Agricultural information supply chains – drivers and directions

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Innovations in Australian mixed cropping under climate change

Dr JA Kirkegaard

Transitioning Cereal Systems to Adapt to Climate Change
November 13-14, 2015

GRDC
Grains Research & Development Corporation
Your GRDC working with you

CSIRO
The Norfolk system (Young 1771)
(1) enclosures without Government assistance
(2) use of marl (lime) and clay (known to Romans)
(3) rotation of crops (Ancient Greeks)
(4) culture of turnips, hand hoed (in rows) (Chinese in 6th century)
(5) culture of clover and rye (Ancient Greeks)
(6) long leases
(7) large farms

4 course rotation [turnips (for fodder) - wheat/barley – clover/rye – wheat/barley]

"individual components of the revolution had a long history but the synergistic interactions in the Norfolk system made it such an effective agent of improvement”

in Evans LT (1998) Feeding the 10 Billion
“On average, about 50% of the increase is due to management and 50% to breeding. The two tools interact so closely that neither of them could have produced such progress alone.”

Duvick (2005) Advances in Agronomy 86
The bad old days....

G x E
Molecular biology
Plant cell biology
Crop physiology

Genetics
Plant breeding

E x M
Farmers
Consultants
Input resellers

Agronomy
Farming systems
A better way....

- Not which has delivered more, but how to identify best synergies
- What traits will suit the systems of the future (not just the climate)?
- What systems are needed to capitalise on new traits?
So what is the obstacle?

- Conceptual - just how we think about things?
- Structural - how we organise ourselves?
- Cultural - how we approach research?
- Statistical - how we analyse data?
- Institutional - how we are rewarded?
Australian environment, soils and system

Dry (300-500mm), infertile soils, unsubsidised agriculture, risky

Mixed farms 2000 ha
1 crop/year May-Nov
Wheat yield 2 - 3 t/ha
The cropping year...

Climatic risks

Sowing

Sowing rain?

Frost

Heat, drought

Summer fallow

Sowing

Flowering

Grain fill

Jan  Feb  Mar  April  May  Jun  Jul  Aug  Sept  Oct  Nov  Dec
Modern, no-till cropping

Stubble-retained, disc-seeder, controlled-traffic, inter-row sowing, 2cm precision
Changing climate....

October Maximum Temperature Anomaly - Victoria

Australian Bureau of Meteorology

10-year running mean


Year

Maximum Temperature Anomaly (°C)

1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0

1969 1979 1989 1999

Based on a 30-year climatology (1981-90)

10-year running averages shown by black curve
Australian wheat production

- **Superphosphate fallowing mechanisation**
- **Phenology**
- **Improved pasture**
- **Semi-dwarf wheat**
- **Herbicides, break crops, N**
- **Millenium drought**
National WUE Initiative

1. WA Sandplain
2. WA Central
3. WA South West
4. WA South Coast
5. EP Farm Systems
7. Upper North FS
8. Hart Field Site Group
9. Mallee SFS
10. MacKillop Farm Management
11. Birchip CG
12. Southern FS
13. Riverine Plains
14. The University of Tasmania
15. Central West FS
16. FarmLink Research

$17.6 Million over 5 years
Improve WUE by 10%

A systems approach to water productivity

Predicted management synergies

Baseline Scenario (Kerang, Victorian Mallee)
Continuous wheat, grazed weedy fallow, burn/cultivate, sow > 25 May (1980s)

Baseline Mean Wheat Yield = 1.6 t/ha

<table>
<thead>
<tr>
<th>System change</th>
<th>Mean Yield (t/ha)</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>Single effect</td>
<td>Additive effect</td>
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<td>1.84</td>
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<td>2.10</td>
<td>4.01</td>
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<td>1.45</td>
<td>4.54</td>
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*Kirkegaard and Hunt (2010) Journal Experimental Botany 61, 4129-4143*
Management and genotype synergy

Capitalising on early sowing opportunities to optimise water use

*Kirkegaard and Hunt (2010) Journal Experimental Botany 61, 4129-4143*
Under climate change (2000 to 2009)

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Baseline Mean Wheat Yield = 1.6 t/ha

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A systems approach to water productivity

Four linked research Themes

1. Break crops and crop sequence

2. Summer fallow management

3. Managing in-season water-use

4. Managing variable or constrained soils

Theme 2 - Summer fallow management

- Fallow weed control – important?
- Stubble management – critical?
- Sheep grazing – soil damage?

6 regional groups across all 4 mainland states
Theme 2 - Summer fallow management

- Pre-experimental modelling (37 sites)
  Summer rainfall contributes 33% (1 t/ha) to yield (0.1 to 2.0 t/ha)

- Experimental validation (20 experiments, 6 regional groups)
  Strict weed control, stubble > 70% cover
  Extra 37mm water and 44 kg N/ha

- Rapid adoption
  Low risk strategy; Widely and rapidly adopted
  $5.70 return on $1 investment

Theme 3 – Managing in-season water use

- Strict summer weed control, stubble >70% cover
  
  In 20 experiments, extra 37 mm water and 44 kg N/ha = ($5.70 return)

- Early sowing of later-maturing wheat (same flowering window)
  
  Deeper roots, reduced evaporation, higher yield potential

- Wider rows/lower density and deferred N to maintain high HI
  
  Avoid excessive early biomass from early sowing

- Whole-farm multiplying effect from improved timeliness
  
  Increases in whole farm wheat yield of 11 to 47%

Experiment 2012 - 177 mm rainfall

- Yield increase 0.6 to 1.9 t/ha, $562/ha increase in gross margin

<table>
<thead>
<tr>
<th>Grain yield (t/ha)</th>
<th>50 plants/m²</th>
<th>100 plants/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGA Eaglehawk (18 April)</td>
<td>5.9*</td>
<td>6.1</td>
</tr>
<tr>
<td>Bolac (26 April)</td>
<td>5.8</td>
<td>5.5</td>
</tr>
<tr>
<td>EGA Gregory (8 May)</td>
<td>5.1</td>
<td>5.2</td>
</tr>
<tr>
<td>Lincoln (17 May)</td>
<td>4.3</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
<td><strong>0.034</strong></td>
<td></td>
</tr>
<tr>
<td><strong>LSD (p=0.05)</strong></td>
<td><strong>0.3</strong></td>
<td></td>
</tr>
</tbody>
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- Deeper roots, less evaporation, better water use, higher yield potential

Yield increase scales up at whole-farm level

Very slow + mid-fast varieties

Average yield = 5.5 t/ha

Mid-fast variety only

Average yield = 4.7 t/ha

Whole-farm benefits

Whole-farm yield increase 11 to 47%
## Demonstrated benefits to WUE >10%

<table>
<thead>
<tr>
<th>Theme</th>
<th>Innovation</th>
<th>WUE Increase</th>
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<tbody>
<tr>
<td>1</td>
<td>Break crops</td>
<td>16 to 83%</td>
</tr>
<tr>
<td>2</td>
<td>Summer weed control</td>
<td>60%</td>
</tr>
<tr>
<td>3</td>
<td>Early sowing</td>
<td>21 to 33%</td>
</tr>
<tr>
<td>3</td>
<td>Wider rows</td>
<td>-6 to -13%</td>
</tr>
<tr>
<td>3</td>
<td>Irrigation timing</td>
<td>12 to 23%</td>
</tr>
<tr>
<td>3</td>
<td>Disease control</td>
<td>20 to 25%</td>
</tr>
<tr>
<td>4</td>
<td>Variable N rates</td>
<td>up to 91%</td>
</tr>
<tr>
<td>4</td>
<td>Responsive systems</td>
<td>22%</td>
</tr>
<tr>
<td>4</td>
<td>Gypsum</td>
<td>15 to 54%</td>
</tr>
<tr>
<td>4</td>
<td>Subsoil manuring</td>
<td>28%</td>
</tr>
<tr>
<td>4</td>
<td>Mouldboard/spade</td>
<td>20 to 80%</td>
</tr>
</tbody>
</table>

Earlier-sown crops can also be grazed!

<table>
<thead>
<tr>
<th>Grain-only crop</th>
<th>Sow</th>
<th>Grain</th>
</tr>
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<tr>
<td>Jan</td>
<td>F</td>
<td>M</td>
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<tr>
<th>Dual-purpose crop</th>
<th>Sow</th>
<th>Graze</th>
</tr>
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<td>Jan</td>
<td>F</td>
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Improved roots interact with management

Preceding crop: 0.5 to 1.8 t/ha
Fallow weeds: 0.65 t/ha
Sowing date: 0.1 to 0.9 t/ha

Impact of improved roots = 0.3 - 0.4 t/ha

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

Achievements on farm?

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3.7 t/ha in 2014
Elements of success

• Industry and growers involved from the outset

• Adopted a $G \times E \times M$ approach at system level

• Multi-disciplinary, but linked to a non-disciplinary goal

• Effective “integrators” needed; valued for broad knowledge

• Longer-term funding horizons

All traits interact with management

Long root hairs = PUE

Early Vigour = WUE/NUE

Restricted tillers = WUE

Precision placement
Formulation

Weed management
N uptake
Grazing

Row spacing
Inter-row sowing

Buffered organic complex — Urea
Ultimately the pathway to impact is personal

- Conceptual - think more broadly - GxExM

- Structural - reward “integrators” as specialists

- Cultural - partner for impact

- Statistical - consider the interactions

- Institutional - impact, not “impact-factor”
Thank-you
Thank you!