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

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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...

Wheat 10 t/ha

Context is critical...

Rainfall, evaporation, soil type, system...

Australian case study

- Unused subsoil water left by annual crops (Passioura 1983)

- 1990s: (wet!) perennial pasture (lucerne) to dewater

- 2000s: (dry) Millennium 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

*Lilley and Kirkegaard (2011) Field Crops Research 122, 118-130*
Achieving deeper roots

**Management**
- Sowing time
- Sowing density
- Deep tillage

**Genetics**
- Winter wheats
- Soluble CHOs
- Vigour
- Low tillering

Adapted from Kirkegaard et al 2007, 2015 Crop and Pasture Science
Wheat roots grow down until anthesis

1.0 to 1.2 cm/day
Earlier sown wheat

Root length density (cm$^3$cm$^{-3}$)

- Janz (sown May)
  - Max depth 1.8 m

- Maroombi (sown March)
  - Max depth 2.2 m

20 mm water uptake from below 1.8 m

Adapted from Kirkegaard et al 2007, 2015 Crop and Pasture Science
Early sowing system - capturing synergies

- Continuous wheat
- Graze summer weeds
- Burn/cultivate
- Sow late May
- Current spring variety

Mean Wheat Yield 1.6 t/ha

- Better Rotation
- Control summer weeds
- No-till
- Sow in April
- New Variety (long coleoptile)

Mean Wheat Yield 4.5 t/ha

Millennium drought years

Mean Wheat Yield 3.1 t/ha

Whole-farm benefits (early sowing strategy)

Early sowing systems can boost Australian wheat yields despite recent climate change

National Impact (wheat)
+ 0.54 t/ha
+ 7.1 Mill tonnes/annum

Earlier sowing systems in canola

~ 1M ha suitable

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

Worth $40/ha/week

Rohan Brill and team NSWDPI; Andrew Ware and team SARDI
Early sown canola = deep water use

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

Max root depth Diamond
Max root depth Archer

Archer extracted 32.8mm extra below 1.8m

Greenethorpe 2018
Early sown canola = deep water use

Gravimetric water at harvest (g/g)

Greenethorpe 2018

<table>
<thead>
<tr>
<th>Variety</th>
<th>Sow Date</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archer</td>
<td>4 April</td>
<td>2.9</td>
</tr>
<tr>
<td>Diamond</td>
<td>7 May</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Max root depth Diamond: ~ 2 cm/day
Max root depth Archer: 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

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)

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

*Kirkegaard JA (2019) Outlook on Agriculture 48, 102-115*
Managing legacies of deep-rooted crops

Converting rainfall to profit across the crop sequence

chickpea, lentil
Where are the deep soils?

Continental Soil Thickness Map
(“Pedolith” circa 2019)

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

Where are the “Deep Frontiers”? 

….and do we have the production systems to take advantage of them?
Numerous colleagues, collaborators, farmers and friends

Thank you