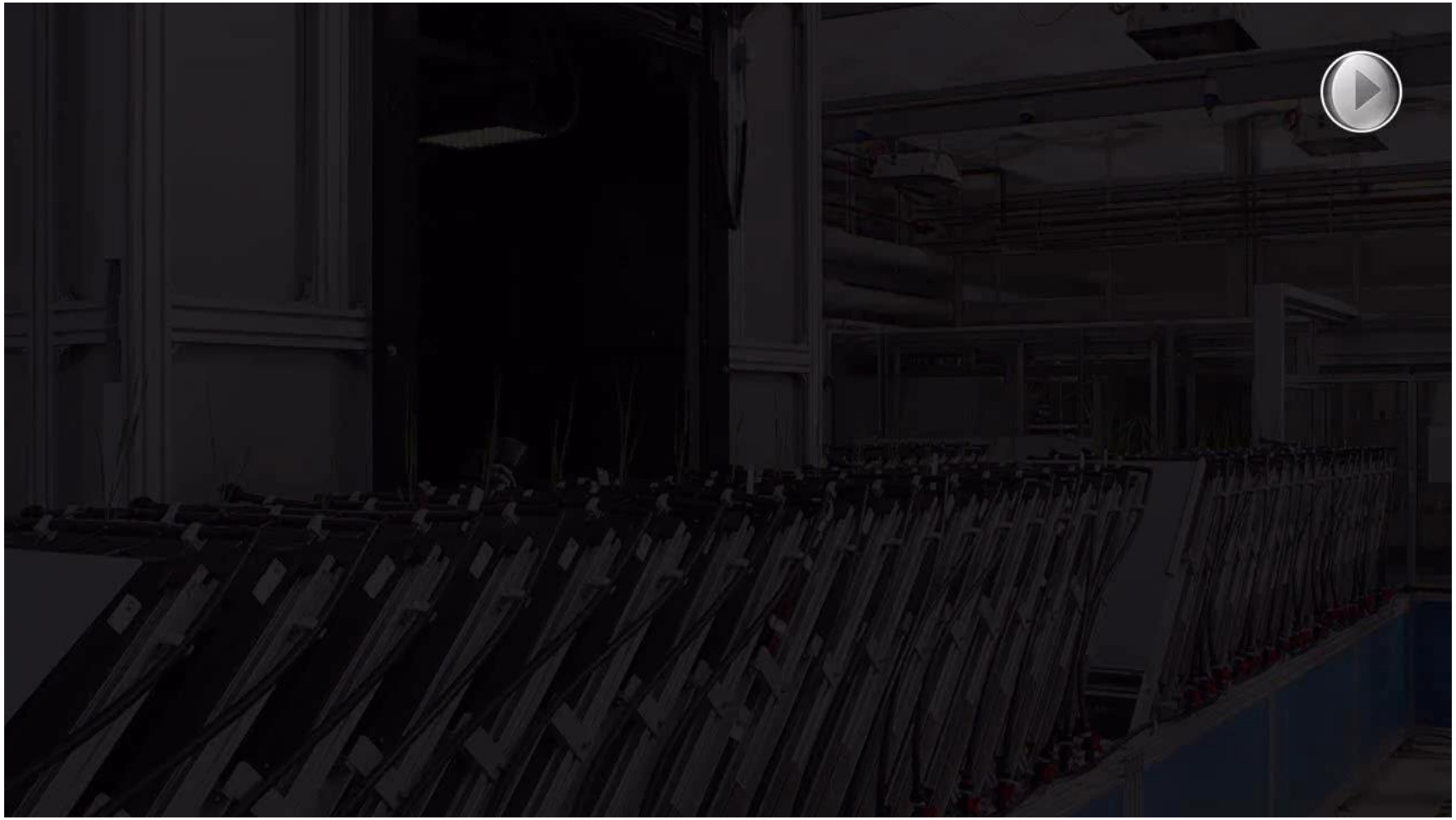
# THAT SIMPLE?


Optimal rainfall
Terminal drought
Early flowering
Late flowering
Penalty for short vegetative period
Reward for short vegetative period
Reward for deeper exploratory roots
Reward for long vegetative period
Reward for most economical root system
Penalty for long vegetative period
Reward for deeper roots
Trends in Plant Science

# WHICH METHODOLOGIES?

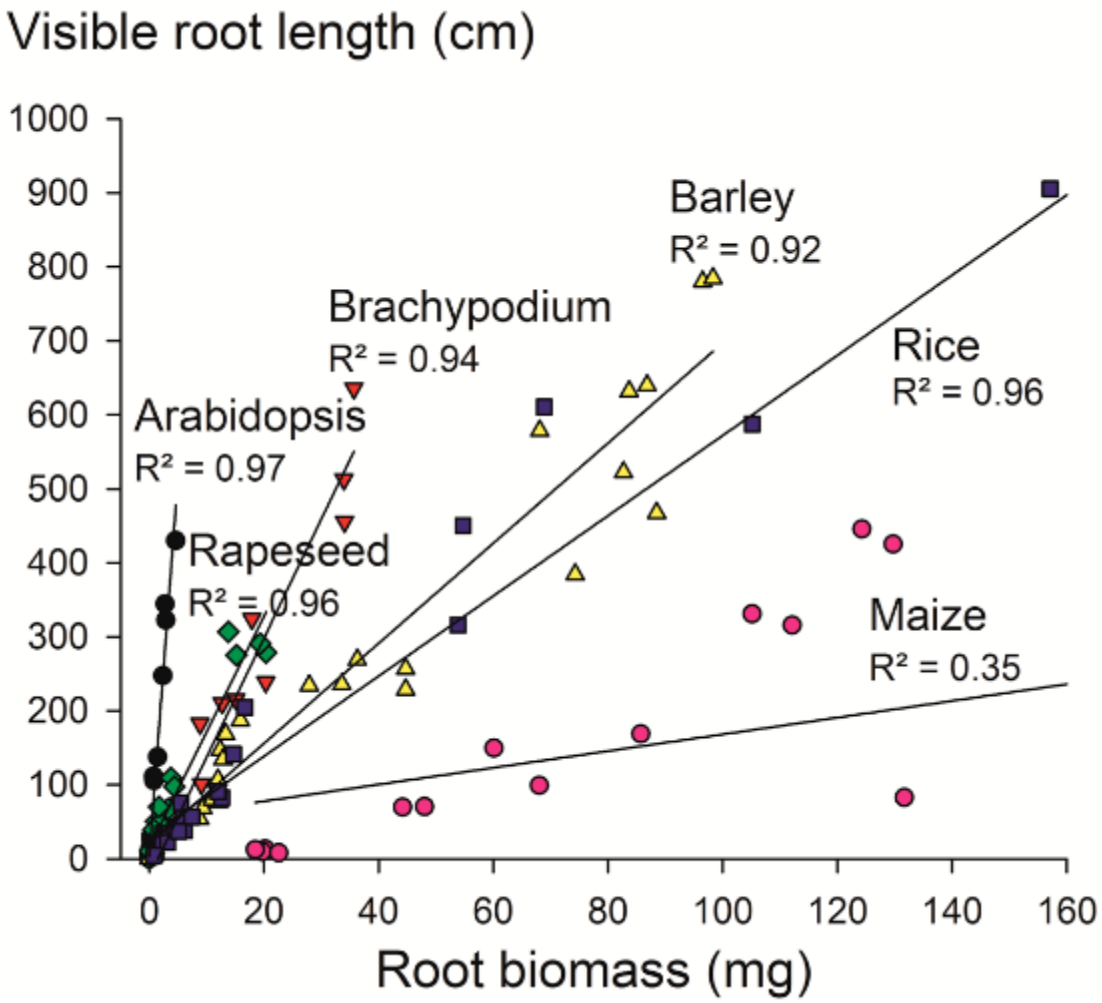



*Postma et al., 2013*




GROWSCREEN RHIZO III FZJ IBG2
Deutsches
Pflanzen
Phänotypisierungs-
Netzwerk
DPPN

# DIGITAL ROOT LENGTH VS. BIOMASS




*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
vation conditions

stically affected
physiological

(growth,

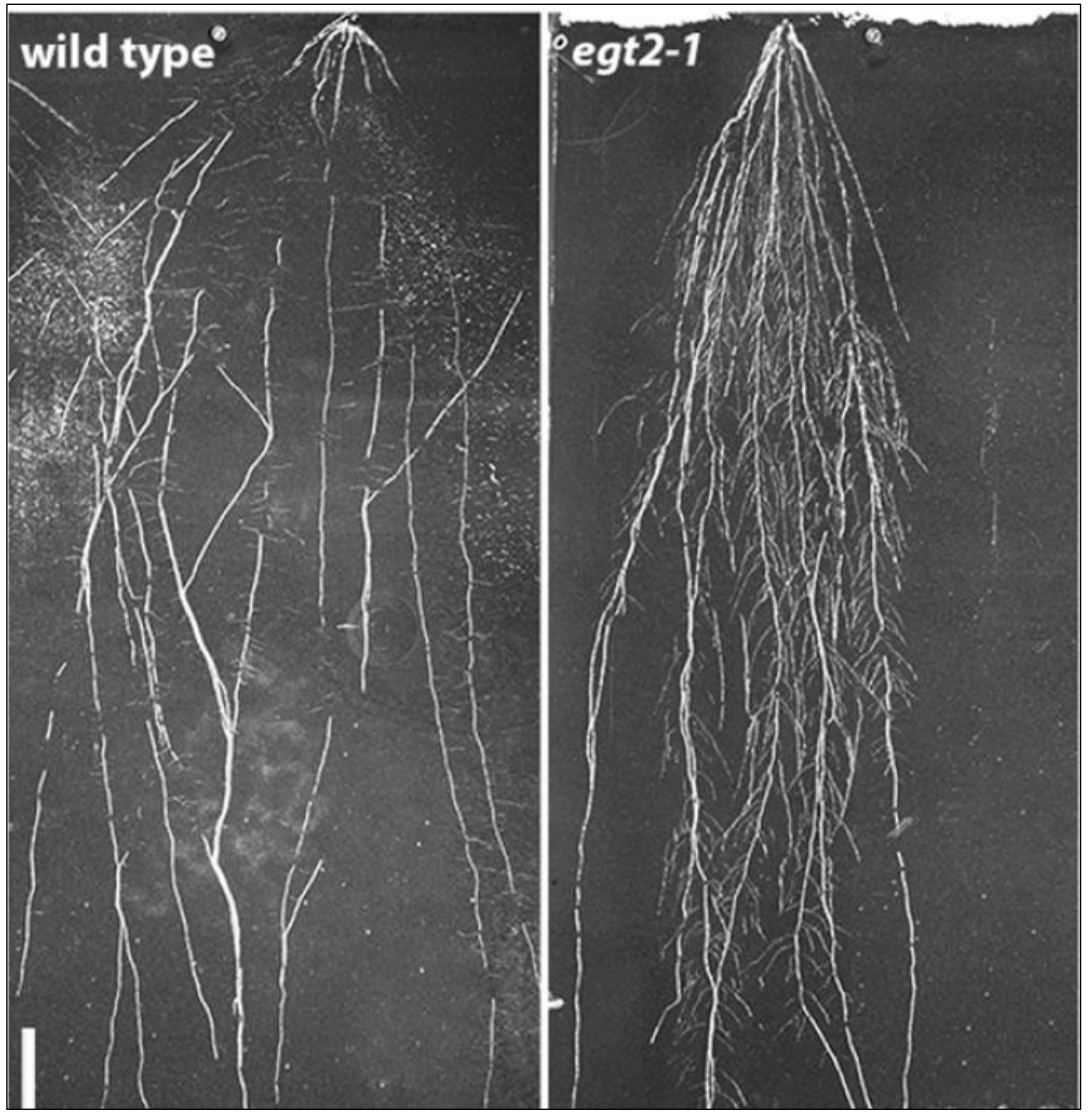
n step moderate;
effects

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

| Treatment | Trait | $\Delta CV_A$ (%) | |
|---|---|---|---|
| | | $\Delta CV_{Apd}$ | $\Delta CV_{Asd}$ |
| 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).

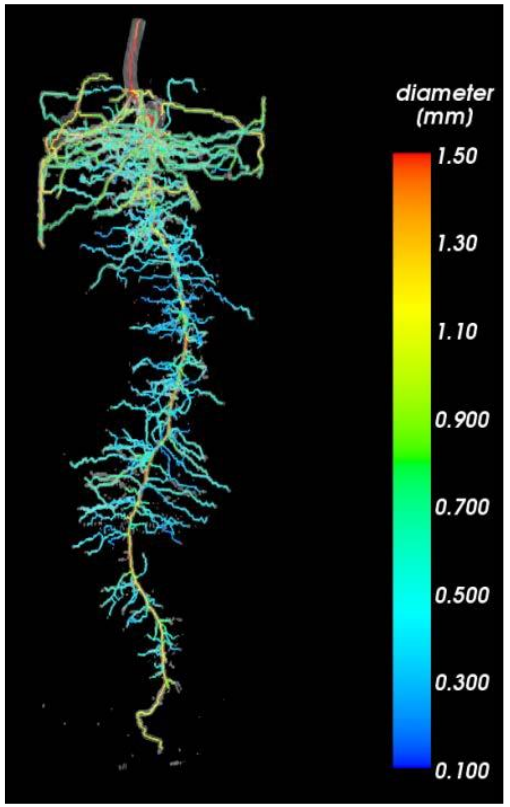
# DISCOVERY OF GENES CONTROLLING ANGLE AND BRANCHING




*Kirschner et al. 2021 PNAS*

4.7T MRI magnet

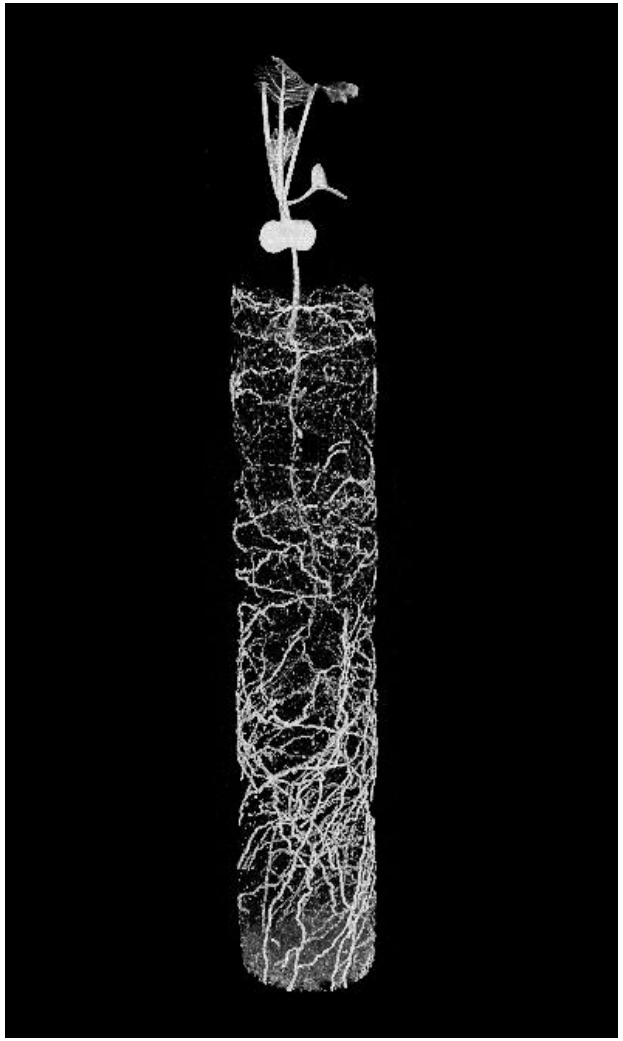
Automated plant handling

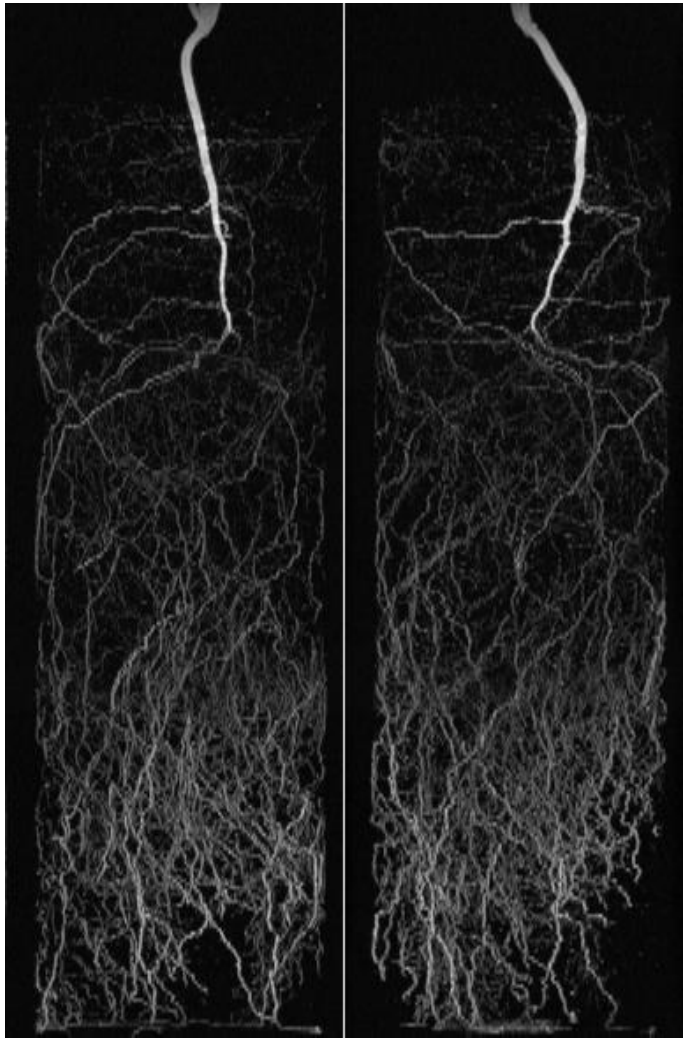



Software: '*NMRooting*'

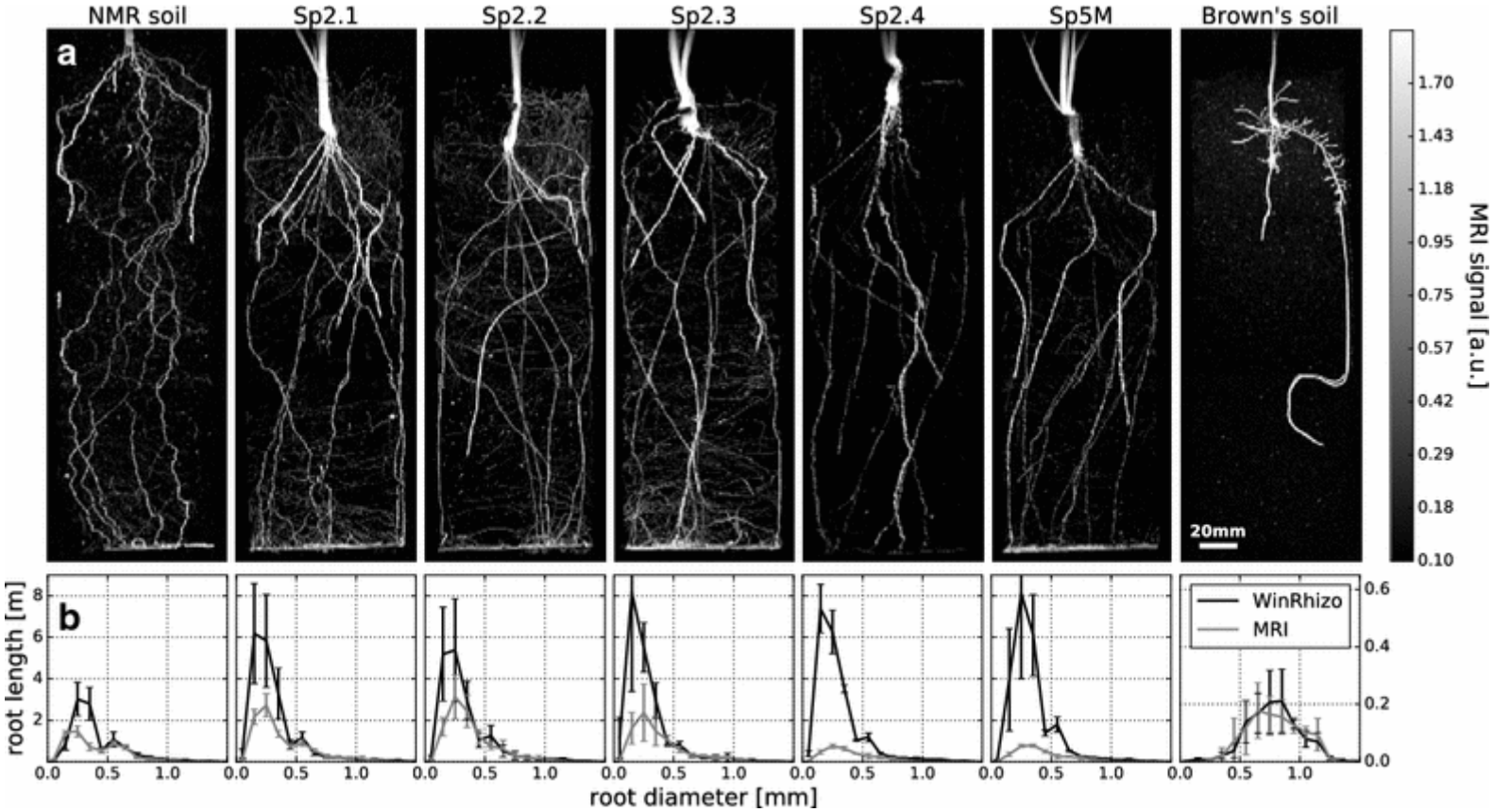
*van Dusschoten et al. 2016, Plant Physiology*

*Schmittgen et al. Journal of Experimental Botany 2015*



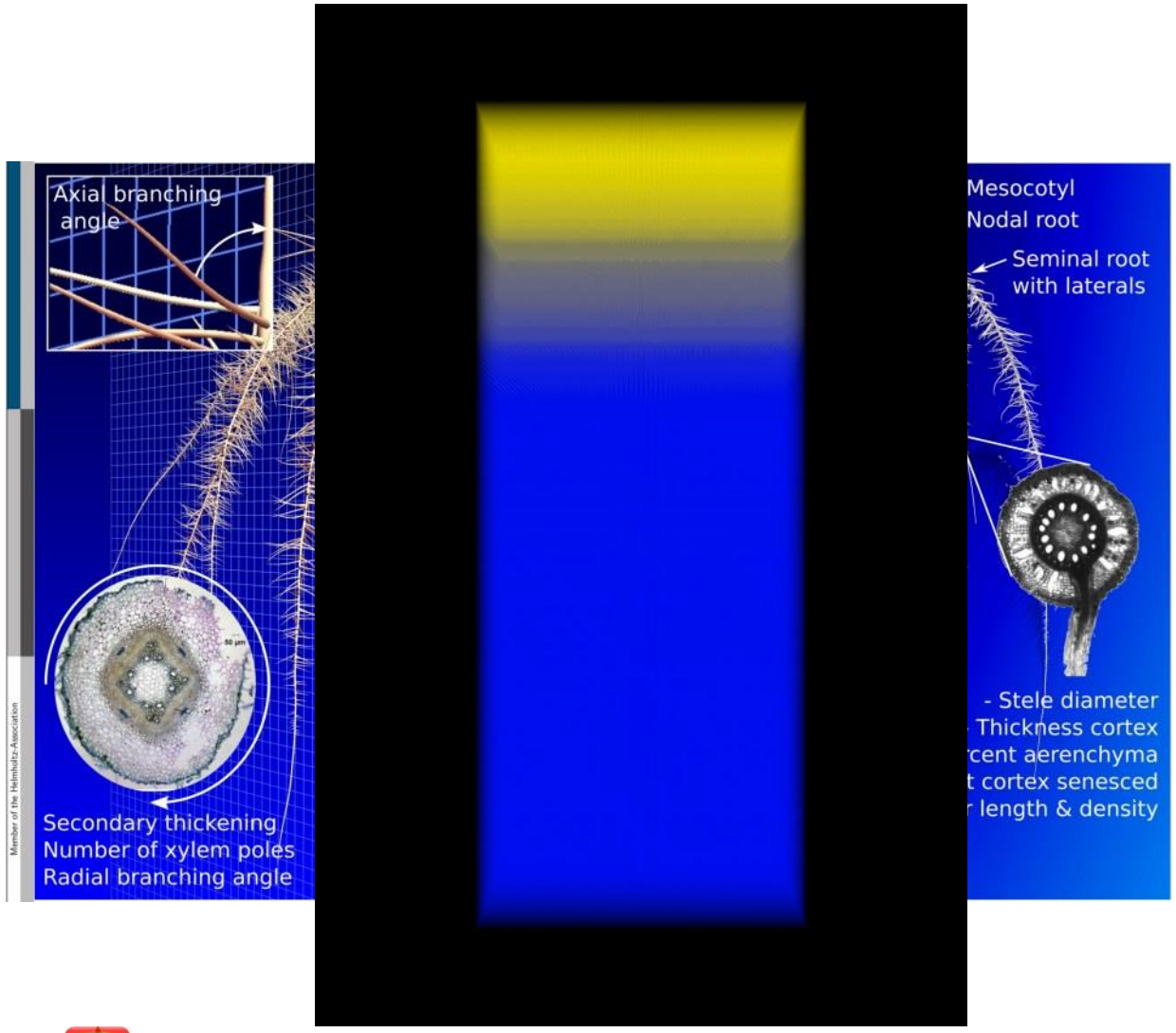


*Courtesy of D. van Dusschoten*




Pflugfelder et al., Plant Methods, 2017

- 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




OPENSIMROOT

*Postma et al., New Phytologist, 2017*


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