

# “Root soil interactions for improved resource capture in crops”

Tim George  
Plant Soil Ecology



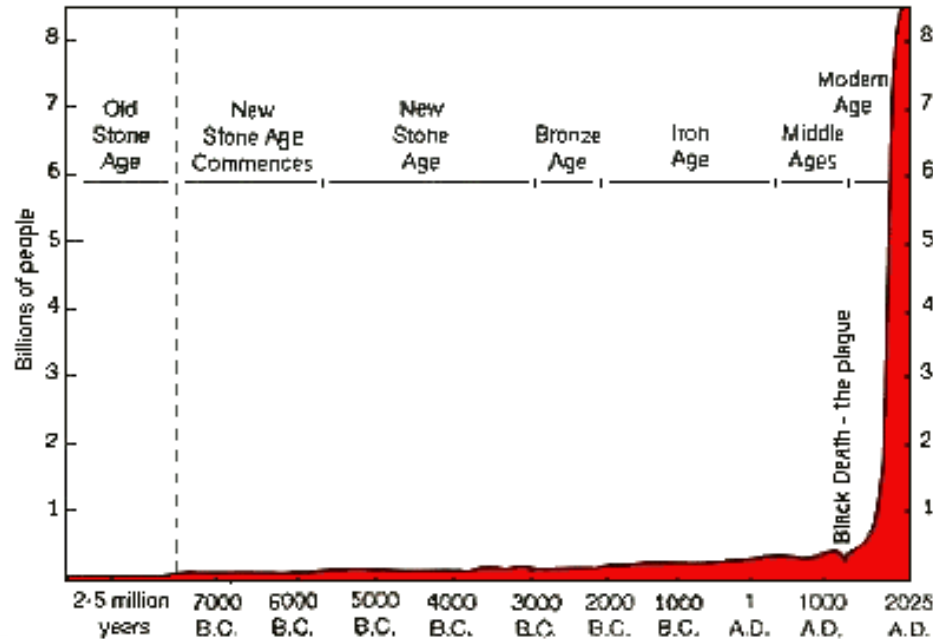
The James  
**Hutton**  
Institute



# The need for food security....

## Population Growth

World Population Growth Through History

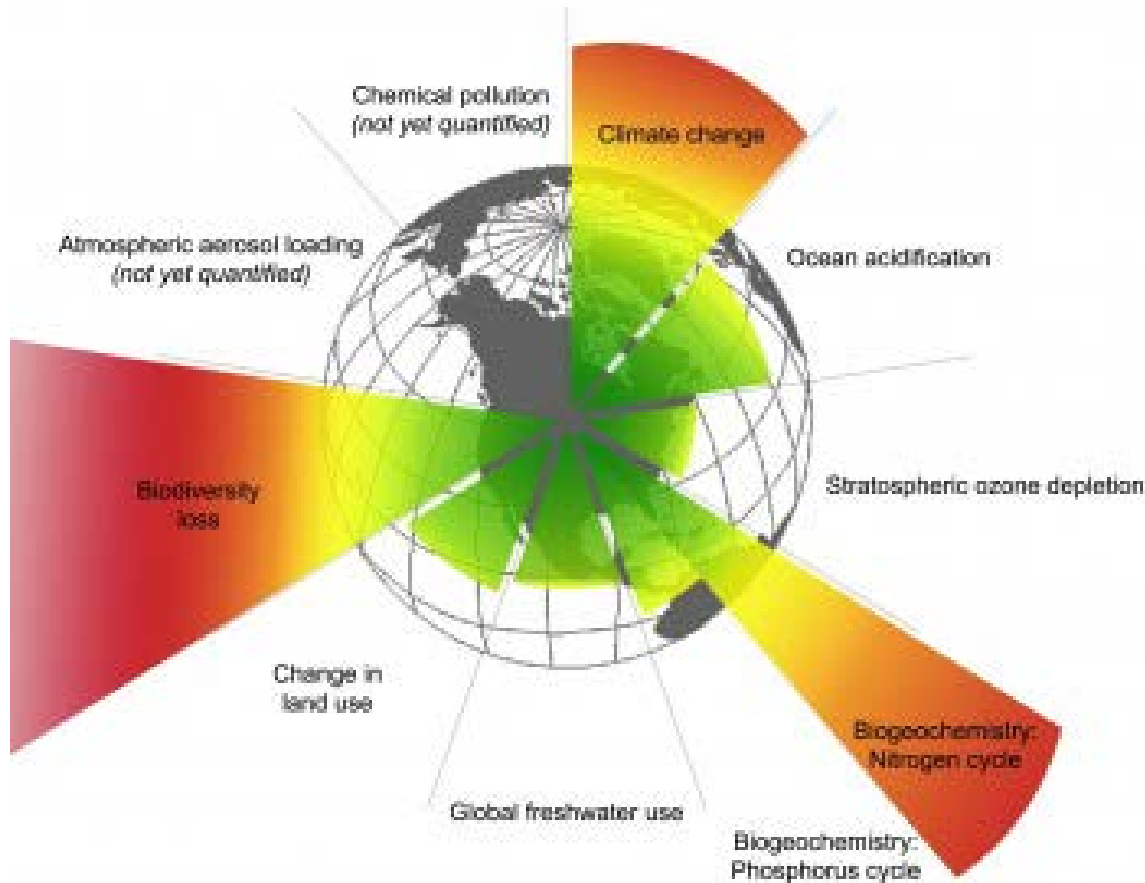


## Balanced "Western" Diet



**We need to produce as much food in the next 50 years as we have in the last 10000**

# ...and environmental protection



- Estimated safe operating space for a range of systems
- Direct agricultural involvement
- Nitrogen cycle beyond limit
- Phosphorus cycle nearing limit (latest update past limit – 2014)
- Use of fresh water critical

# Research Focus

**Landscape Scale** – Green manure systems in riparian buffers



**Field Scale** – Field trials, Field Scale Evaluations and soil samples from long-term field platforms



**Whole Plant Scale** – Screening interspecific and intraspecific variation, mutant populations and transgenics



**Rhizosphere Scale** – Measuring biological, chemical and biochemical characteristics in close proximity to roots

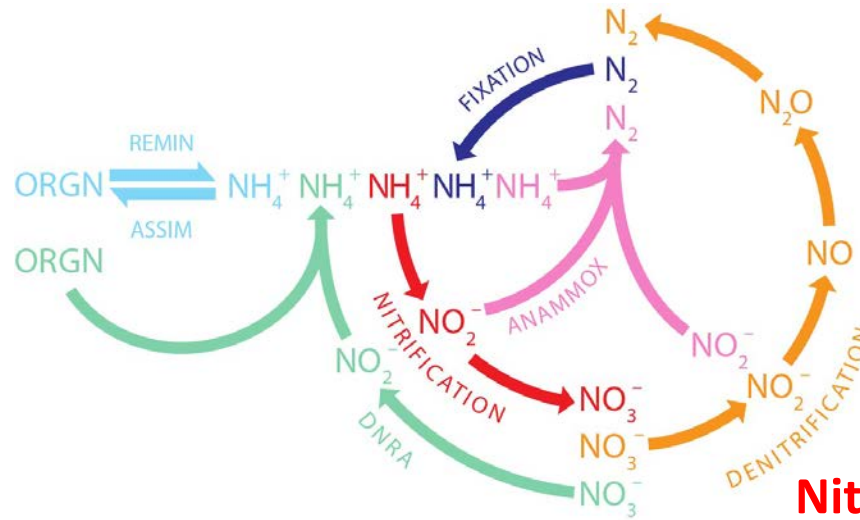


**Soil Particle Scale** – Interaction between exudates and soil surfaces; soil fungi and fertiliser particle

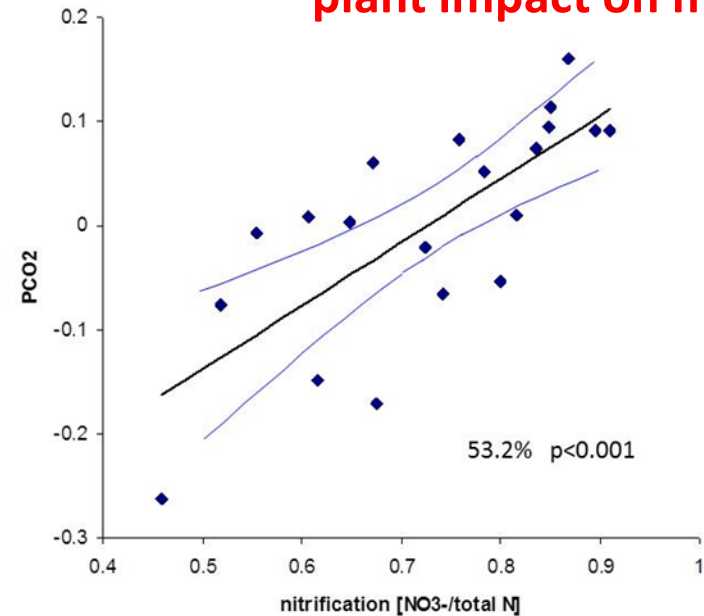
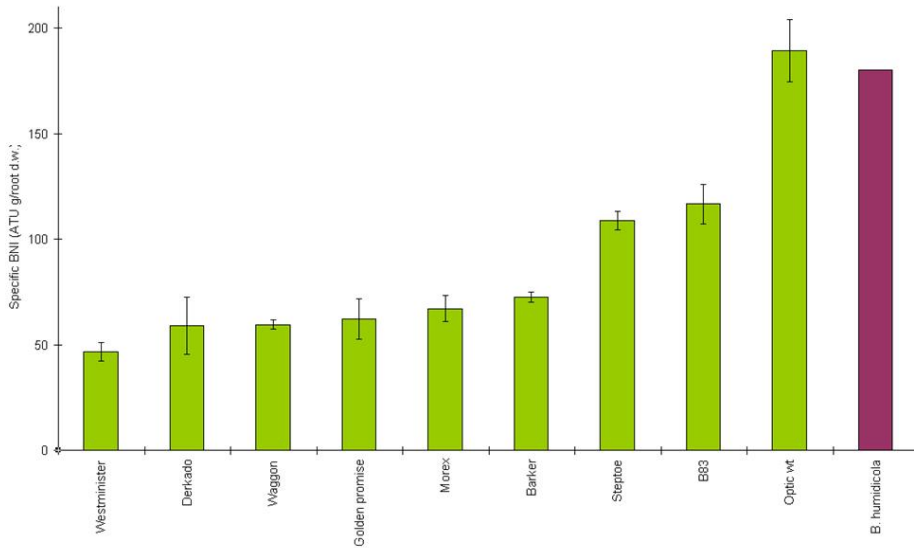


**Cellular Scale** – Expression of candidate genes – P deficiency and drought tolerance

# Plant Exudates inhibit nitrification

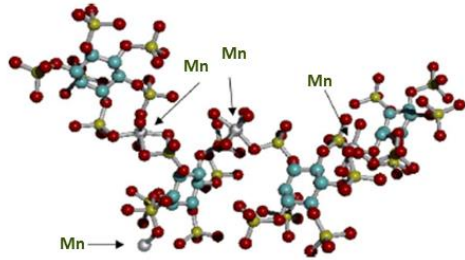


**Nitrification related to plant impact on microbes**



# Root phytases for micronutrient availability

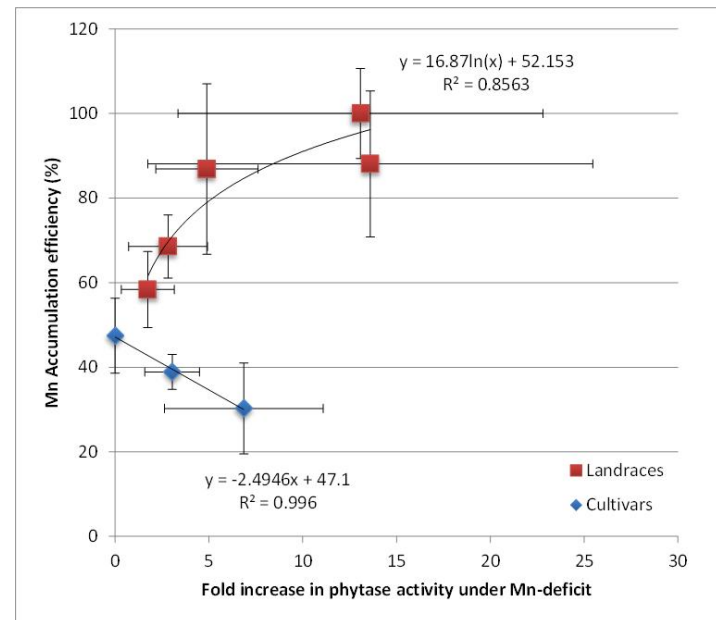
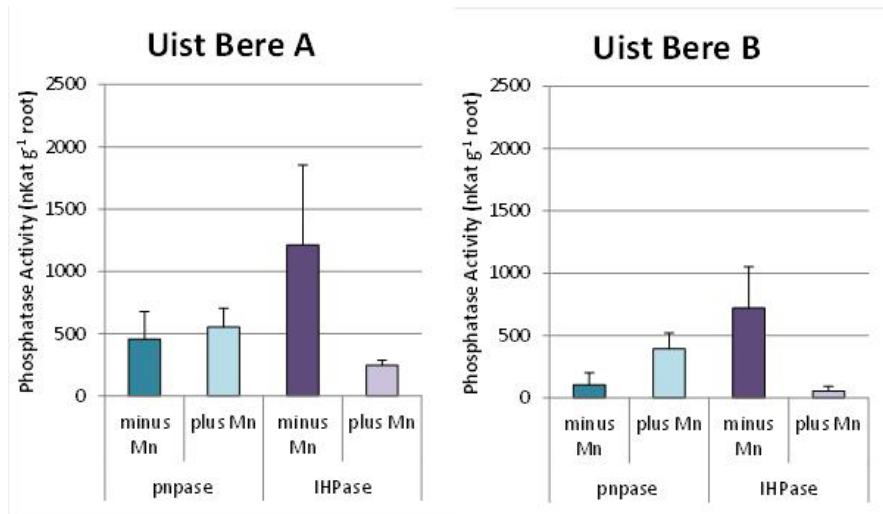
## Micronutrient -IHP Complexes



+ Phytase

=

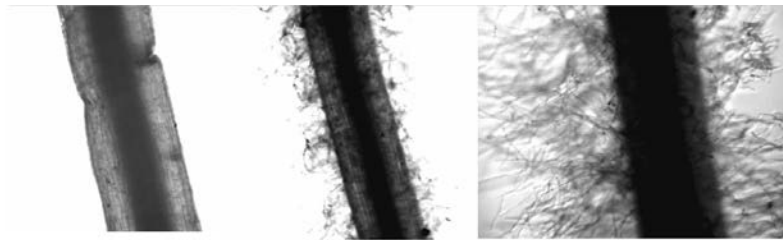
$6xPO_4 + \text{Inositol} + \text{Mn}$



# Root hairs for sustainable production



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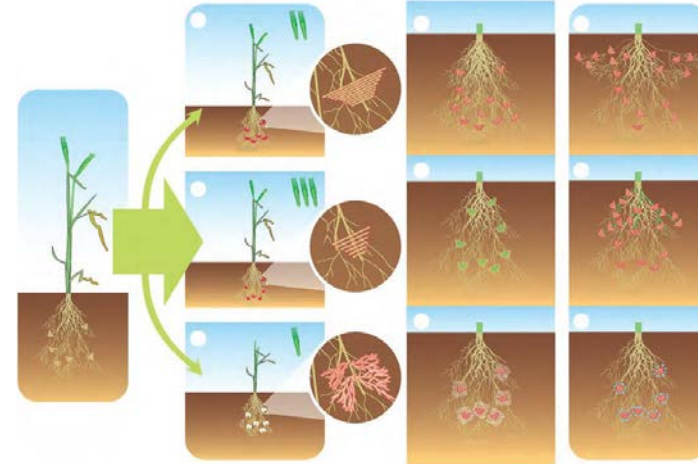


No Root Hairs  
(NRH)

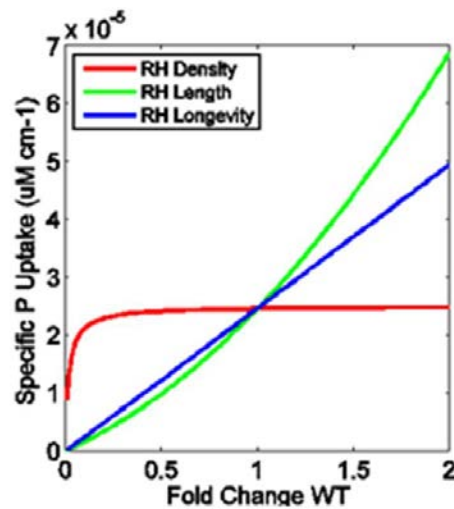
Short Root Hairs  
(SRH)

Long Root Hairs  
(LRH)

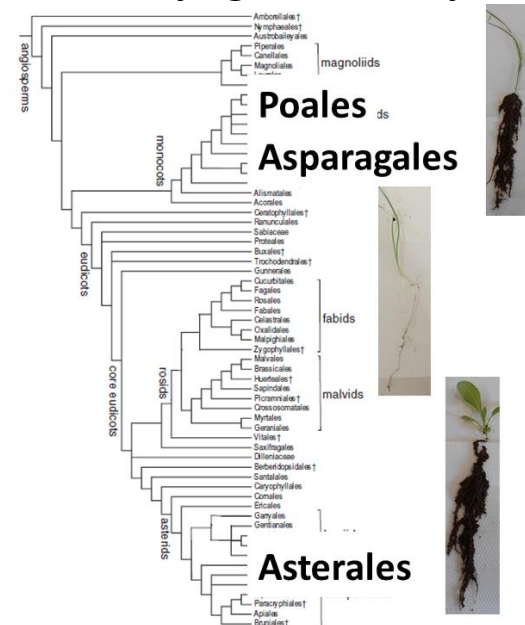
## Conceptual Model



## Root Hair Benefit Model

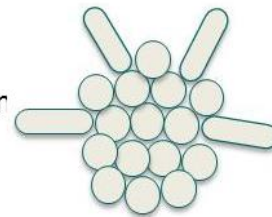


## Phylogenetic Study

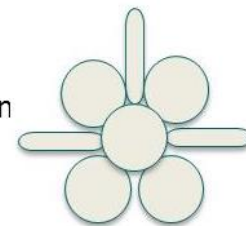


## Low Cost Root Hair Zones

Fewer Cell Files  
Larger cells  
Less Cell wall production  
Larger vacuoles  
= Less Cost



More Cell Files  
Smaller cells  
More Cell wall production  
Smaller vacuoles  
= Greater Cost



# Rhizosheath genetics



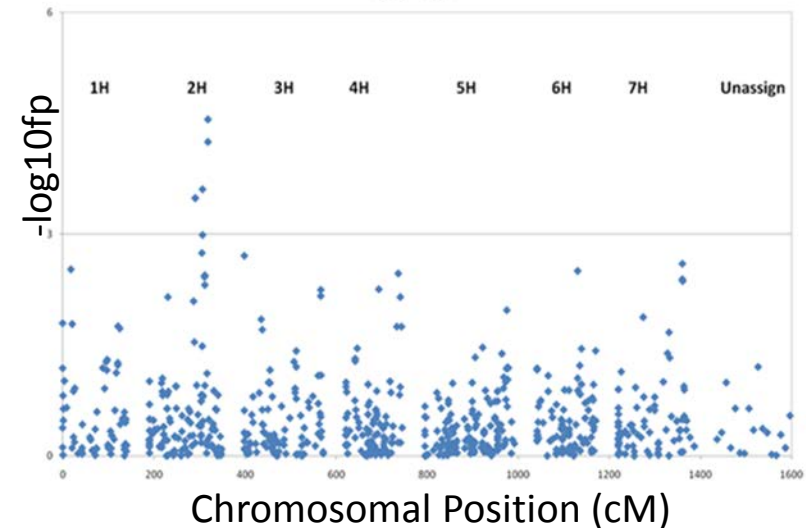
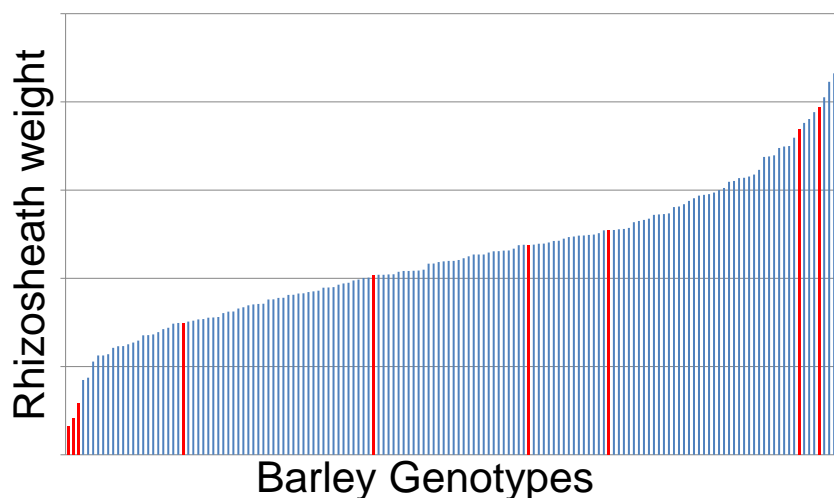
Illumina Oligo Pool Assay



- Rhizosheath is a trait that quantifies soil root contact
- It contributes to tolerance of combined abiotic stress
- Easy to screen large populations
- Large genotypic variation
- QTL for rhizosheath confirmed in two barley populations

## Putative candidate genes include:

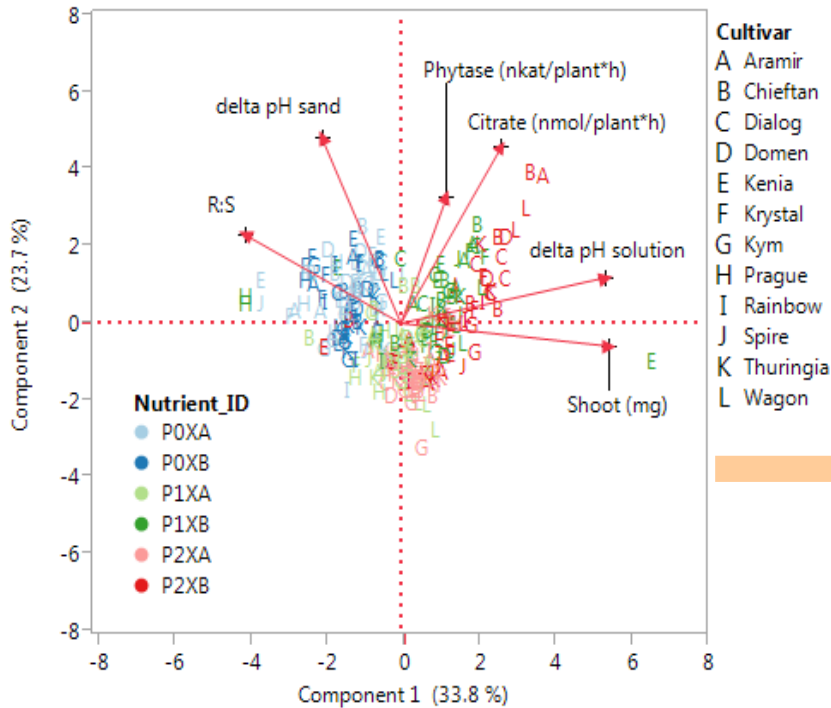
- calcium/calmodulin-dependent protein kinase (**OsCDPK7**) → Drought tolerance
- glutamate receptor (**GLR3.1**) → Root elongation
- QTL's on 2H → Root length, Root dry weight



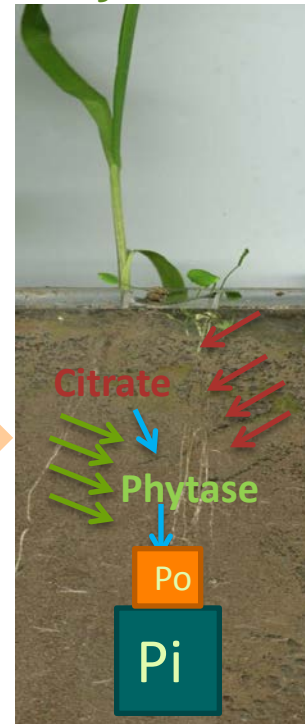


# Rhizosphere Complementarity for Enhanced Use of Phosphorus

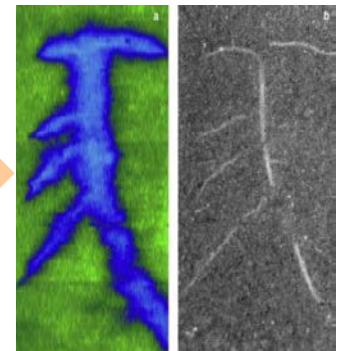
## Selection of complementary rhizospheres



## Optimised intercropping systems



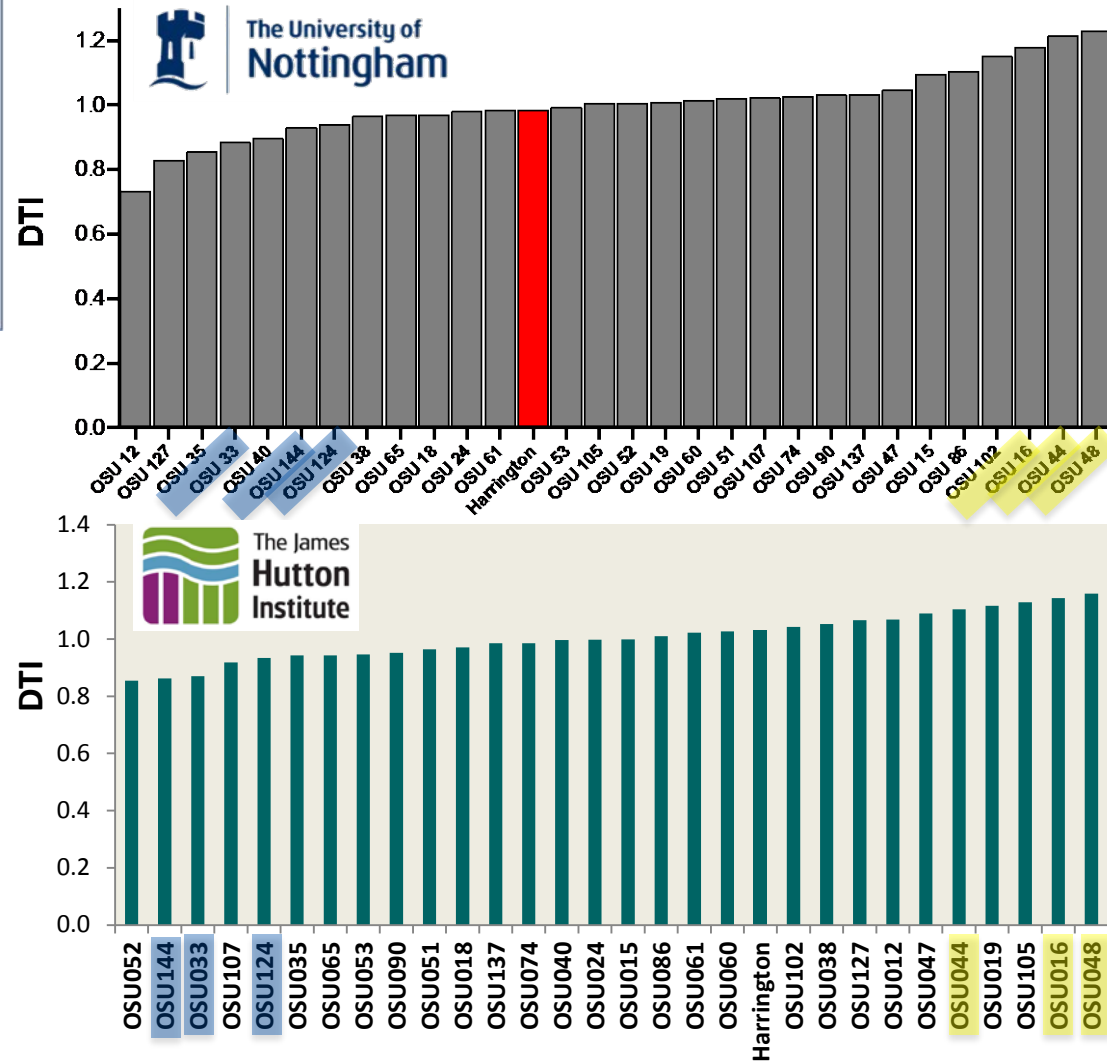
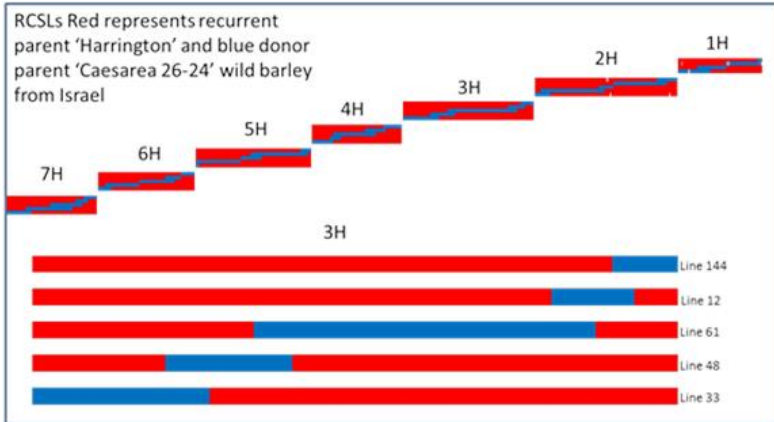
## Geochemical models of Organic P dynamics



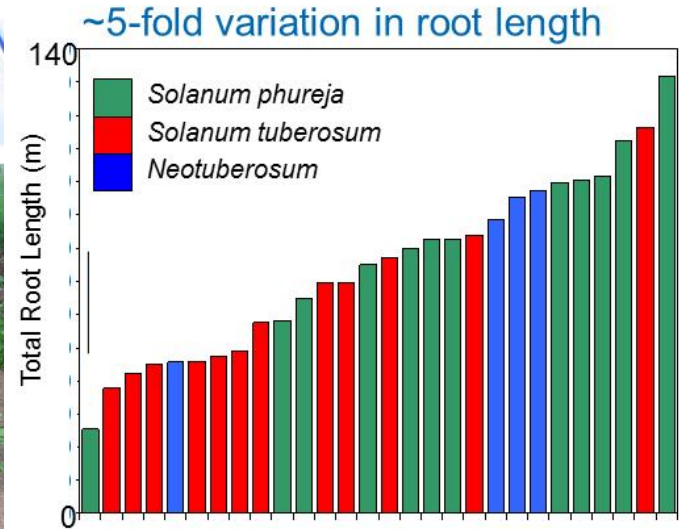
BBSRC (BB/K017047; 2014-2017)

**Alternative Agronomy**

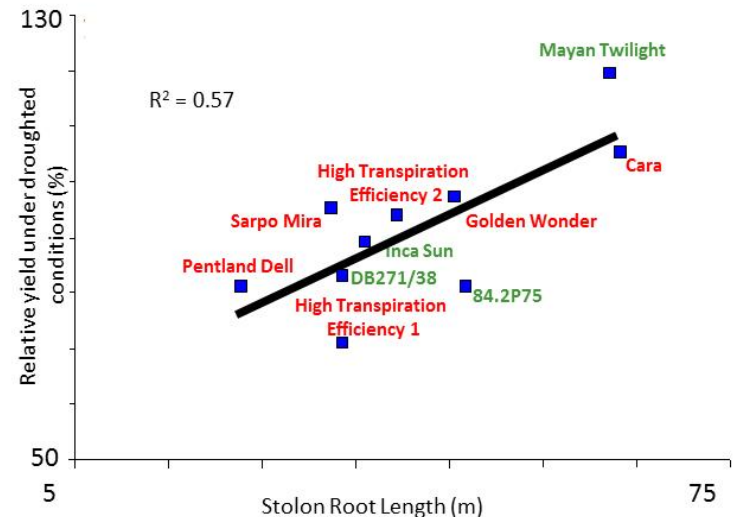
# Genetics of drought tolerance



# Potato root length important to drought tolerance

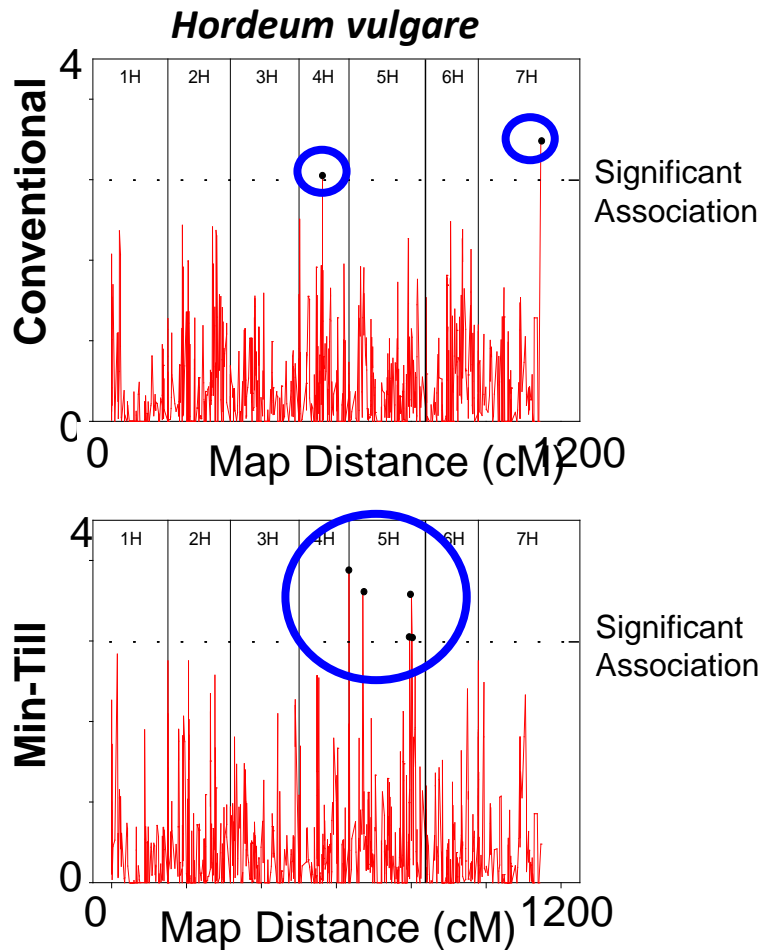


Longer stolon roots = better drought tolerance

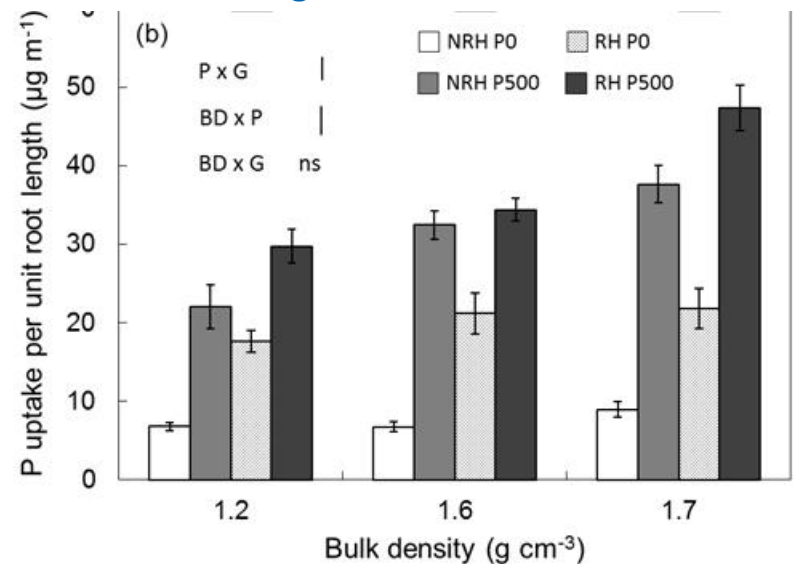


# Interactions between Tillage and P

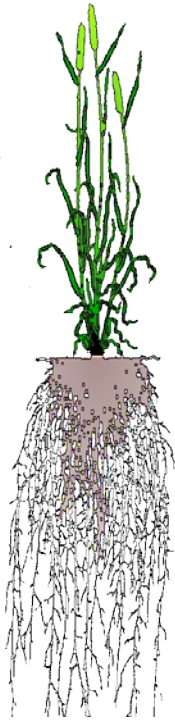
QTL for Phosphorus Use Efficiency (PUE) vary with tillage



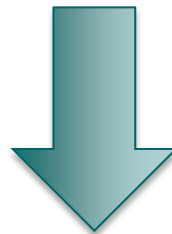
Strong soils increase soil root contact reducing the need for root hairs



# Translation



**Root Ideotypes  
Designer Rhizospheres  
Improved Crop Cultivars  
Improved Agronomy  
Packages for Sustainability**



Translation

**SUSTAINABLE PRODUCTION**

Environmental Change

Field to Region

Barriers to Uptake

Acceptability



# Acknowledgements



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\*MIP = Most Important People

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