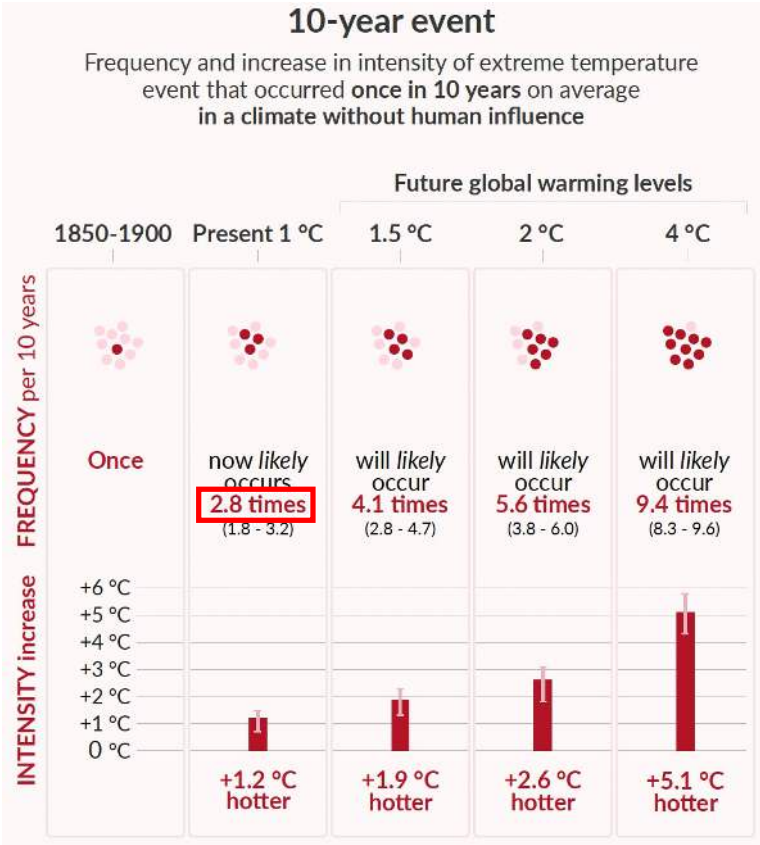
Sowing summer grain crops in late winter or spring: effects on root growth, water use, and yield

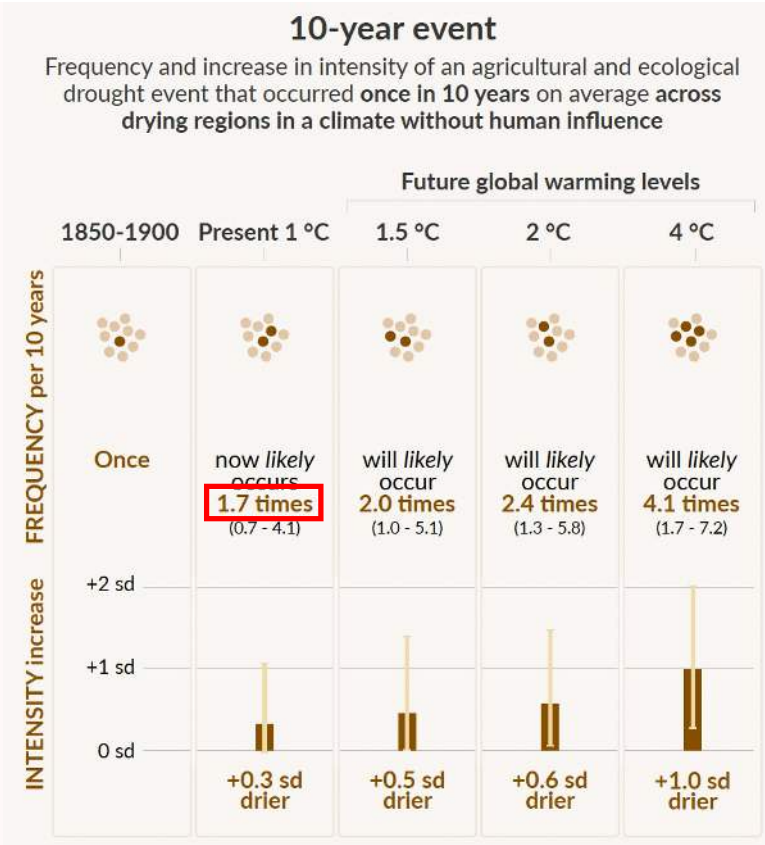
Zhao et al., (2024) Plant and Soil, 1-18. https://doi.org/10.1007/s11104-024-06648-0

Global climate

Temperature extremes

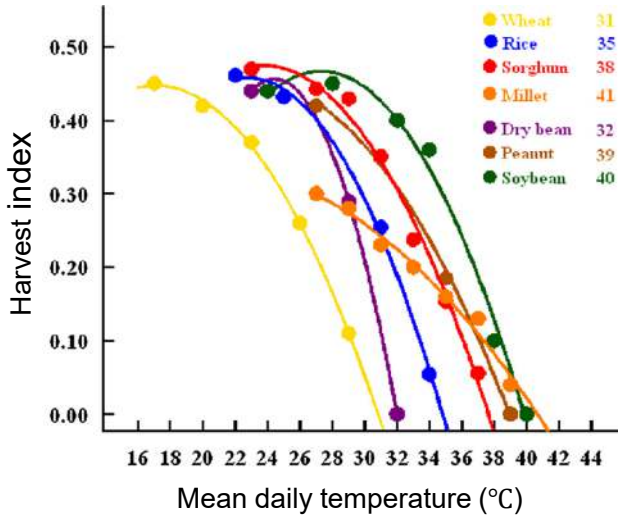


Agricultural droughts

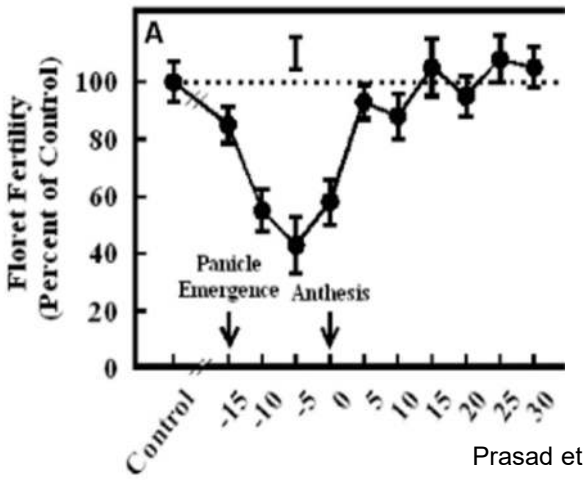


IPCC AR6, 2021

Foresighting options to manage heat stress in sorghum



Prasad et al., 2017

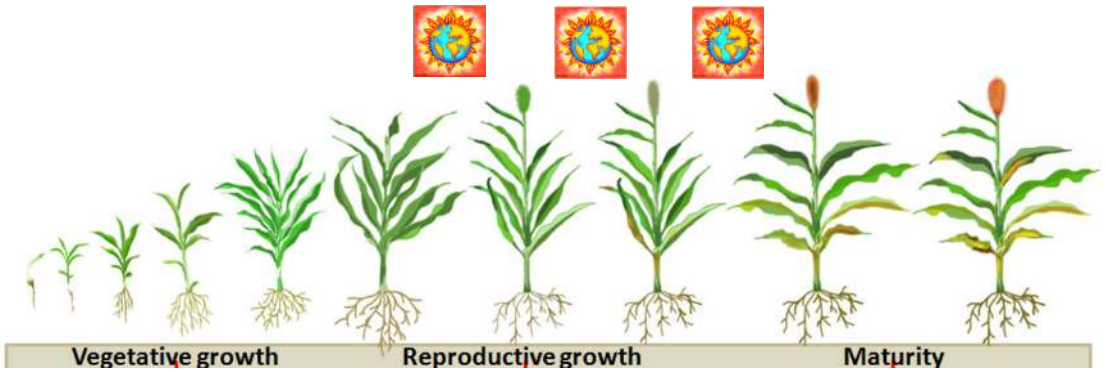


Prasad et al., 2019

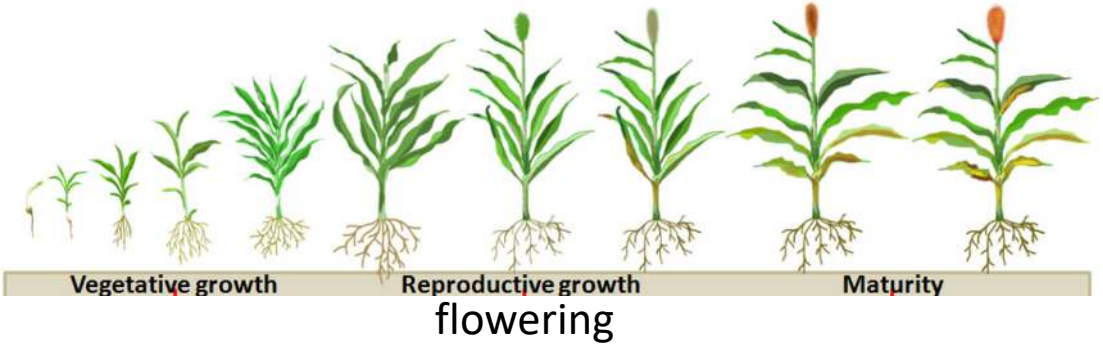
Tolerance and avoidance as two important adaptation strategies

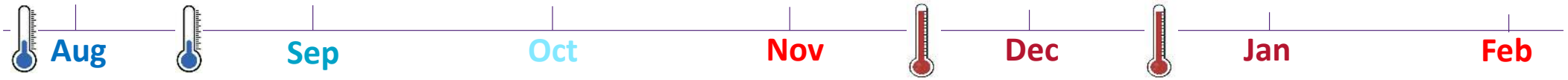
Managing heat stresses in sorghum by agronomic avoidance e.g., early sowing

Regular sowing



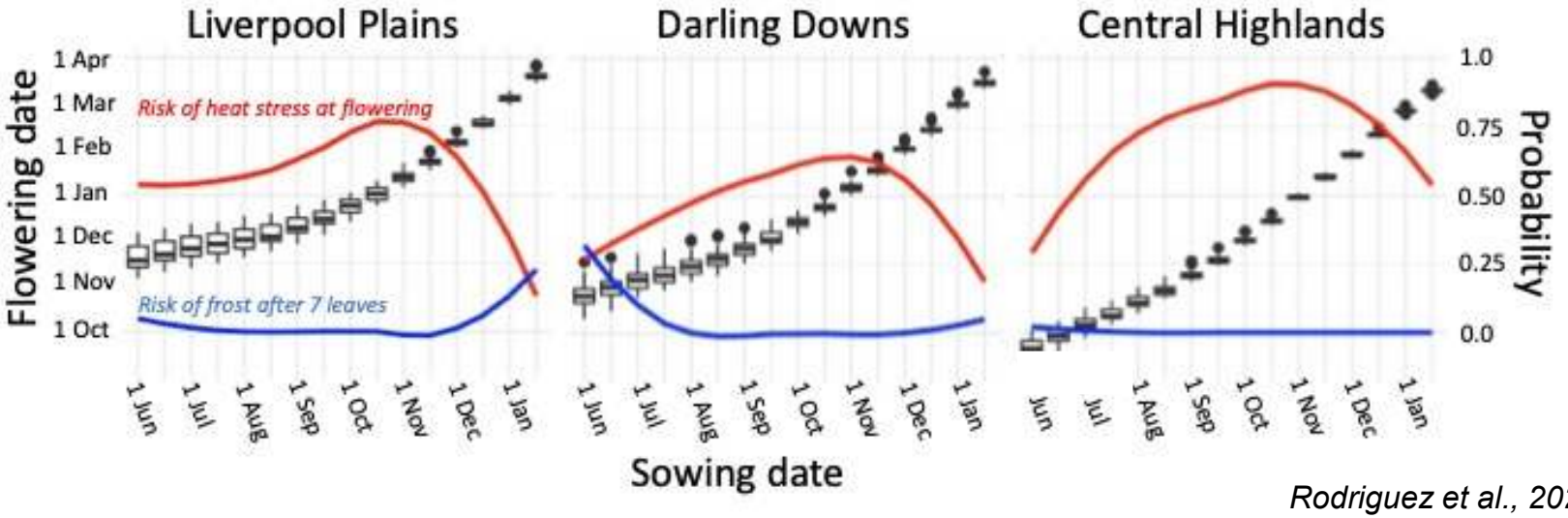
Early sowing





Avoidance of heat stress

APSIM simulations of ***heat*** and ***frost stress*** for MR Buster for the period ***1970-2018*** from ***Breeza NSW*** to ***Emerald Qld***



Rodriguez et al., 2024

There is potential for sowing in early to significantly reduce heat stress losses

Managing heat stresses in sorghum by agronomic avoidance e.g., early sowing (GRDC project UOQ 1808-001RTX)

Research questions:

1. What is the impact of cold soils on crop emergence and establishment?
2. Are there differences in cold tolerance between varieties?
3. ***Does sowing sorghum in winter affect root growth and function?***
4. ***Are there benefits in yield and water use efficiency?***
5. What is the likely impact of frosts?
6. What are the implications at the cropping system level?

Rodriguez *et al. (2024). Agronomic adaptations to heat stress: Sowing summer crops earlier. Field Crops Research, 318, 109592.*

Zhao *et al. (2024). Sowing summer grain crops early in late winter or spring: effects on root growth, water use, and yield. Plant and Soil, 1-18.*

Mumford *et al. (2023). Incorporating environmental covariates to explore genotype× environment× management (G× E× M) interactions: A one-stage predictive model. Field Crops Research, 304, 109133.*

Two years of on-farm trials

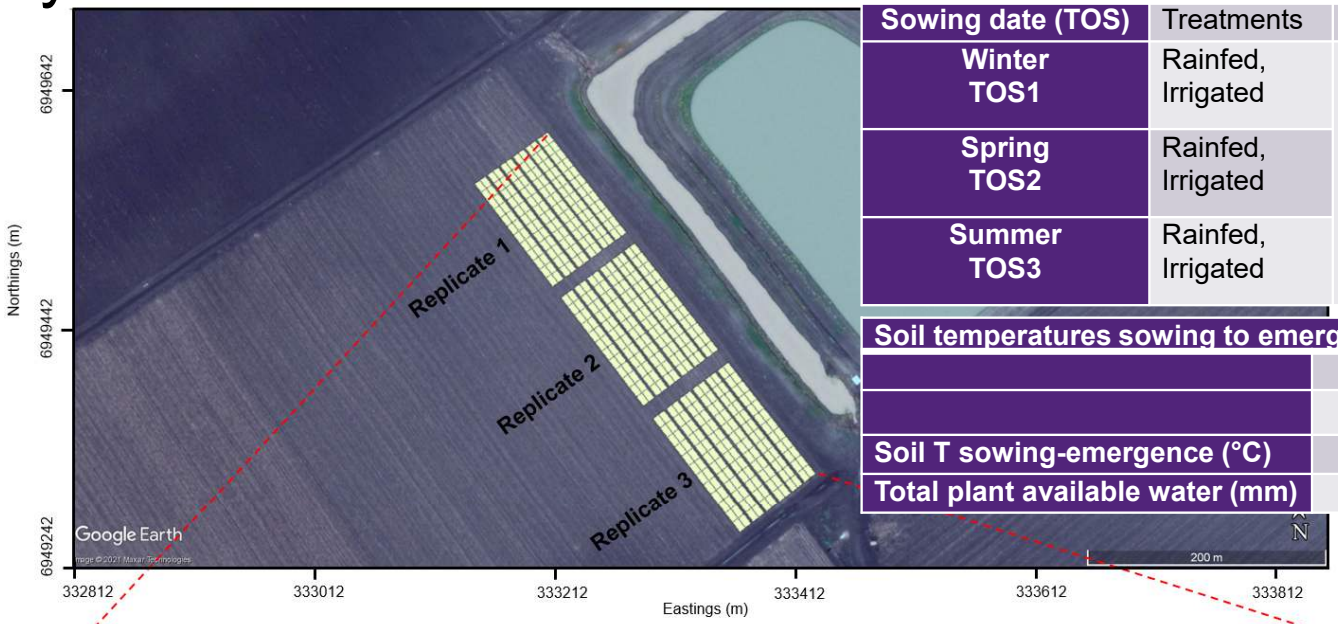
Experimental designs

Sowing date (TOS)	Treatments	Hybrids	Densities (pl m^{-2})	Row configurations (m)
Winter TOS1	Rainfed, Irrigated	6 core hybrids	3, 6, 9, 12	1
Spring TOS2	Rainfed, Irrigated		3, 6, 9, 12	1
Summer TOS3	Rainfed, Irrigated		3, 6, 9, 12	1

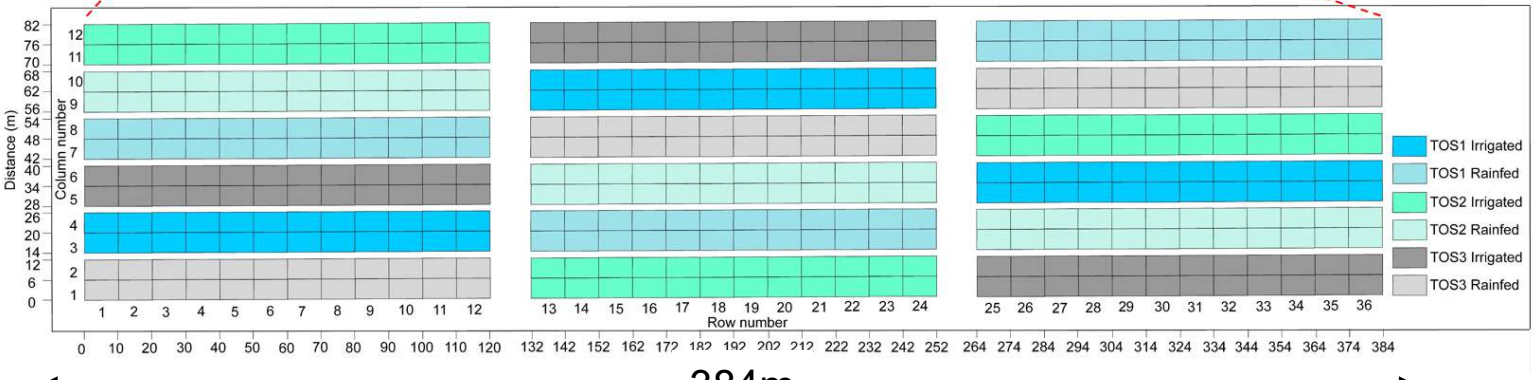
Soil temperatures sowing to emergence

	2019-2020			2020-2021		
	Winter	Spring	Summer	Winter	Spring	Summer
Soil T sowing-emergence (°C)	**10**	**12.8**	**15.4**	**15.7**	**18.9**	**20**
Total plant available water (mm)	271	289	263	478	496	603

a)



b)



82m

384m

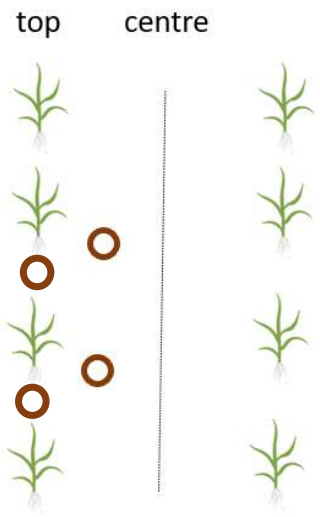
Systems agronomy research

- **Shoot and root sampling at flag leaf** *(3 TOS, 1 hybrid, 2 water regimes, 1 population density, 3 reps, 2 seasons at Nangwee Qld)*

- **Proximal soil water and root activity sensing using electromagnetic induction – EMI** *(3 TOS, 6 hybrids, 2 water regimes, 4 population densities, 3 reps, 2 seasons at Nangwee Qld)*

- **Maturity harvest** *(3 TOS, 6 hybrids, 2 water regimes, 4 population densities, 3 reps, 2 seasons at Nangwee Qld)*

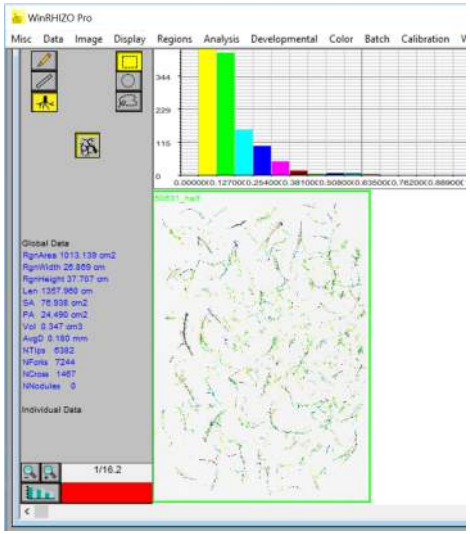
- **Shoot and root sampling at flag leaf** *(3 TOS, 1 hybrid, 2 levels of irrigation, 2 seasons at Nangwee Qld, 3 reps)*



Root sampling

Processing

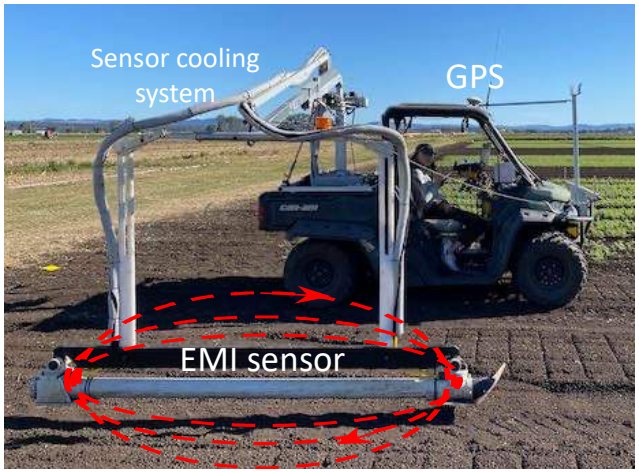
WinRHIZO Pro®

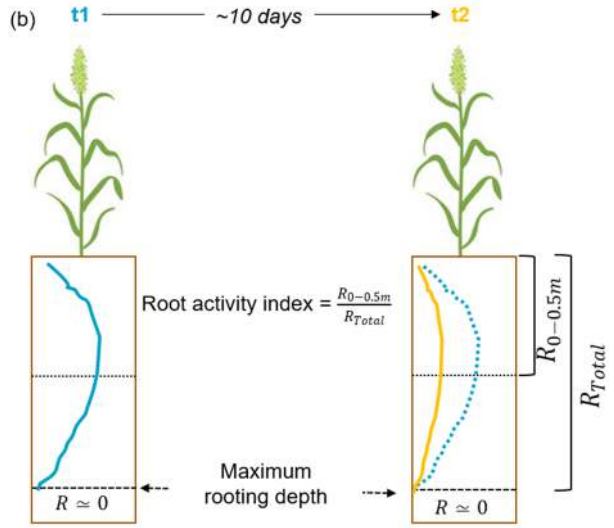


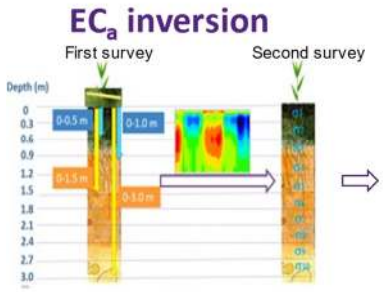
Scanning and analysing

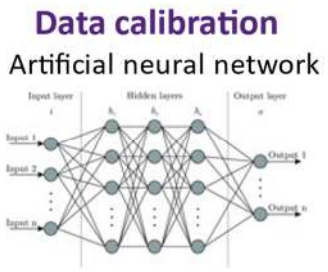
- Root length
- Diameter
- Surface area
- Volume
- Root length density
- Specific root length
- Root dry weight
- Shoot dry weight
- Root length to shoot dry weight ratio

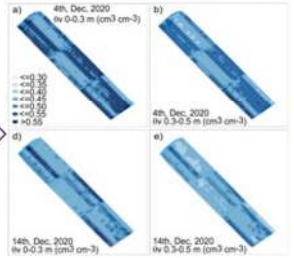
• Proximal soil water and root activity sensing using electromagnetic induction

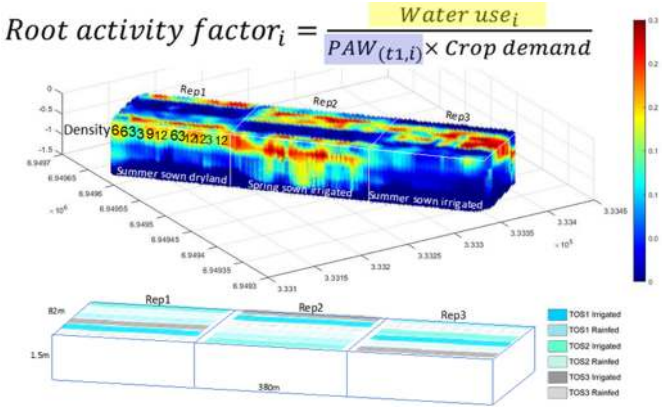




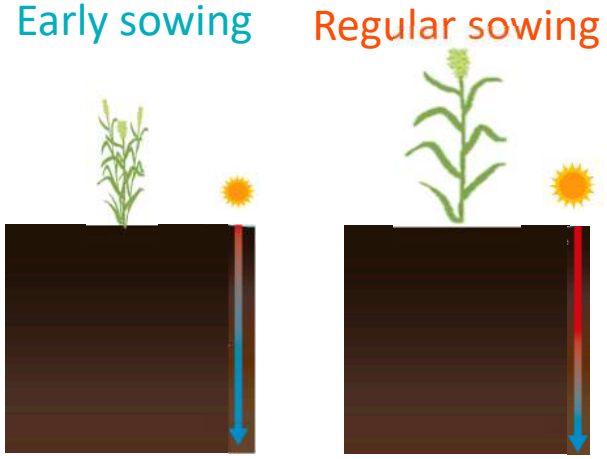


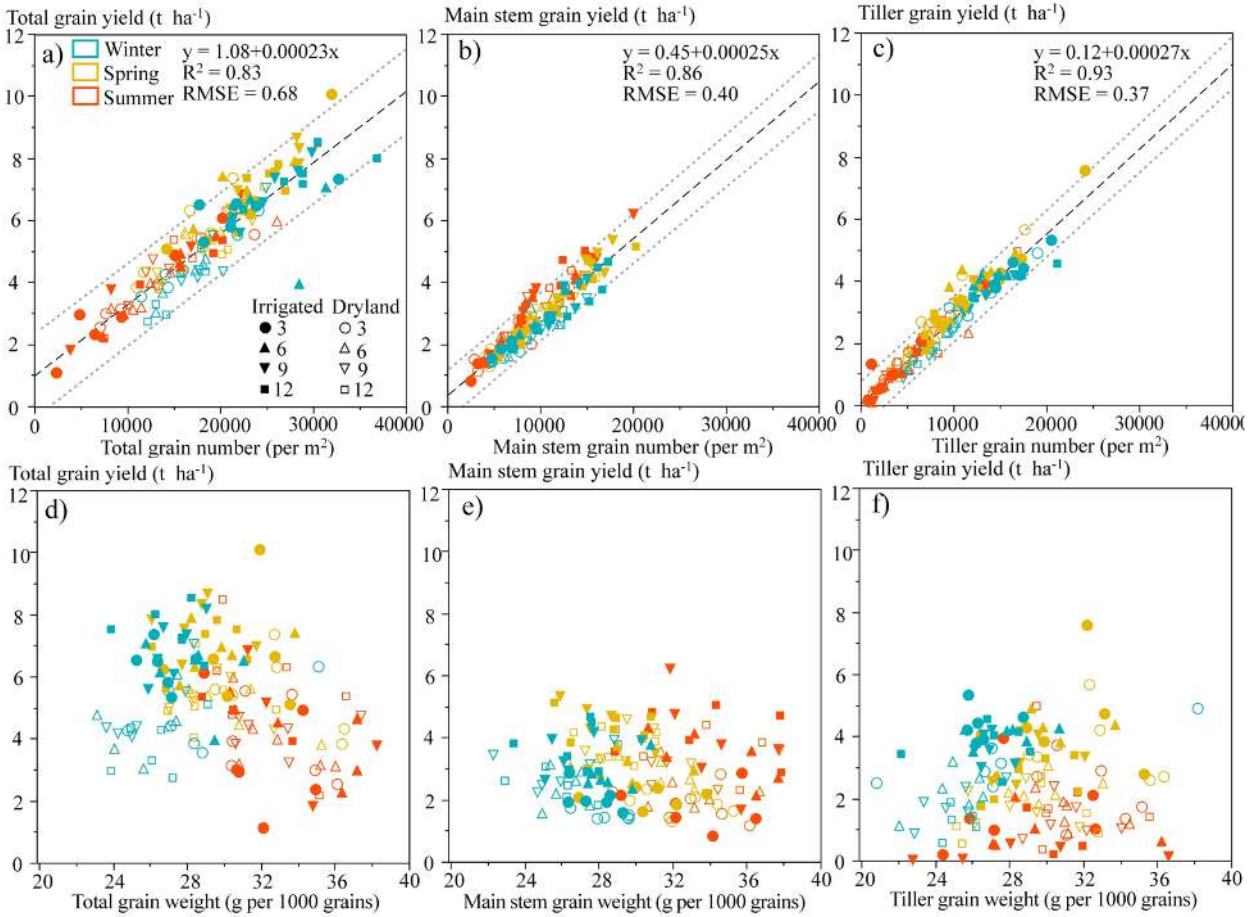






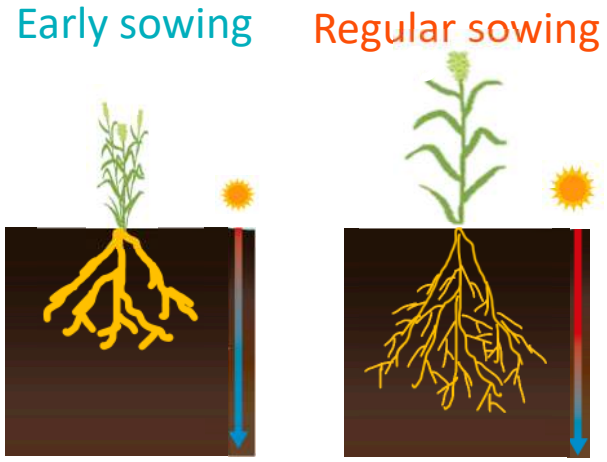
Does early sowing affect grain yield and yield components?

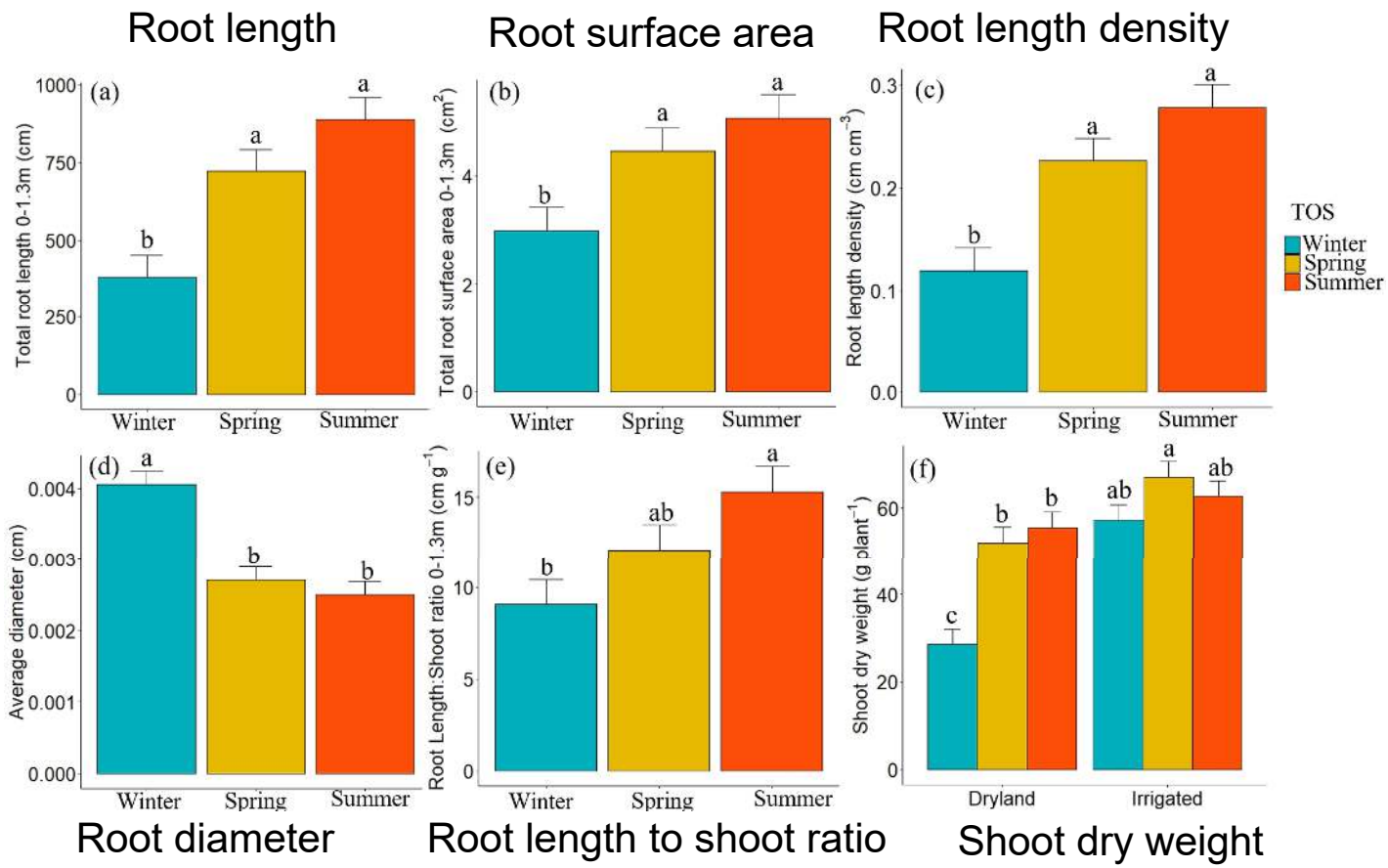




- Larger yield and grain number, but smaller grain weight with more tillers

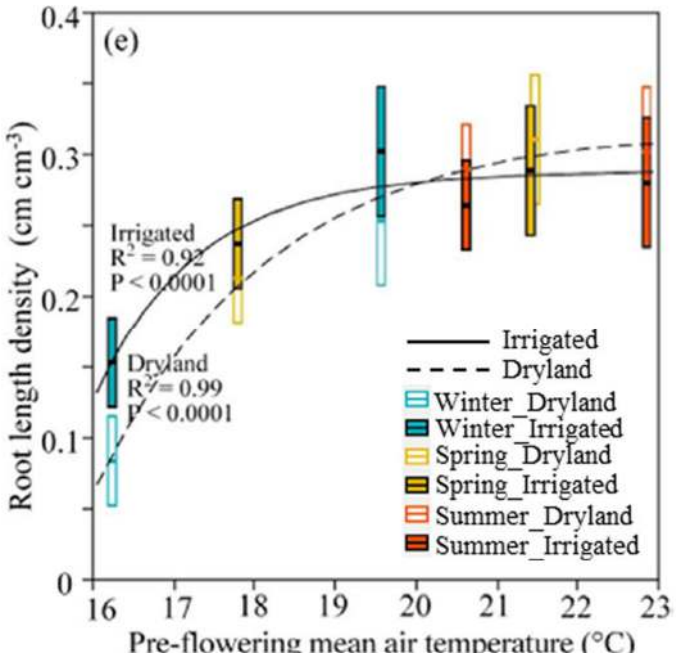
Does early sowing affect crop and root growth?

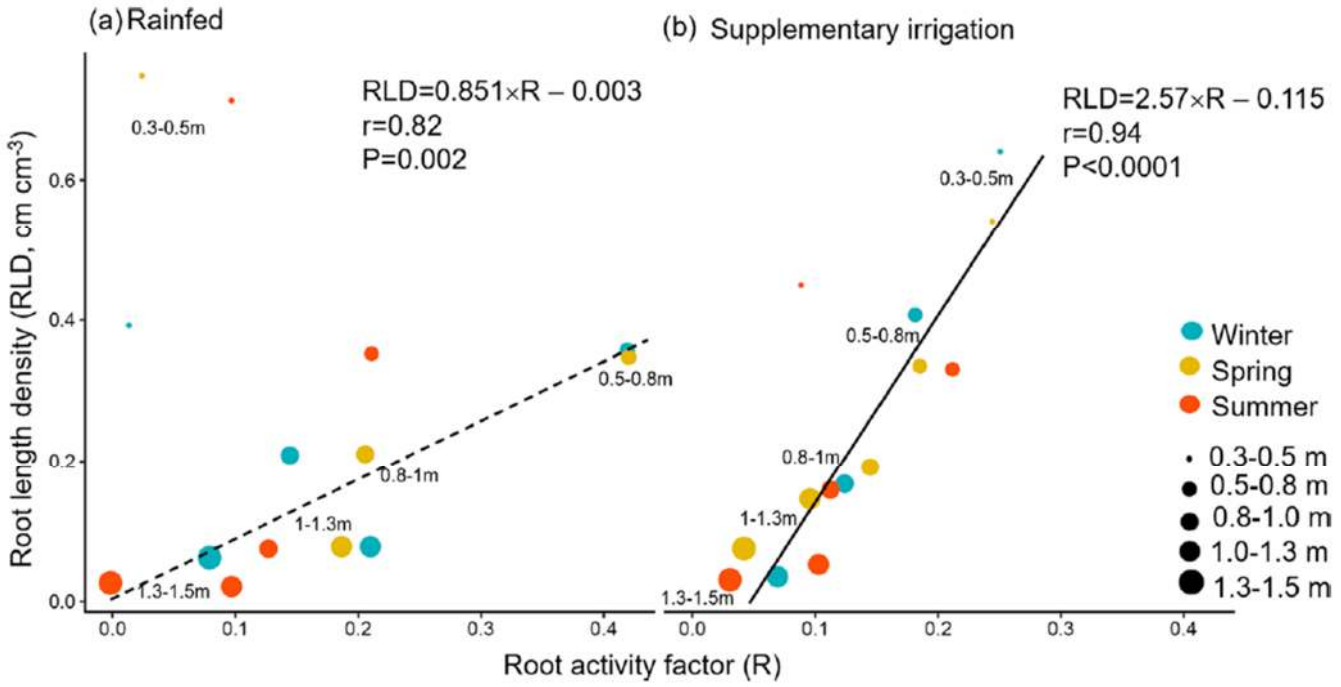




- Smaller crops, root systems and root length to shoot ratios, but thicker roots

Does early sowing affect root growth and activity?

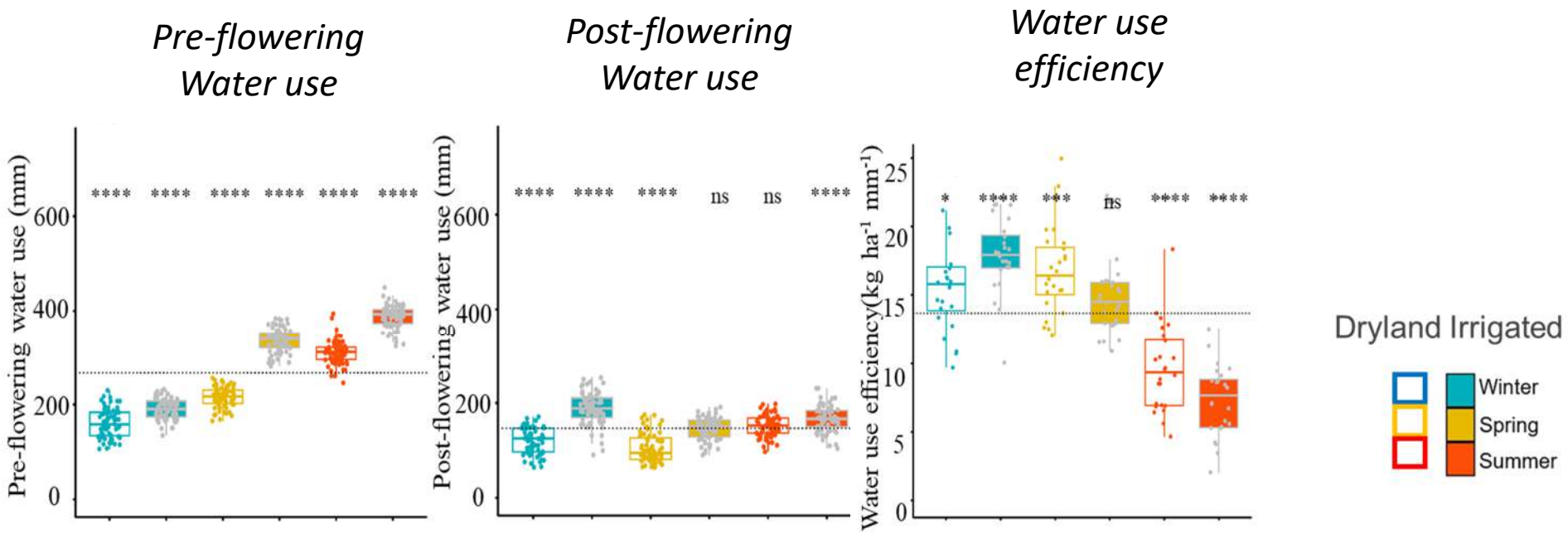




- Pre flowering temperatures lower than 20°C reduced root length density in early sown crops.
- Root-length density alone is insufficient to assess root water uptake.

Does early sowing affect water use and water use efficiency?

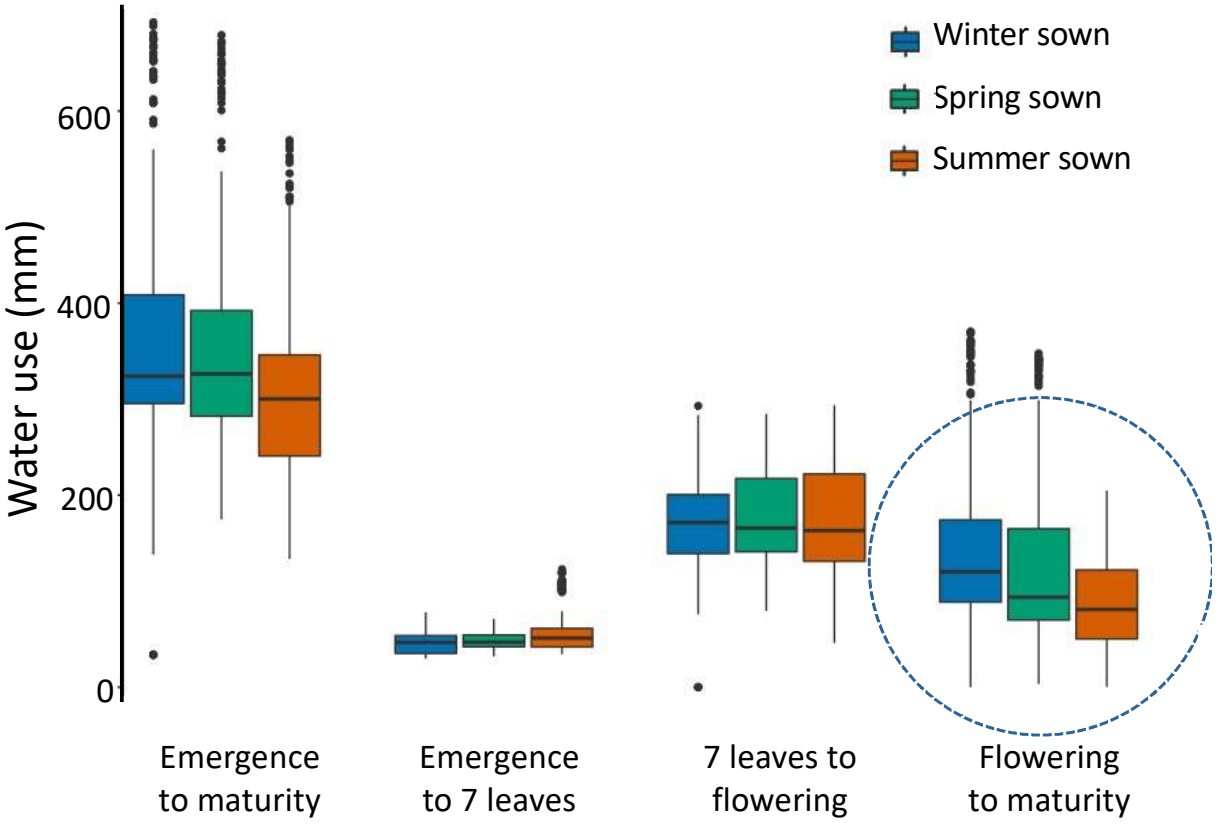
Proximal sensing of crop water use (DualEM21S)



- Early sown crops transferred water use from pre-flowering stage to post-flowering stage and had high water use efficiencies

Does early sowing affect water use and water use efficiency?

APSIM simulations for two seasons (2018-2020) of on-farm trials (n=1032) from Breeza NSW to Emerald Qld



Rodriguez et al., 2024

Take home messages

- Early sown sorghum can avoid heat stresses around flowering increasing the likelihood of higher grain yields
- Larger grain yields in early sown crops were driven by larger grain numbers, particularly in tillers
- Above-ground crop growth and below-ground root growth was reduced in early sown crops (smaller crop and rooting systems)
- Higher water use efficiency in early sown crops attributes to higher values of the photothermal quotient and lower values of vapour pressure deficit during the growing season (not shown)

Thank you

We acknowledge the Grains Research Development Corporation for their financial support of sorghum agronomy research which is conducted under GRDC project UOQ 1808-001RTX