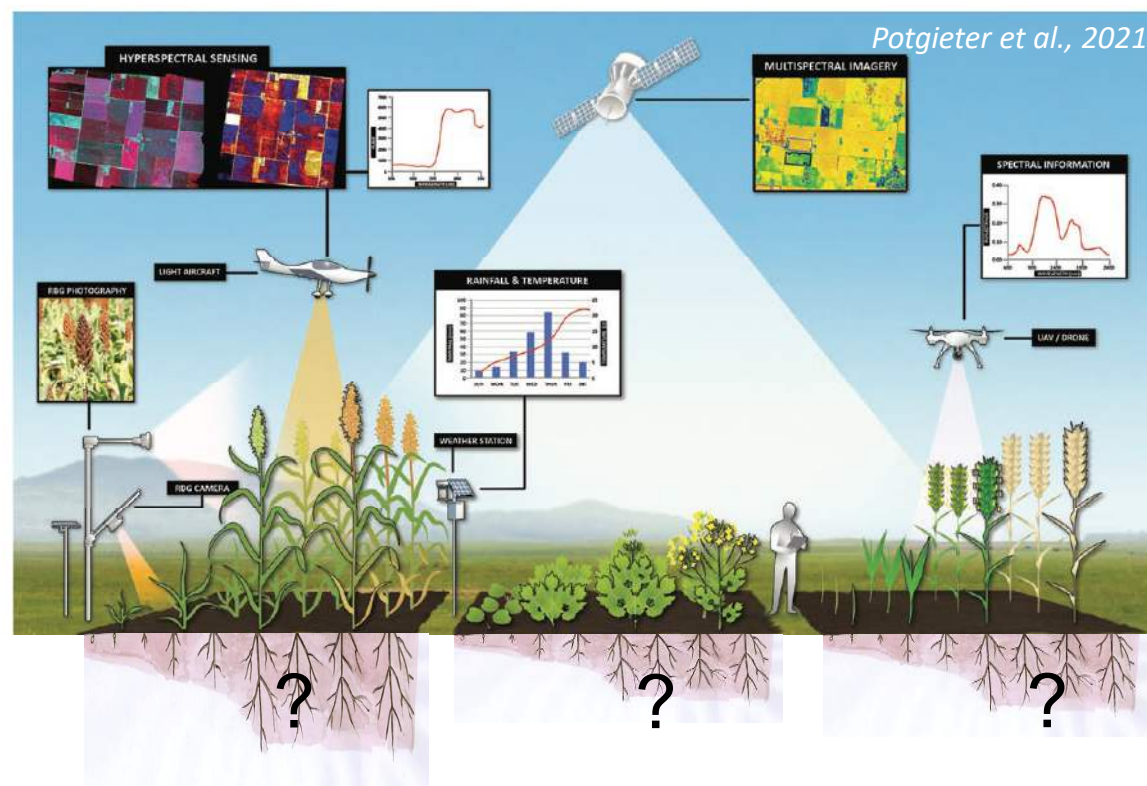


# Designing crops bottom up: matching rooting systems to sites and seasonal conditions

*Dongxue Zhao, Raul Gimenez, Peter de Voil and Daniel Rodriguez*

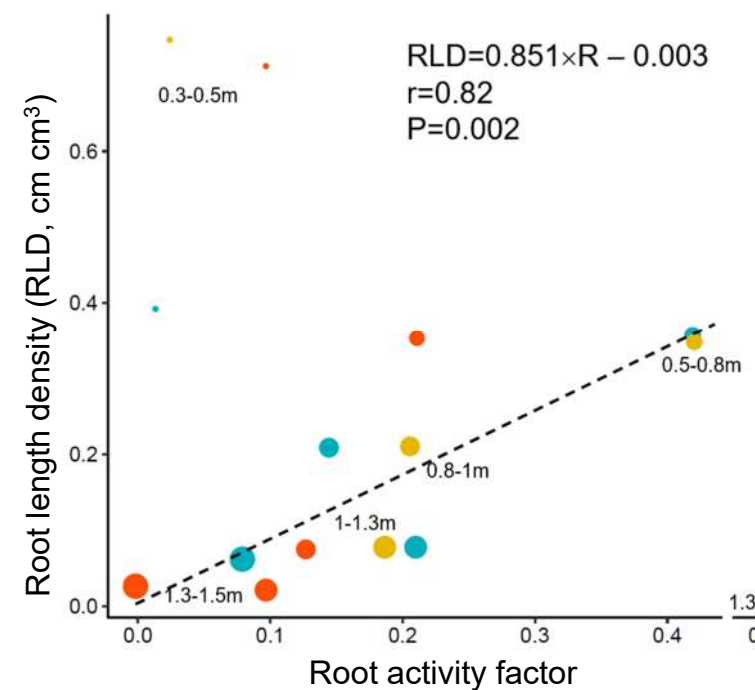
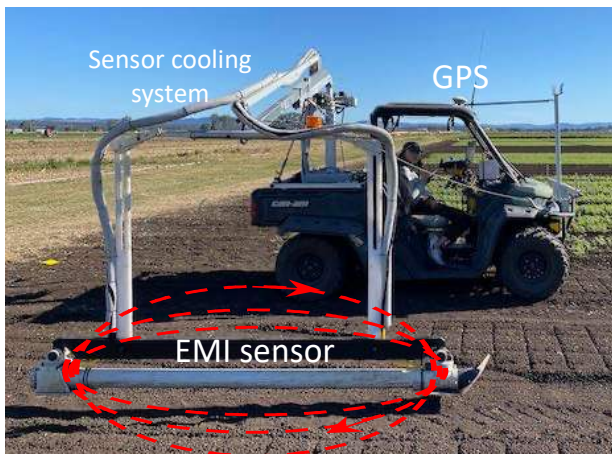
# Phenotyping applications for breeding & agronomy



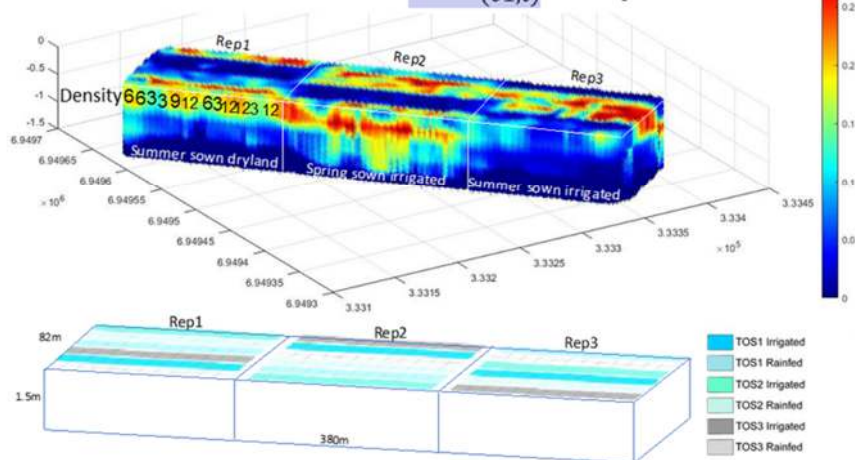
Do all sorghum hybrids have the same type of root system?

Does the root system of different hybrids respond the same to drought?

# Functional root phenotyping



$$\text{Root activity factor}_i = \frac{\text{Water use}_i}{\text{PAW}_{(t_1,i)} \times \text{Crop demand}}$$



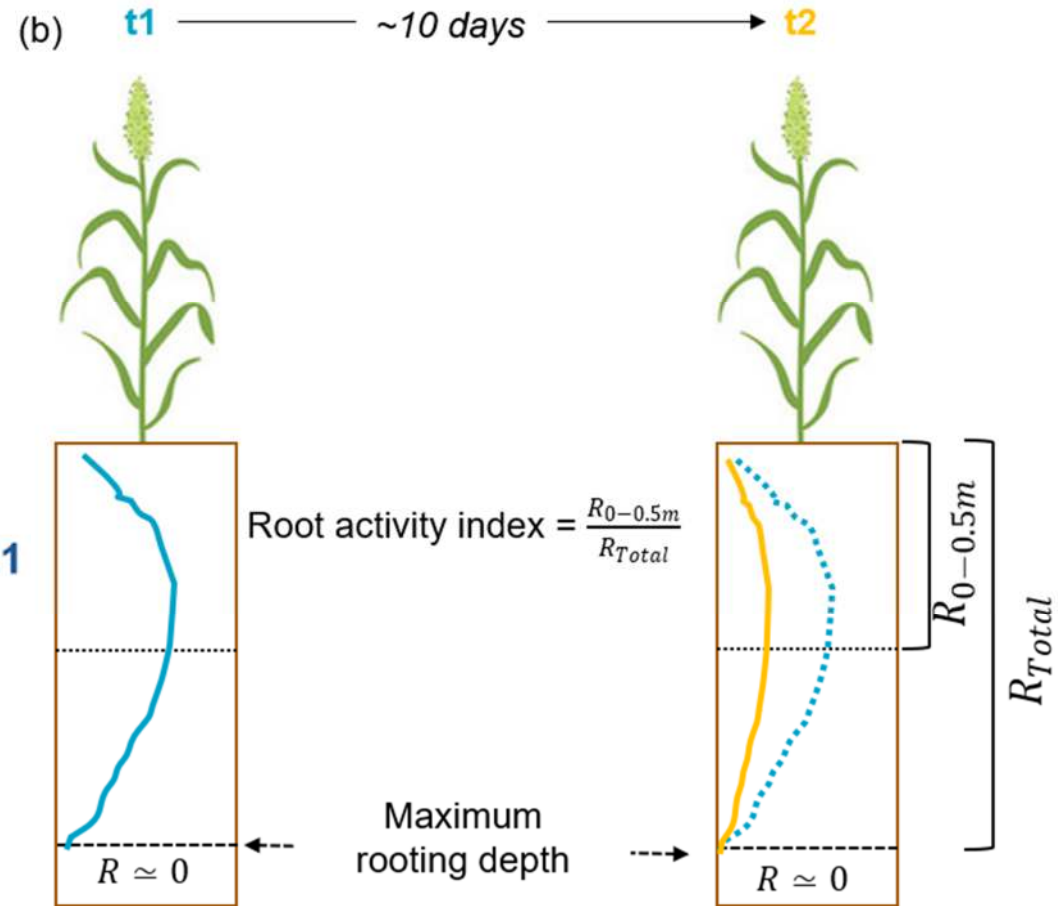
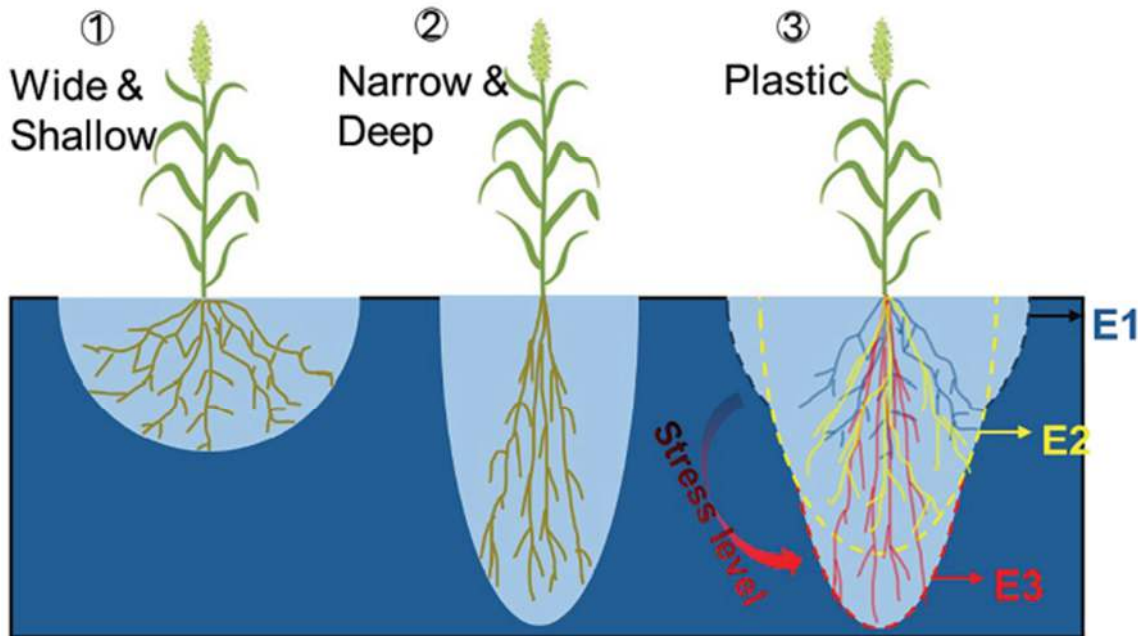
Zhao et al., 2022

Zhao et al., 2024a

The sensed root activity factor from EMI is highly correlated with root architecture and function

# Functional root traits

## Different sorghum root phenotypes

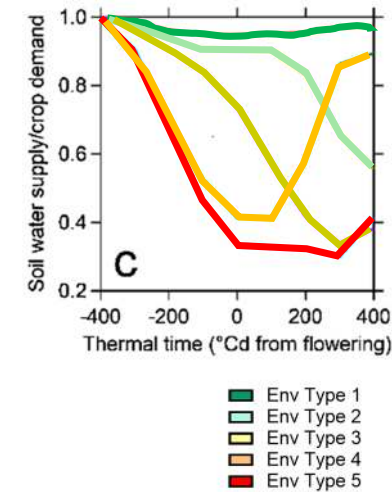
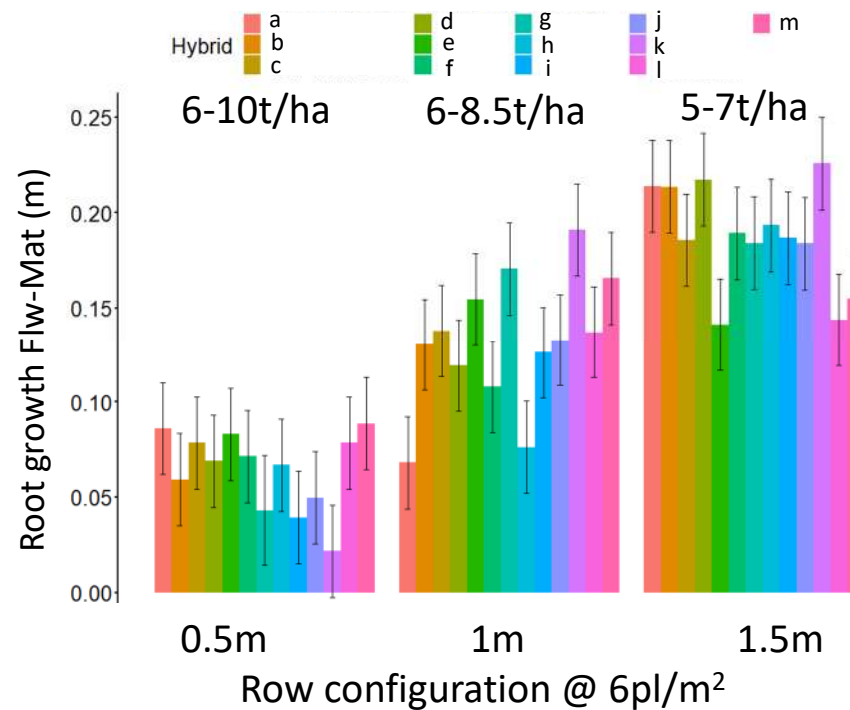
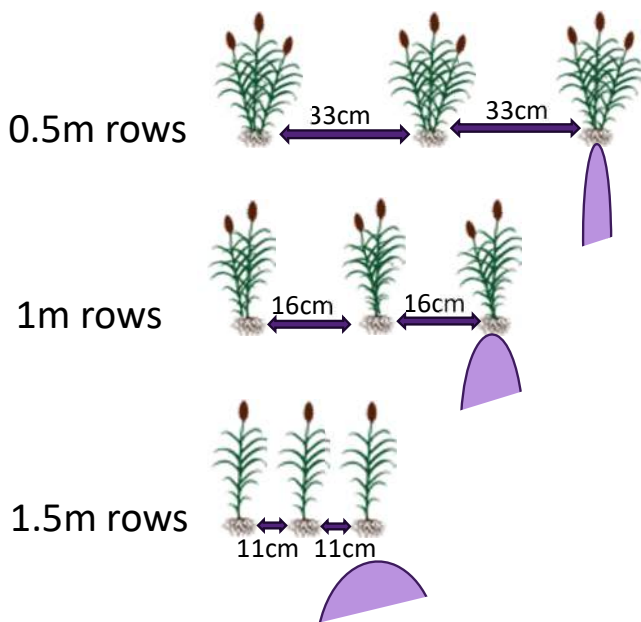


# Narrow and deep root system in a wet season



Tosari Qld 2024, 13 sorghum hybrids 6pl/m<sup>2</sup>, wet season (ET1)

## 3 Row configurations

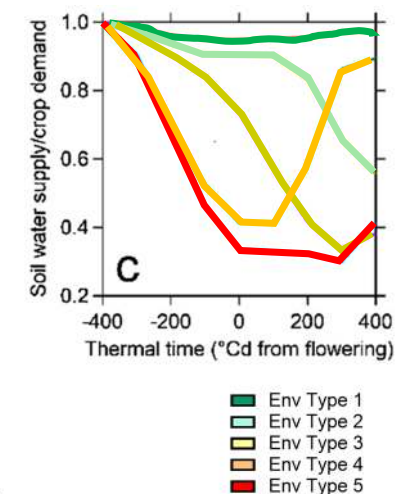
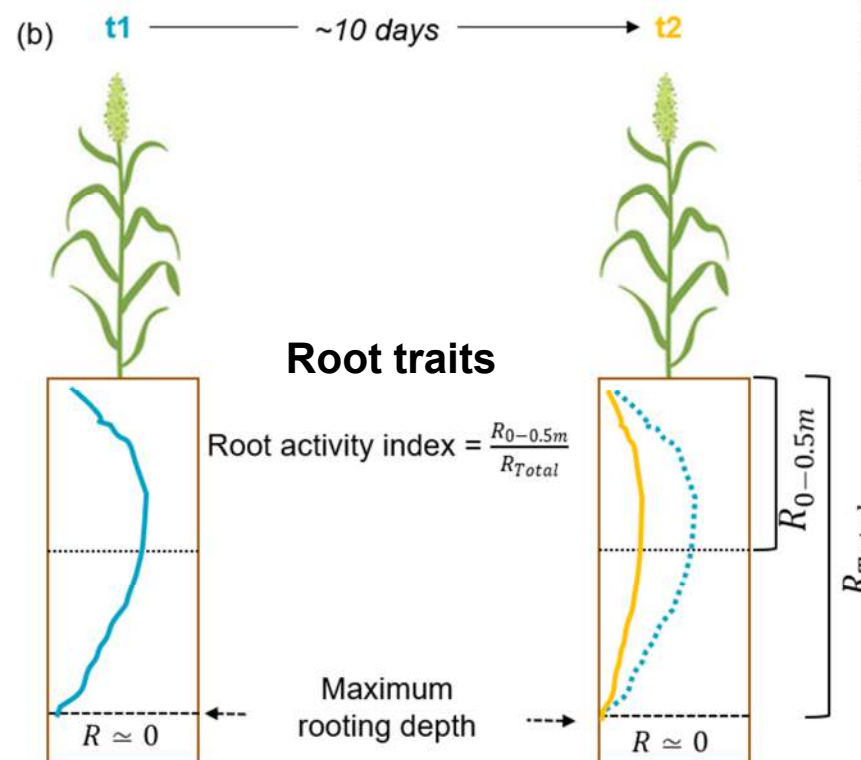


Narrower row configurations reached maximum rooting depth by flowering  
Different hybrids had different capacity to grow roots after flowering when sown in wider rows

# Narrow and deep root system in a dry season

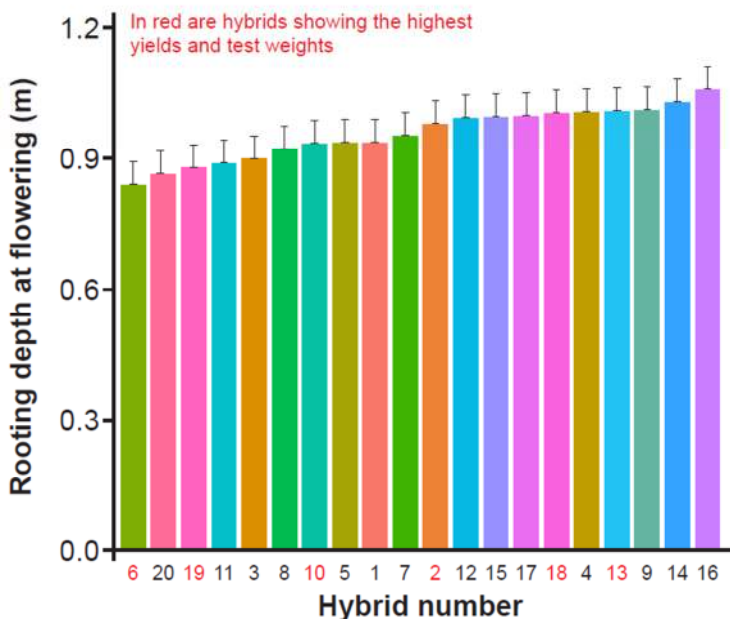
Brookstead Qld 2023, 20 sorghum hybrids 1 environment (ET5)

7mm from flowering to maturity, yield: 2.4 to 4.6 t/ha dry

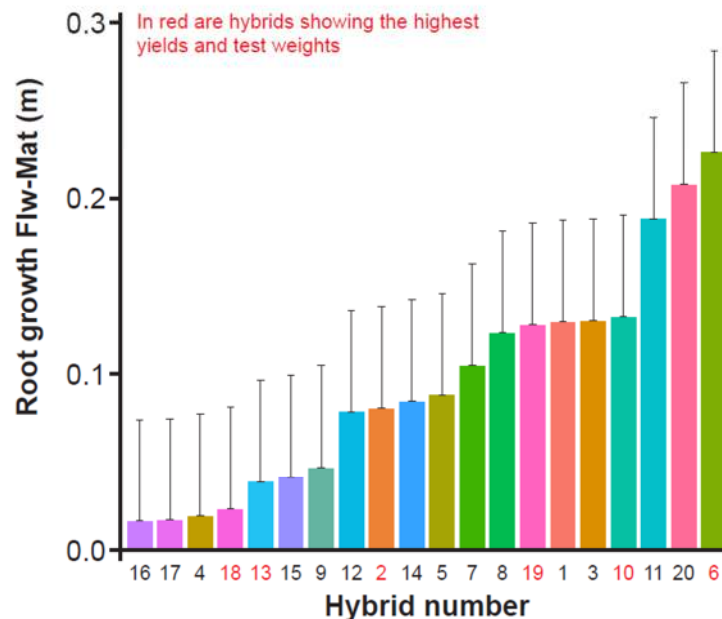


# Narrow and deep root system in a dry season

## Brookstead Qld 2023, 20 sorghum hybrids 1 environment (ET5)



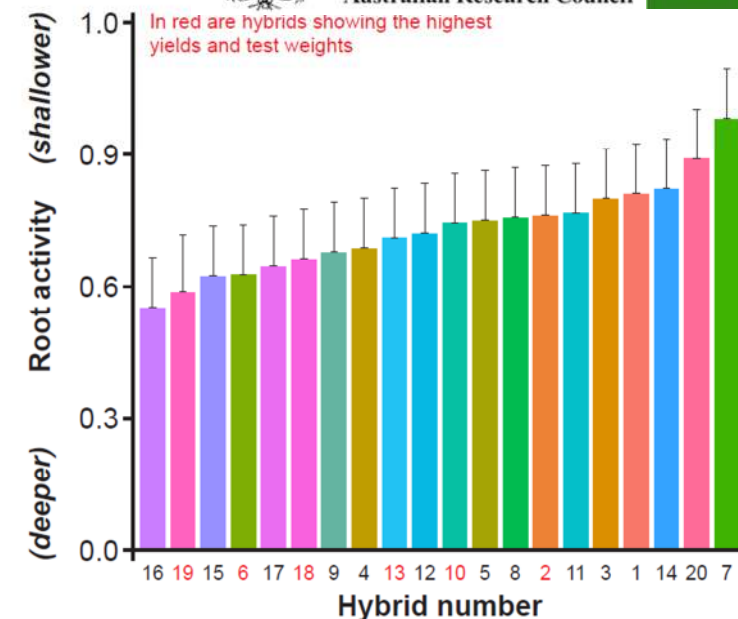
No association with yield



Lower yielding Higher yielding

Less root growth from Flw to Mat

Deeper root growth from Flw to Mat



Higher yielding Lower yielding

More water use from deeper layers

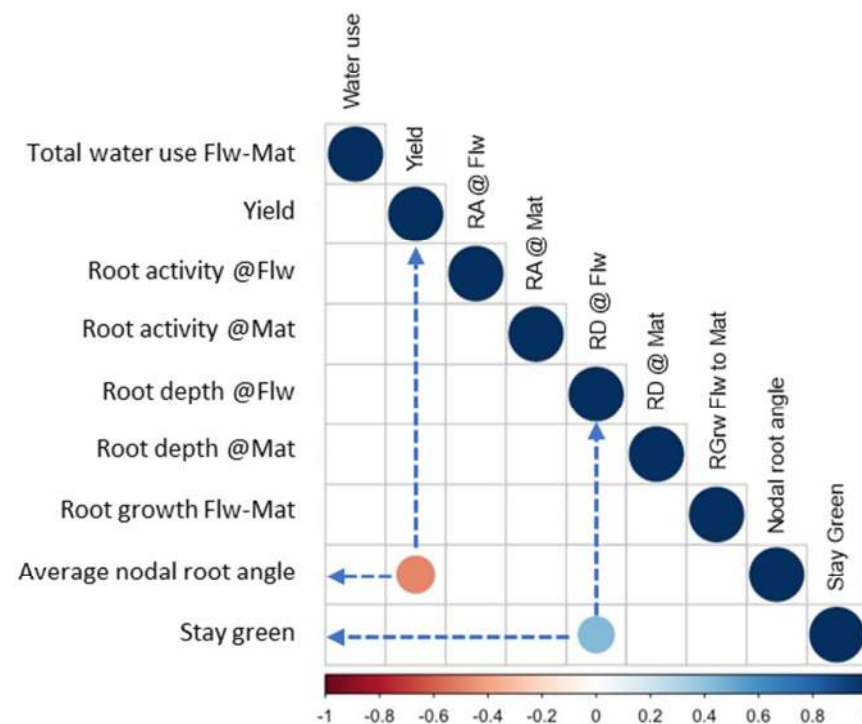
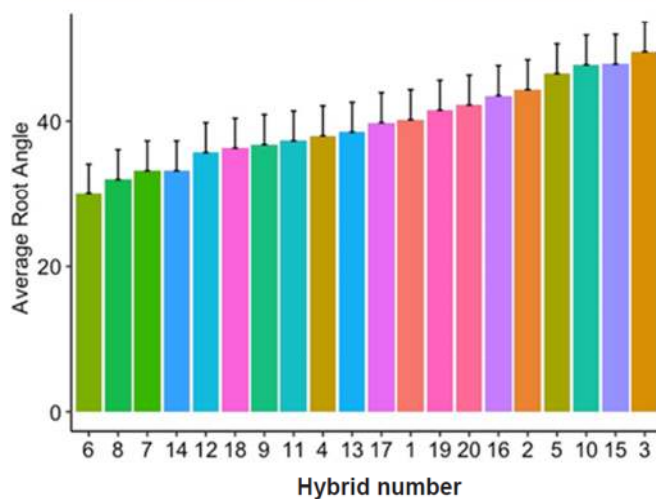
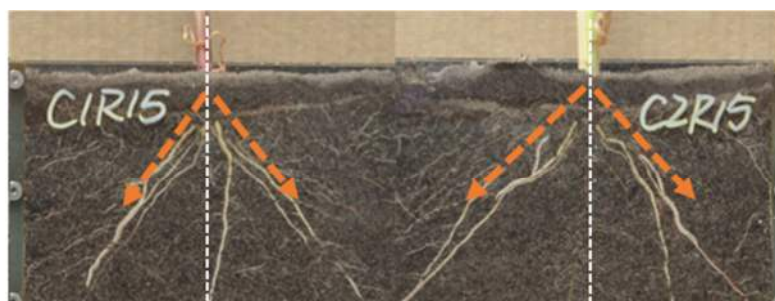
Less water use from deeper layers

In a dry season, root growth after flowering was associated to higher yields

# Narrow and deep root system in a dry season

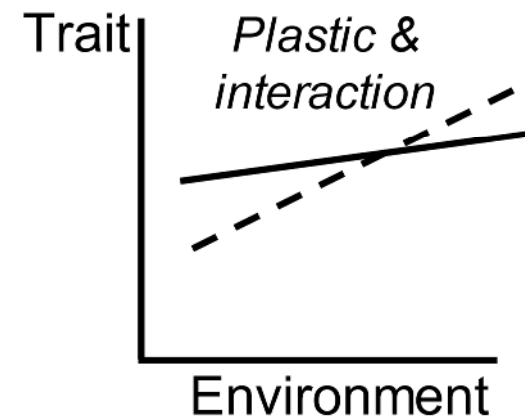
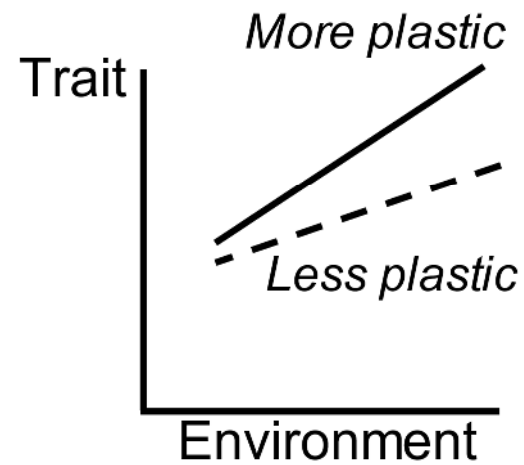
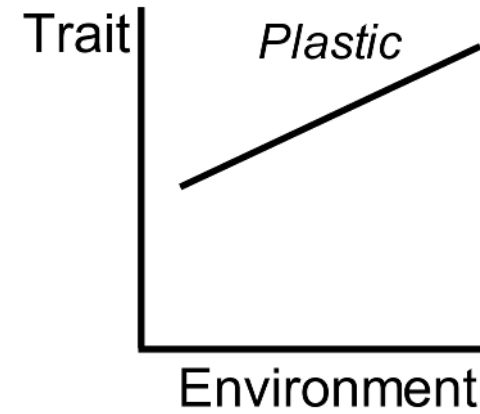
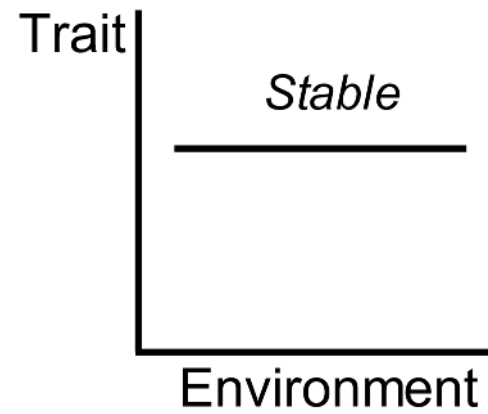


Brookstead Qld 2023, 20 sorghum hybrids 1 environment (ET5)



Narrower nodal root angle → higher yields

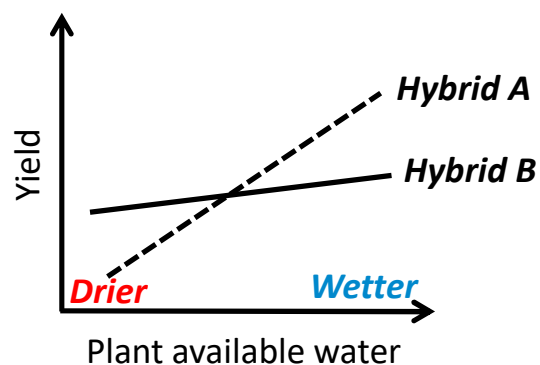
# Narrow, deep and plastic root system



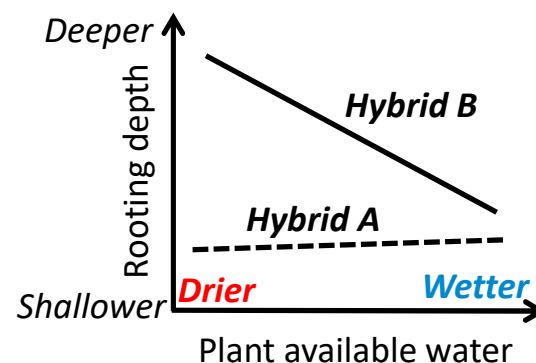
# Narrow, deep and plastic root system



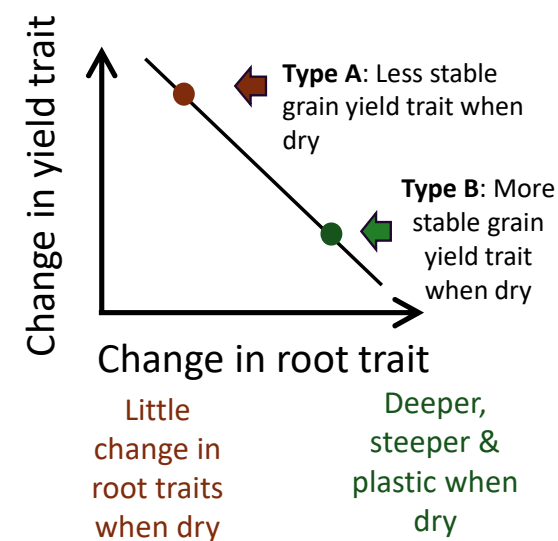
Yield change in response to dry or wet conditions



Root changes in response to dry or wet conditions



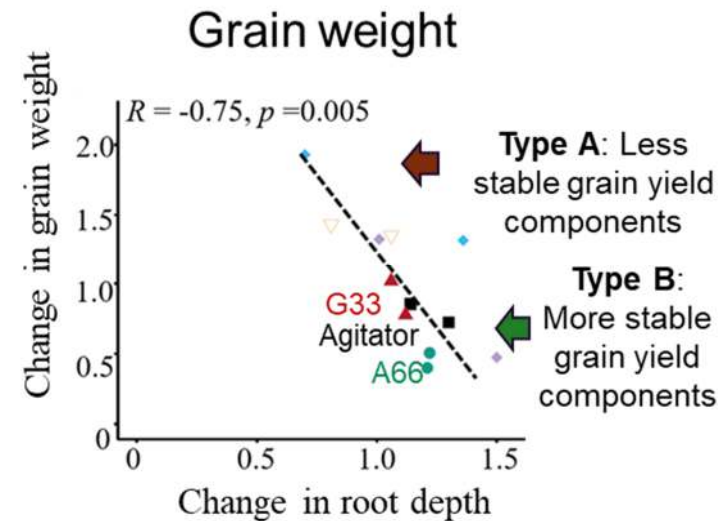
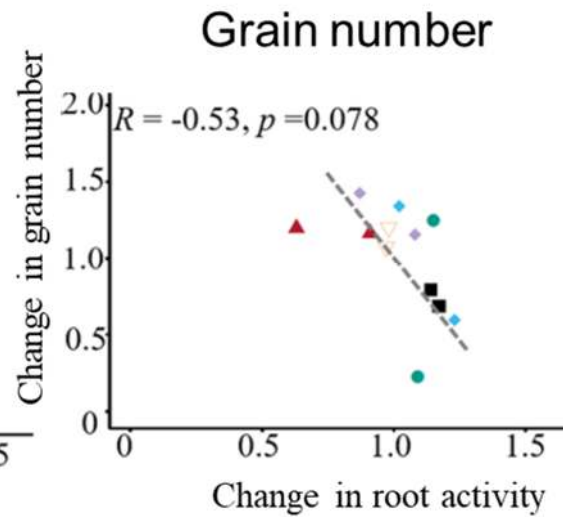
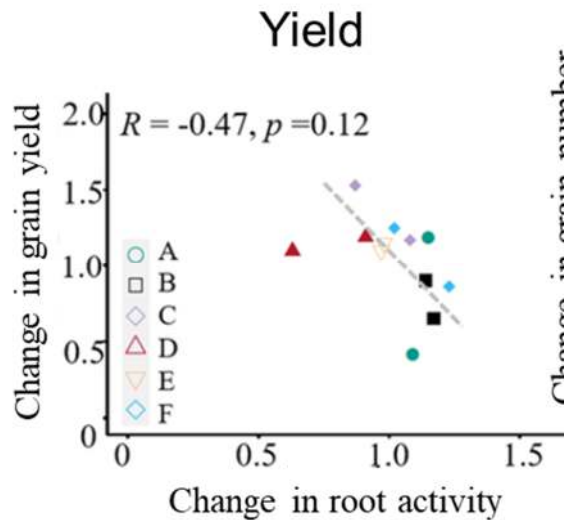
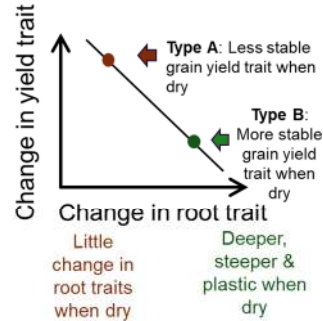
Yield change in response to dry or wet conditions



# Narrow, deep and plastic root system

Change in yield components in response to dry or wet conditions

Yield change in response to dry or wet conditions



Zhao et al., 2024b

Plastic root traits were associated to more stable yield and yield components

## A new method was developed to phenotype root systems in the field

- DualEM combined with drone imagery can be used to rapidly and cheaply characterise genetic and management effects on root traits of importance
- The functional phenotyping of rooting systems shows opportunity to design rooting systems to fit site and seasonal conditions and inform agronomic practice

## Opportunities from the technology for the northern grains region

- Match genetics and agronomy to target environments to increase yields and reduce downside risks
- Data sets to improve the capacity of crop models to capture G and M effects on root growth and yield
- New tools for precision agriculture e.g., maps of PAWC, maximum rooting depth across fields, root activity and root diseases.
- Phenotyping of NVT sorghum trials

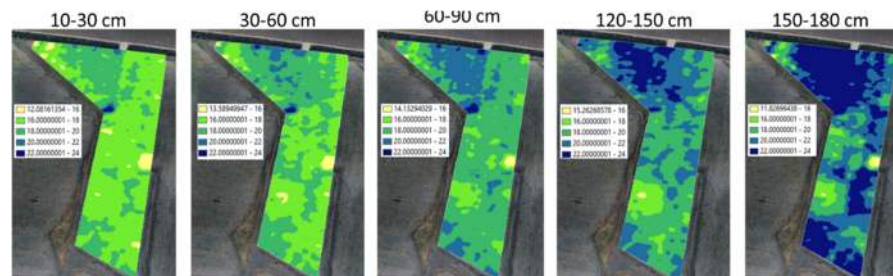


Fig. 6 Spatial distribution of PAWC<sub>LL15</sub> at each depth calculated based on the estimated DUL and LL15 from the first EMI survey.

# Acknowledgement

## We acknowledge the funding from GRDC and ARC through projects:

- GRDC “Root structure and function traits: Overcoming the root phenotyping bottleneck in cereals” (UOQ2312-009RTX)
- GRDC “Optimising sorghum yield through agronomic management” (UOQ 1808-001RTX)
- GRDC “A proof of concept for the proximal 3D sensing of plant available water capacity” (UOQ 2304-006RTX)
- ARC ECI “Drought tolerance in sorghum: the roots of the solution”
- We thank our research and industry partners for directly contributing to this work

