

## Deep and meaningful?: Using systems agronomy to capture benefits from deep roots

CSIRO AGRICULTURE AND FOOD

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*John Kirkegaard and Julianne Lilley, CSIRO Australia*



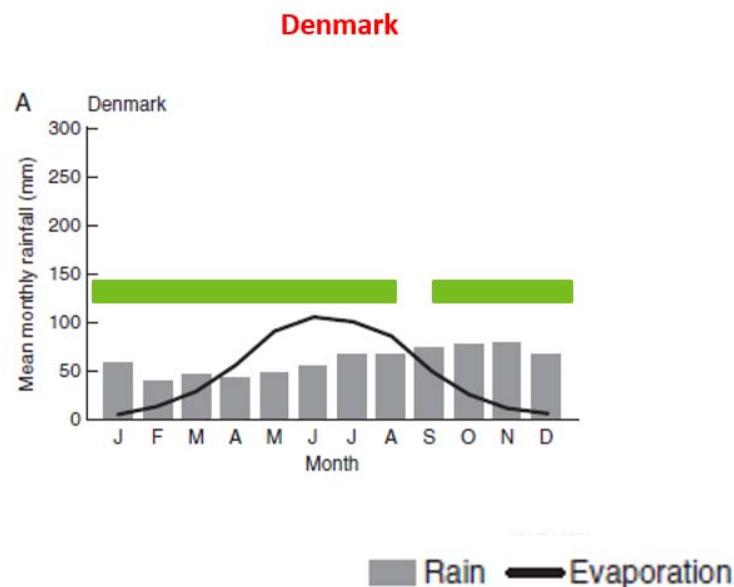
# Universal questions

- Are roots functioning at depth (2 - 5m)?
- Can we capture benefits within a productive system?
- What is the scale of the opportunity globally?
- Case study: Deep water use in Australian dryland farming  
(because I like a challenge!)



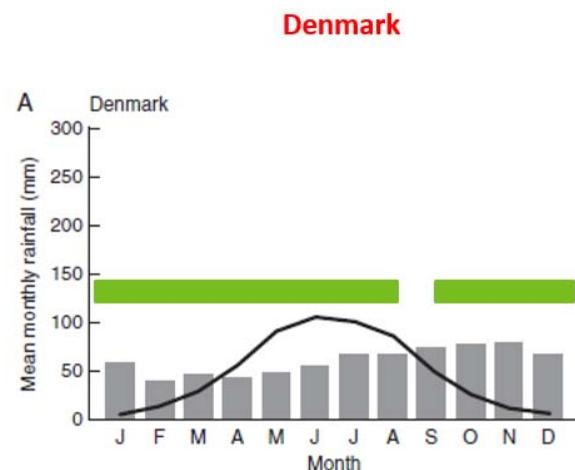
# Context is critical...

Rainfall, evaporation, soil type, system...



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Rainfall, evaporation, soil type, system...



■ Rain — Evaporation



Thorup-Kristensen and Kirkegaard (2016) *Annals of Botany* 118, 573-592

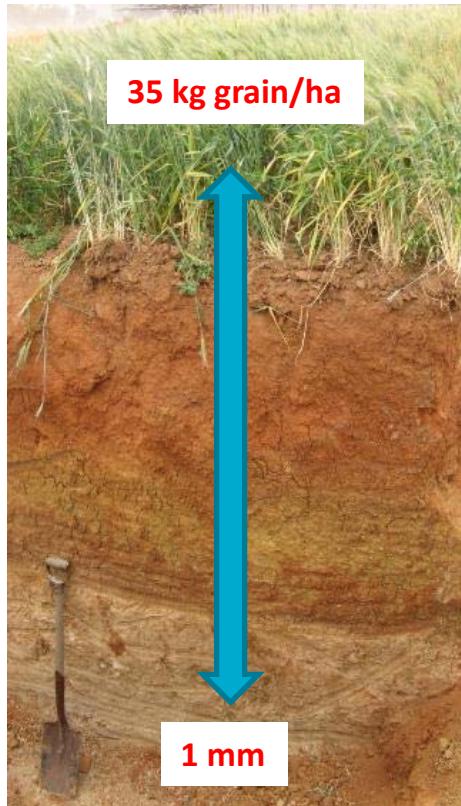


# Australian case study

- Unused subsoil water left by annual crops (Passioura 1983)
- 1990s: (wet!) perennial pasture (lucerne) to dewater
- 2000s: (dry) Millenium drought; 2010's climate change – legacy effects
- Use deep water effectively by ***“using more of the soil and more of the season”***



# Evaluating benefits of deep water



## Experimental studies

60 kg grain /ha.mm

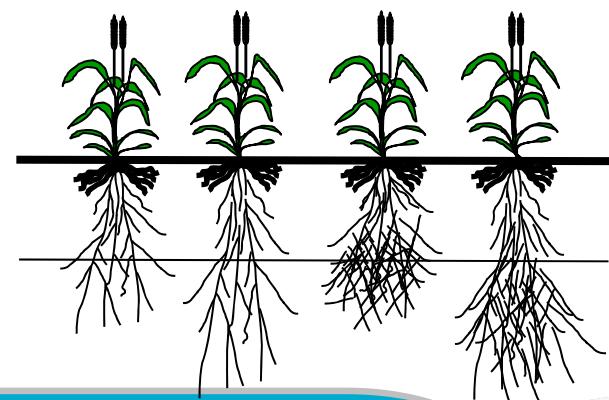


## Simulation studies

0 - 100 kg grain /ha.mm

35 kg grain /ha.mm

0.3 - 0.4 t/ha



Kirkegaard et al (2007) Aust J Agric Res 58:303-315

Lilley and Kirkegaard (2011) Field Crops Research 122, 118-130

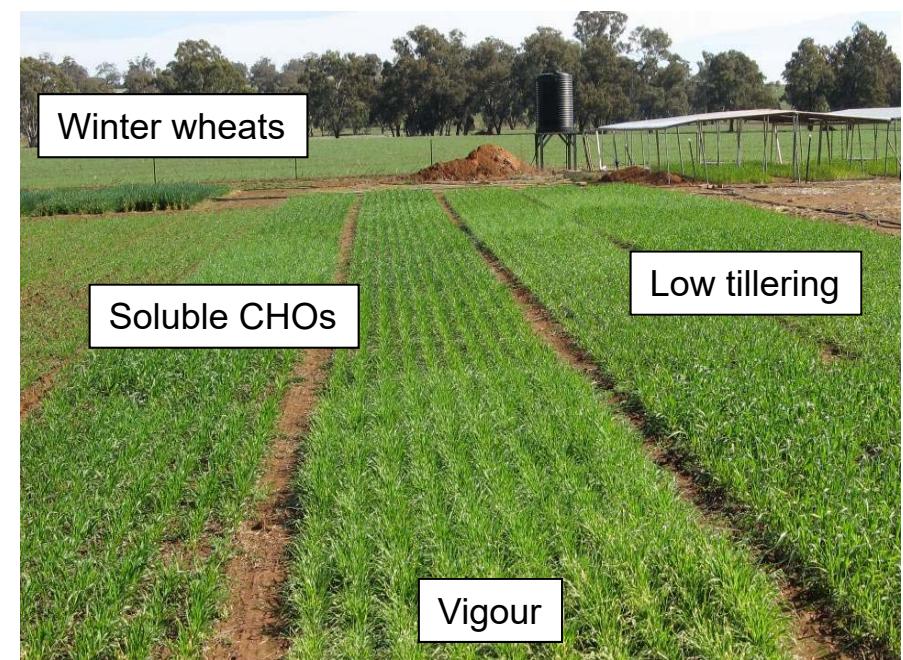


# Achieving deeper roots

## Management



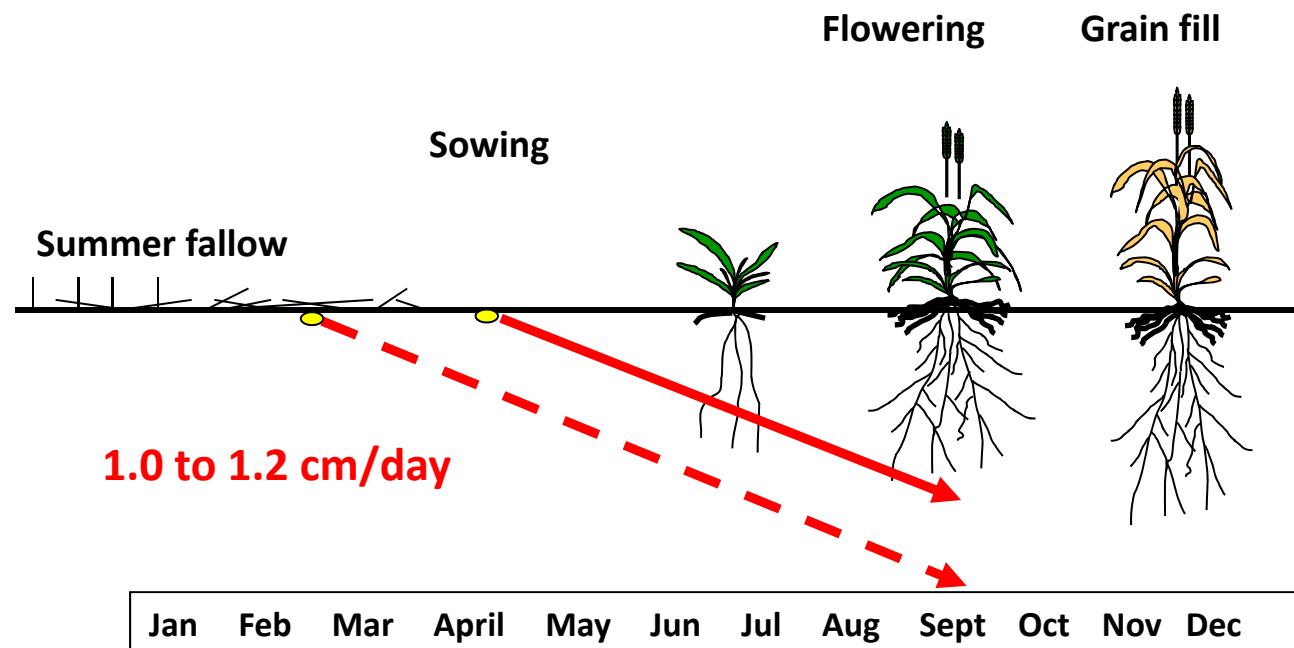
## Genetics



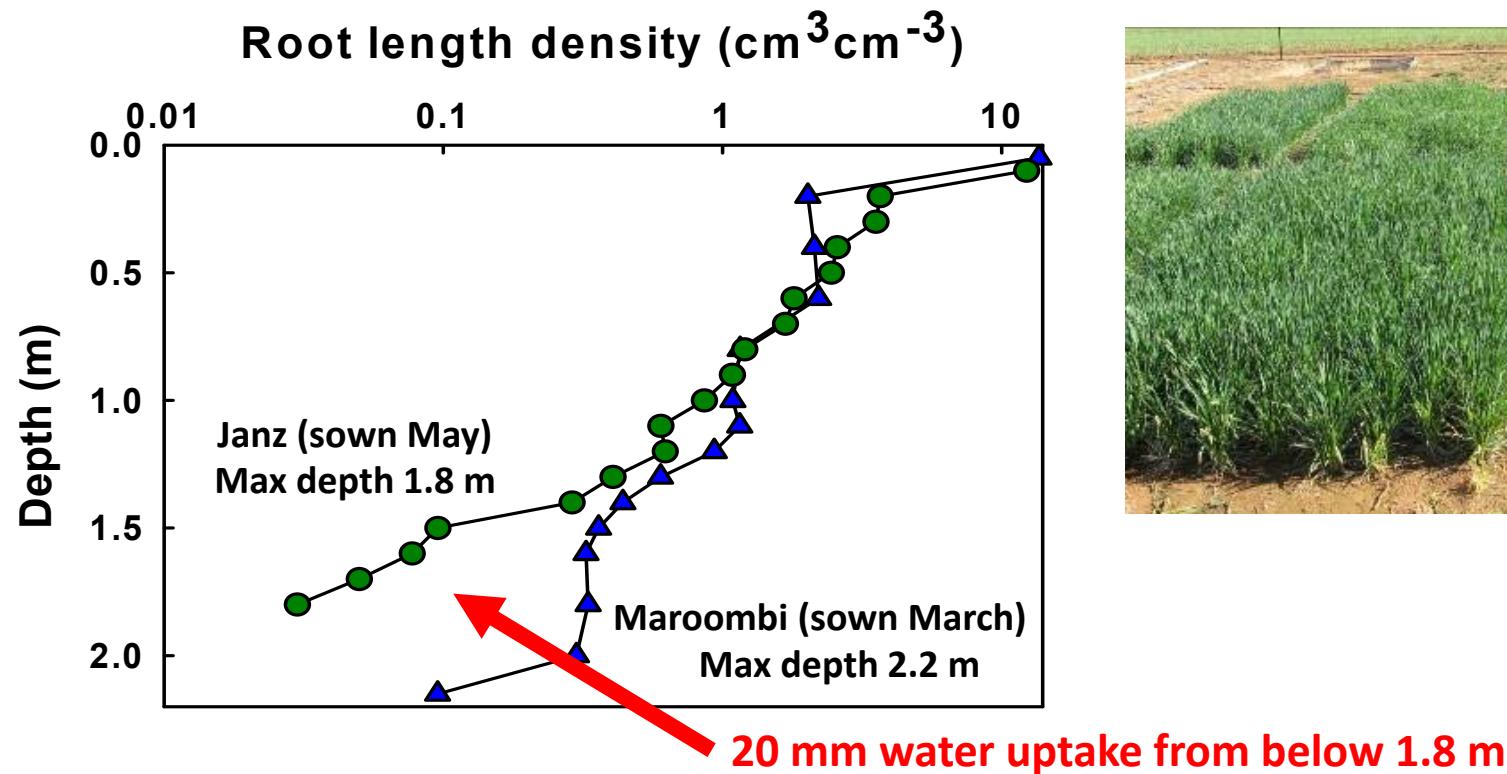
*Adapted from Kirkegaard et al 2007, 2015 Crop and Pasture Science*



# Wheat roots grow down until anthesis



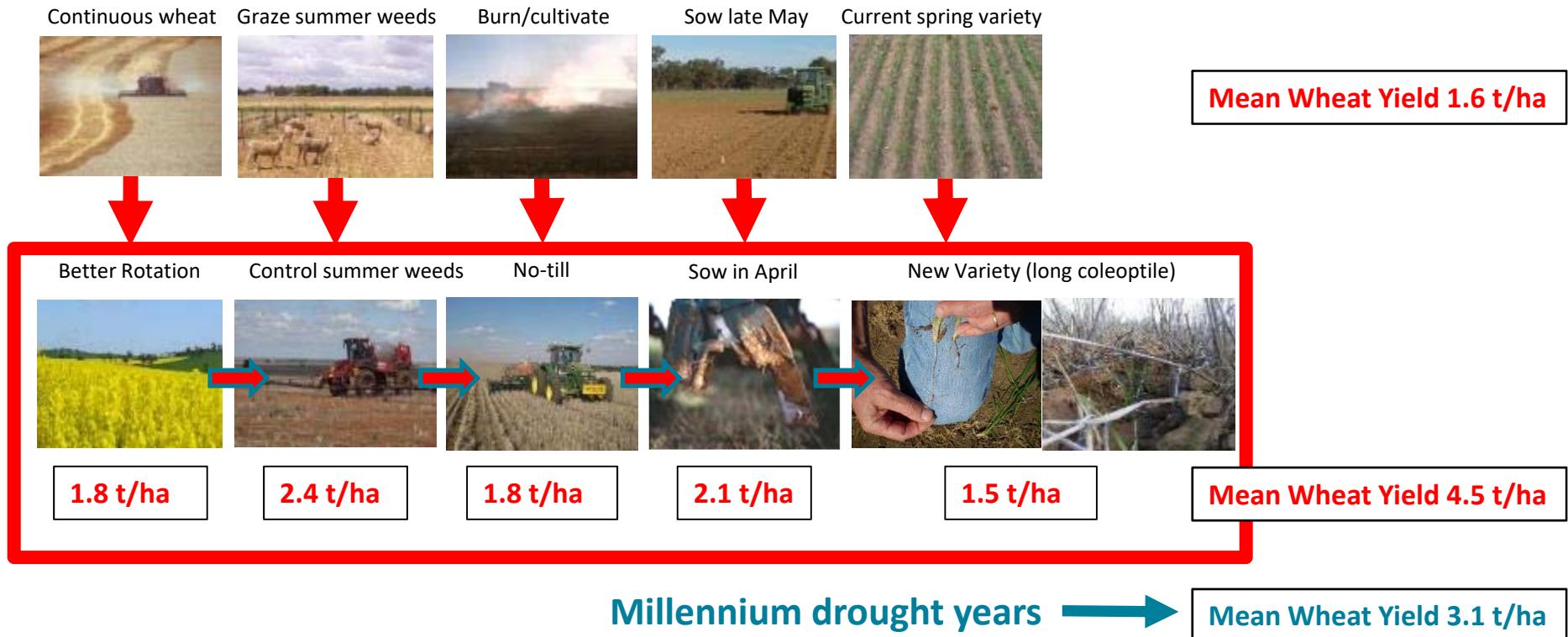
# Earlier sown wheat



Adapted from Kirkegaard et al 2007, 2015 Crop and Pasture Science



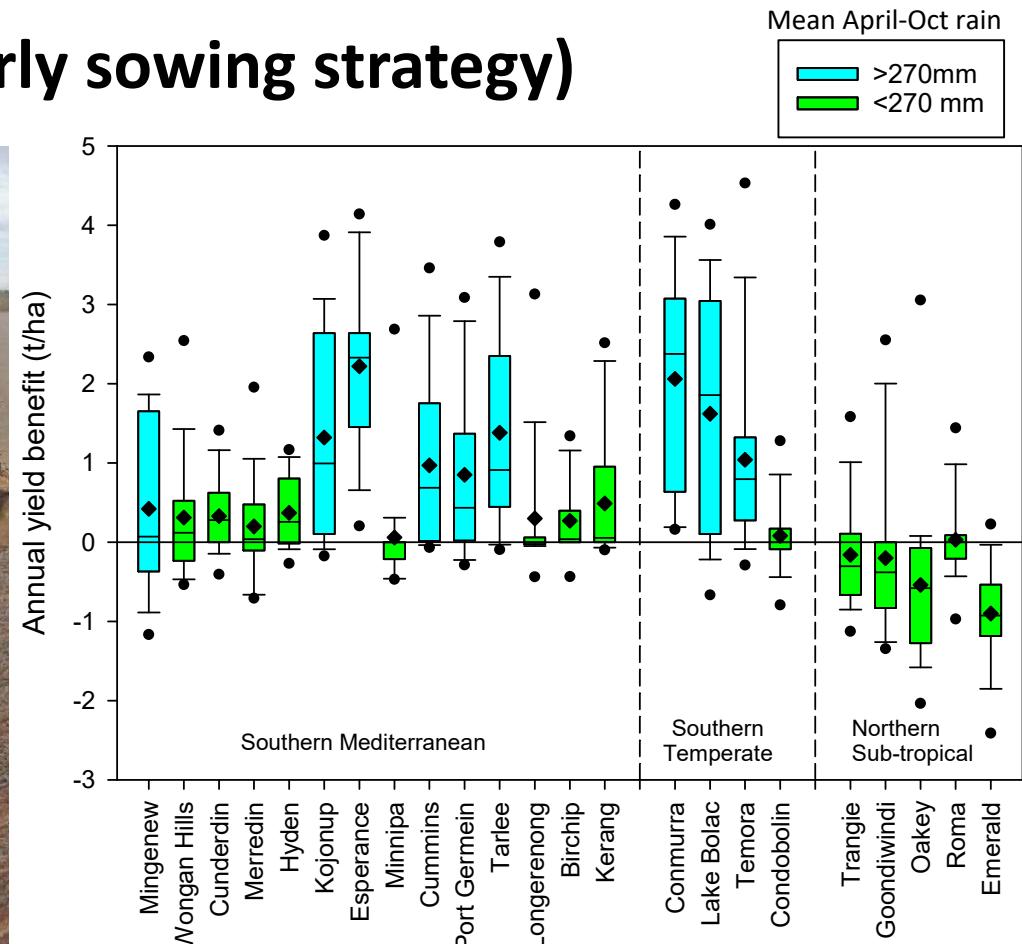
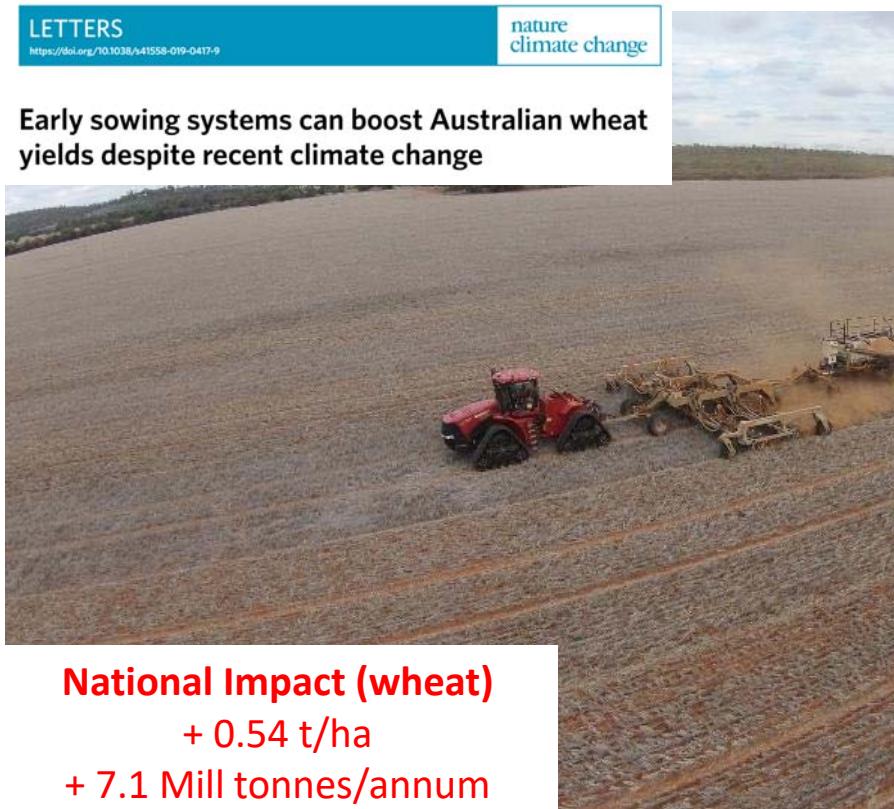
# Early sowing system - capturing synergies



Kirkegaard and Hunt (2010) Journal Experimental Botany 61, 4129-4143



# Whole-farm benefits (early sowing strategy)



Hunt et al., (2019) *Nature Climate Change* 9:244-247



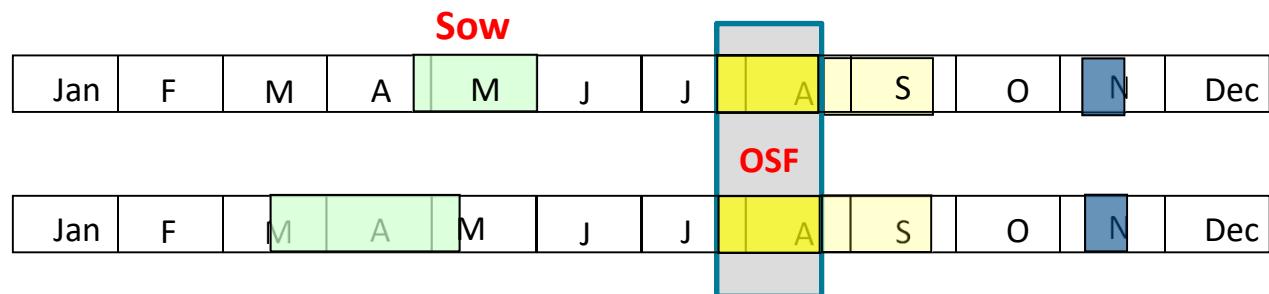
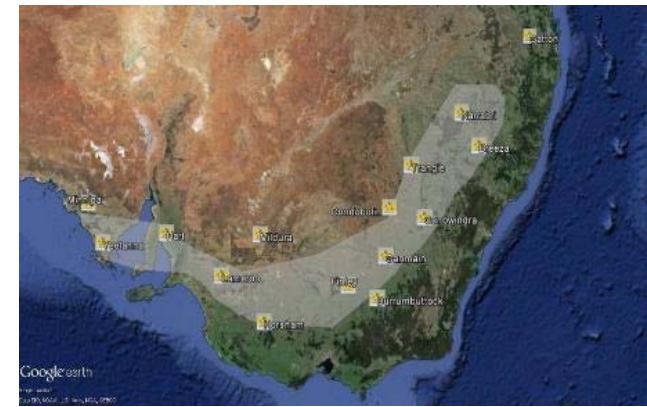
# Earlier sowing systems in canola



~ 1M ha suitable

Yield ~ 6%/week  
Oil ~ 1%/week

Worth \$40/ha/week

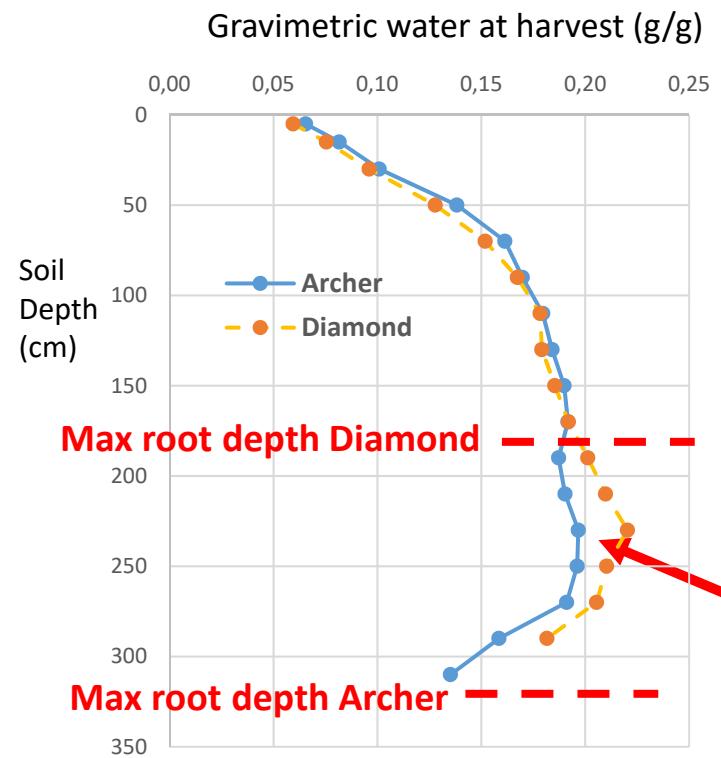


Kirkegaard et al., (2016) *Crop and Pasture Science* 67, 381-396

Rohan Brill and team NSW DPI; Andrew Ware and team SARDI



# Early sown canola = deep water use

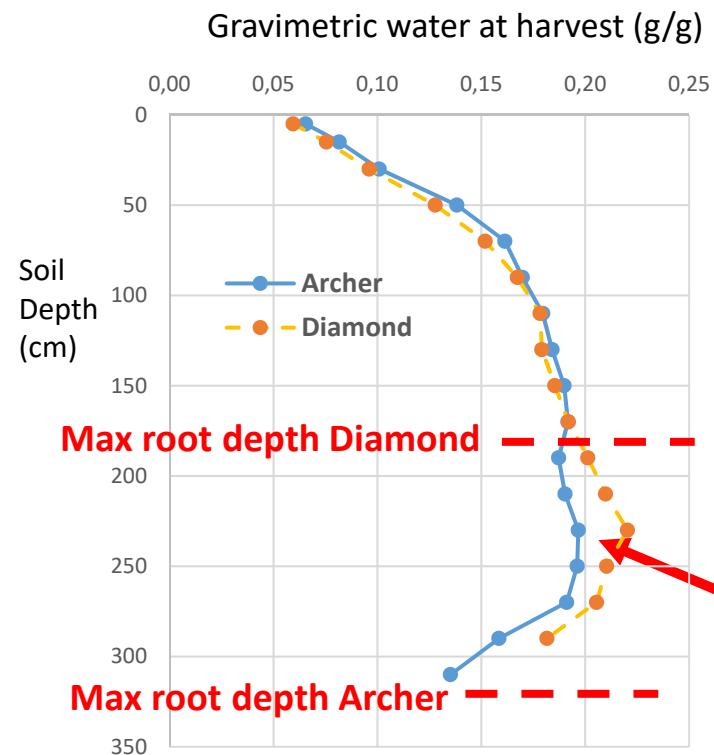


Greenethorpe 2018

Variety	Sow Date
Archer	4 April
Diamond	7 May



# Early sown canola = deep water use



Greenethorpe 2018

Variety	Sow Date	Yield (t/ha)
Archer	4 April	2.9
Diamond	7 May	1.7

Rooting depth  
~ 2 cm/day

Archer extracted  
32.8mm extra below 1.8m



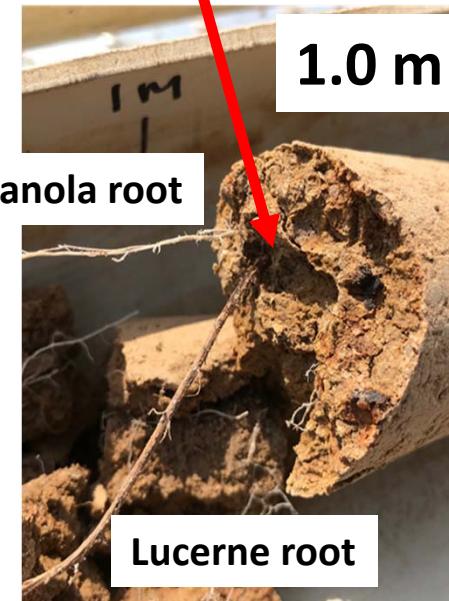
# Deep canola roots (>4m)



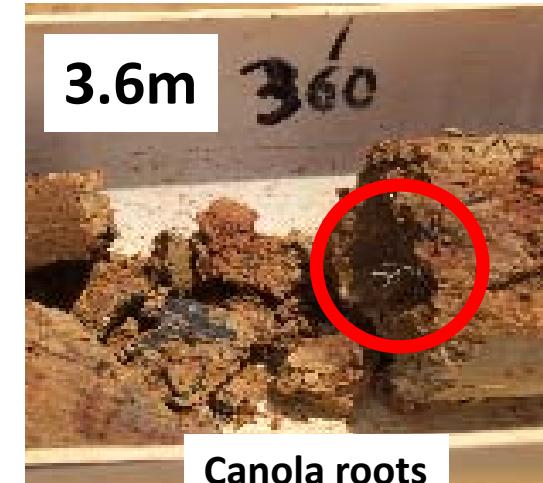
Greenethorpe 2019

2.0 to 2.5 cm/day pre-flowering; 1.2 cm/day post-flowering

Lucerne biopore



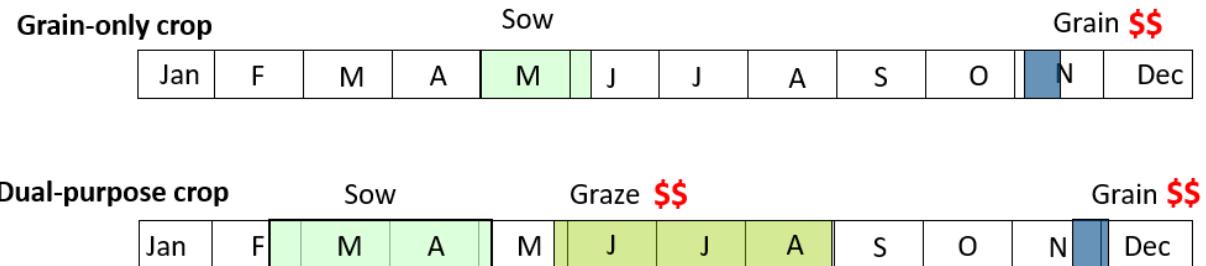
Lucerne root



Canola roots



# Earlier sown crops can be grazed



- Higher income in good years
- Risk management in dry years
- No resource trade-offs



**Legacy effects?**

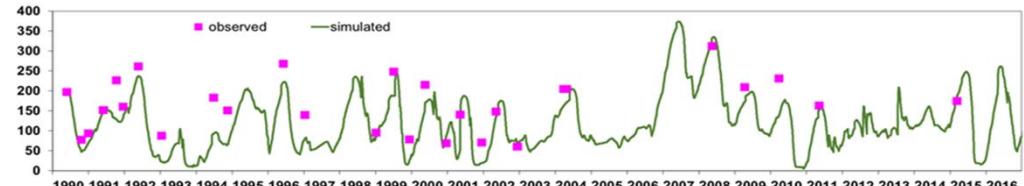
**Will the bucket refill?**

# APSIM model validation

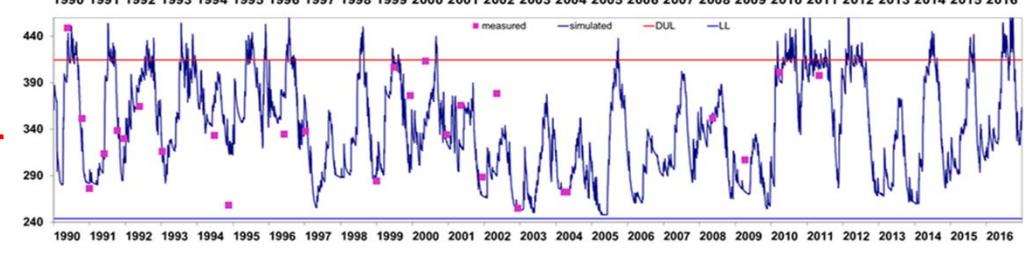
Harden Site – 28 yr sequence  
(spring crops sown mid-May)



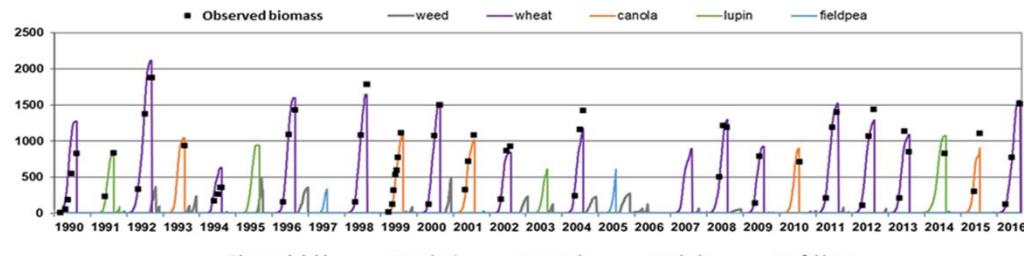
Soil Min-N



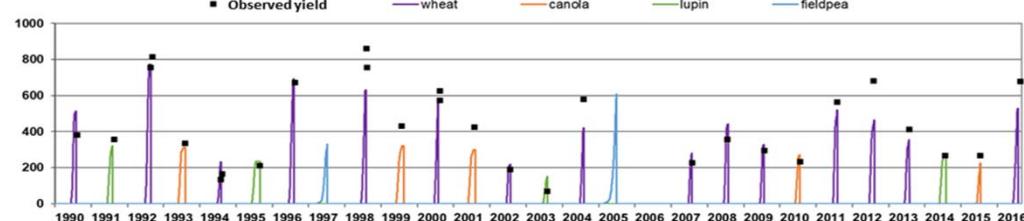
Soil Water



Biomass



Yield



Lilley et al., (2001) Australian Agronomy Conference (Hobart)

Kirkegaard and Lilley (2019) Agronomy Conference



# Predicted effects of “new agronomy”



- Summer weed control
- Slower maturing wheat, sown earlier (from March)
- Slower maturing canola, sown earlier (from March)
- Higher N fertiliser (extra 50 kg N/ha each year)

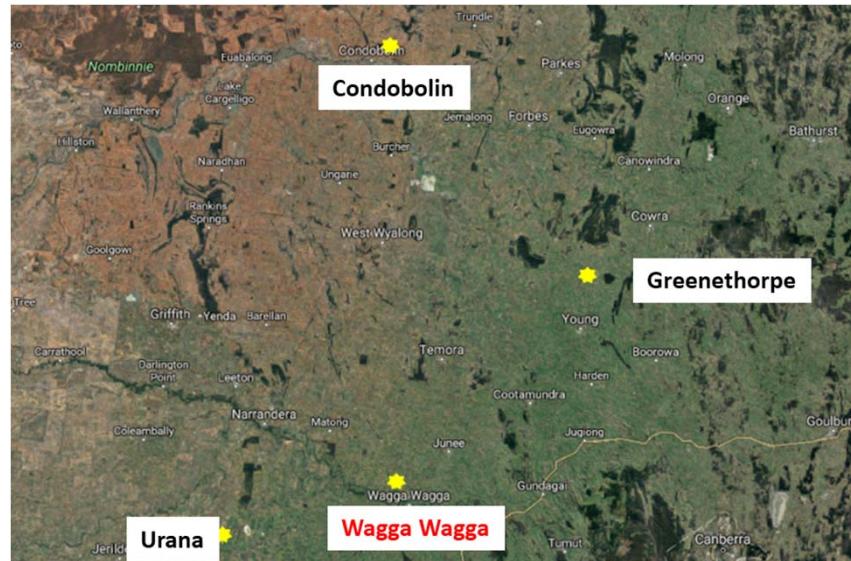
Crop	Baseline (measured)	Weed Control	Weed Control Early wheat	Weed control Early wheat Early canola	Weed control Early wheat Early canola +50 kg N/ha/yr
Wheat	<b>4.5</b>	4.7	5.6	5.5	6.0
Canola	<b>2.9</b>	3.1	2.9	3.3	5.0

*Kirkegaard and Lilley (2019) 19<sup>th</sup> Agronomy Conference, Wagga Wagga*

*Kirkegaard JA (2019) Outlook on Agriculture 48, 102-115*



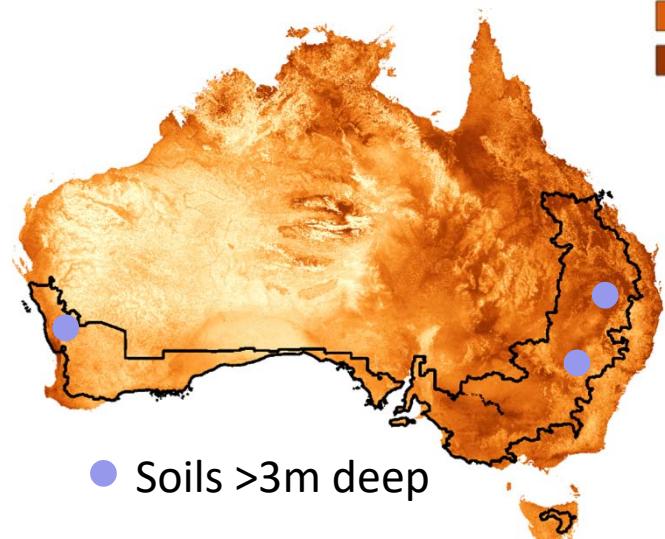
# Managing legacies of deep-rooted crops



Converting rainfall to profit across the crop sequence



## Where are the deep soils?



● Soils >3m deep

## Continental Soil Thickness Map ("Pedolith" circa 2019)

- GA Outcrop observations (n=14616)
- Bore log observations (n=355,097)

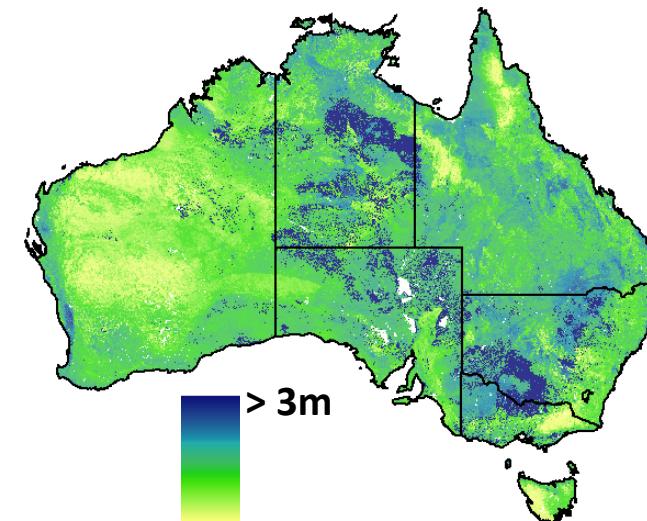


Image: Ross Searle [www.clw.csiro.au/aclep/soilandlandscapegrid](http://www.clw.csiro.au/aclep/soilandlandscapegrid)

Lilley and Kirkegaard (2016) *J Exp Bot* 67:3665-3681



## Where are the “Deep Frontiers”?



*....and do we have the production systems to take advantage of them?*



*Numerous colleagues, collaborators, farmers and friends*



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**Thank you**

