Adaptation of crops and cropping systems to drought in Australia

www.csiro.au

John Kirkegaard and teams, CSIRO Agriculture and Food Australia

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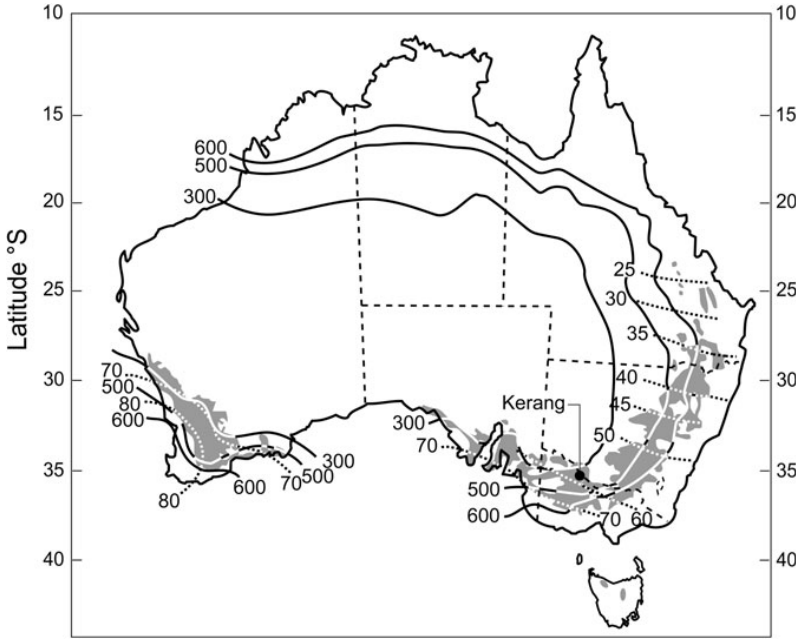
Main idea

- Many small changes can be transformational

Case study

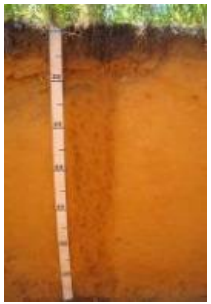
- Early sowing systems in Australia since 2010

Dryland grain production in Australia



- 20 Million hectares crop
- Dry, Variable (300-500mm annual rainfall)
- Infertile soils with significant constraints
- Unsubsidised agriculture = risky
- Average farm size 2,000 ha

Deep acidic sands



Compact loams

Heavy cracking clays

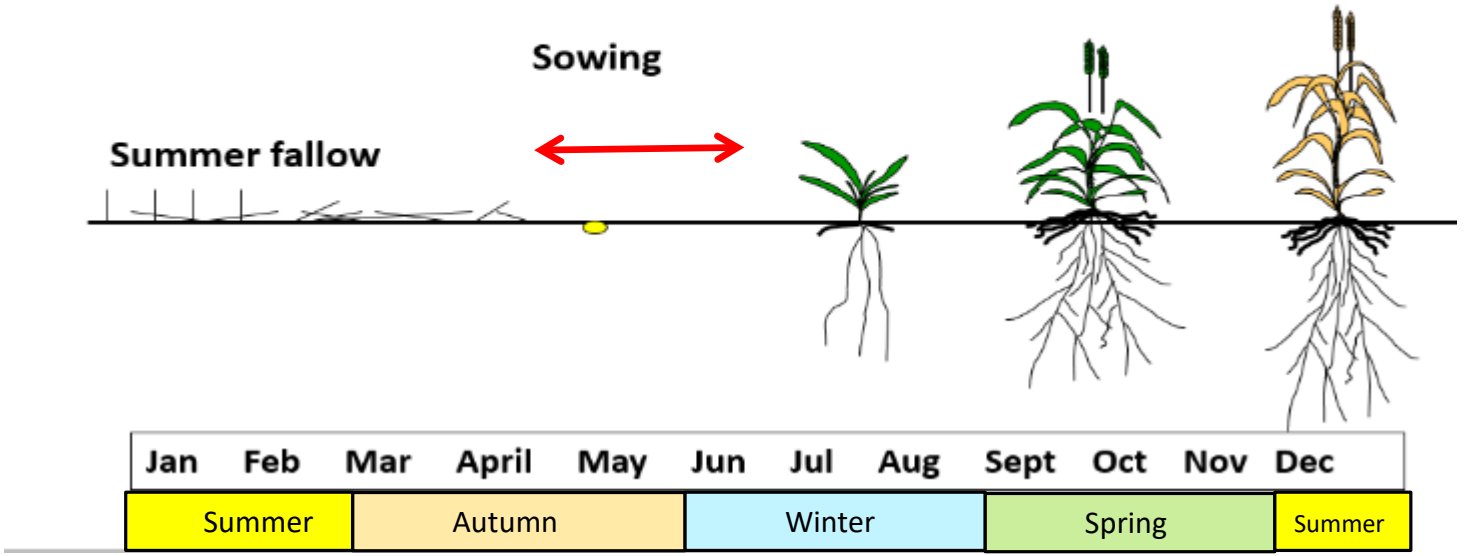
Grain production in Australia

Climatic risks

Sowing rain? ("Autumn break")

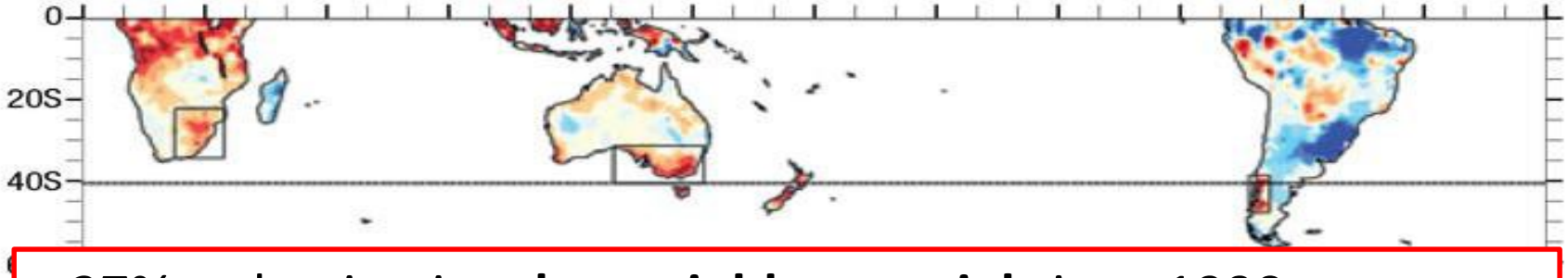
Frost?

Heat, drought?



Autumn rainfall decline in south-eastern Australia

- 24% reduction in April-May rainfall since 1997
- Associated with the position of sub-tropical ridge (Cai *et al.* 2012)
- Partly attributable to anthropogenic climate change (Cai *et al. 2013*)
- Synoptic systems for 'autumn break' less frequent (Pook et al. 2006, 2009)

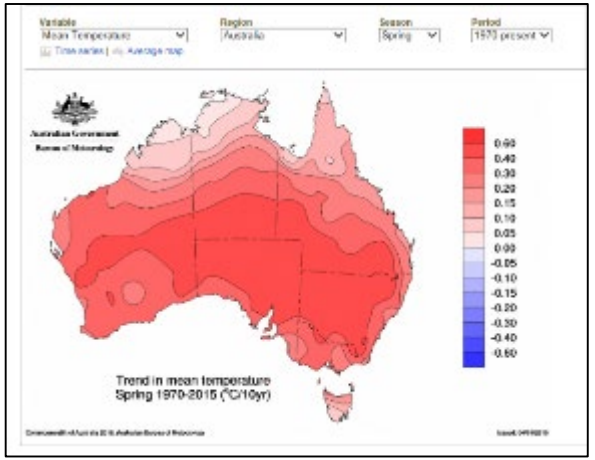


- 27% reduction in **wheat yield potential** since 1990

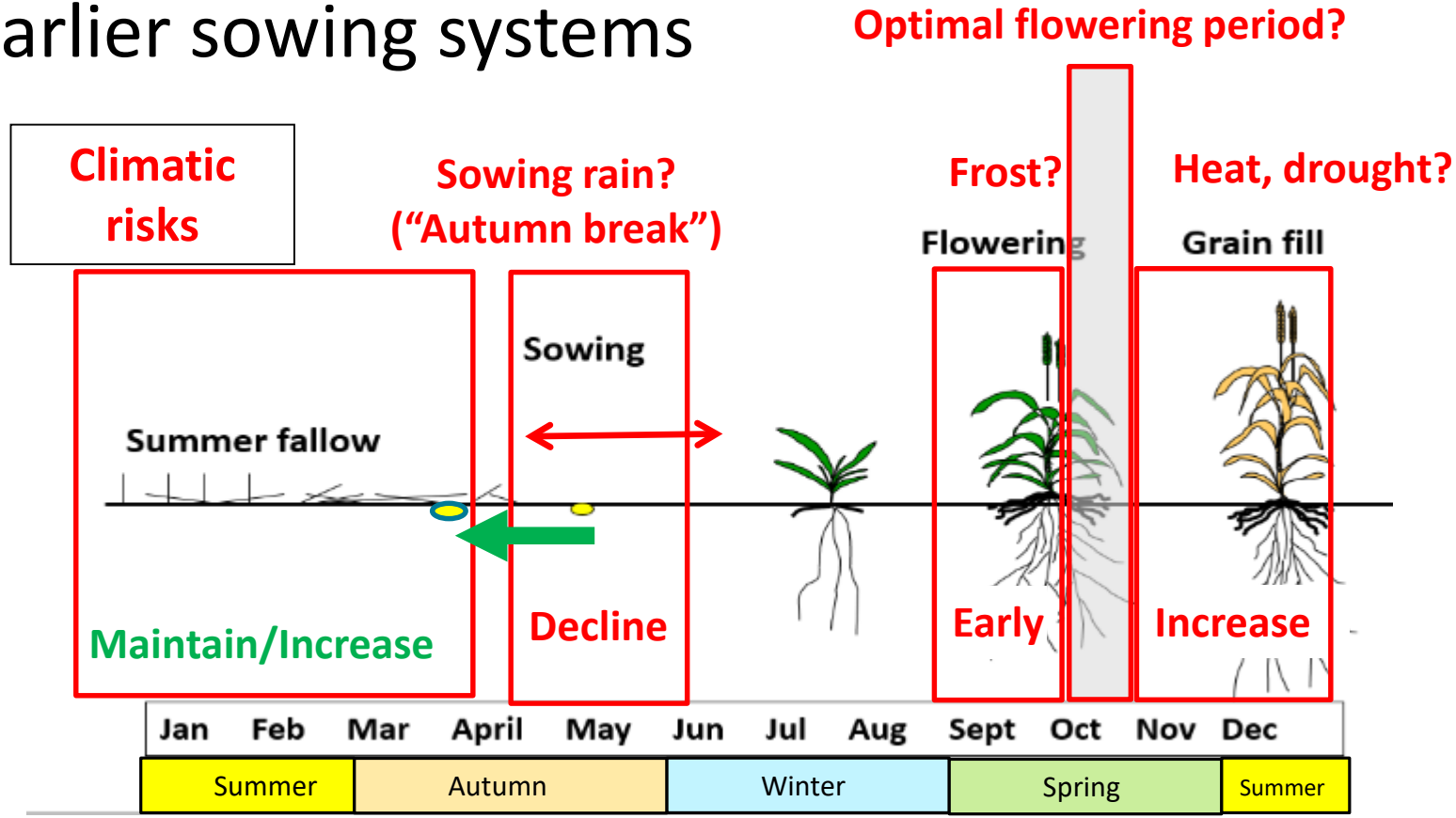
  - warmer, drier, more extreme (CO_2 offset only 4%)

Other changes on farms…

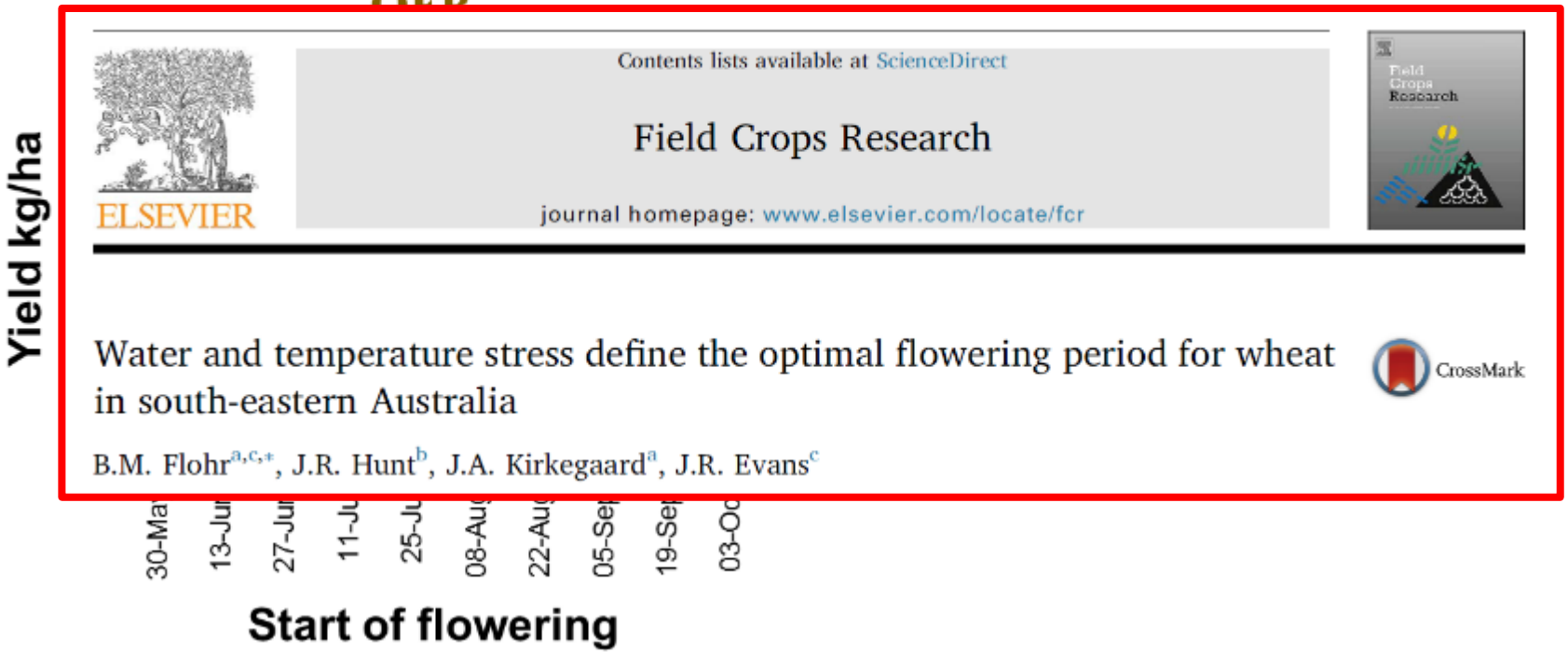
- Changing seasonal conditions
  - Dry/warm springs
  - Increased late summer/early autumn rainfall
- Changing management
  - Improved fallow management
  - Improved seeding equipment
- Larger farms



Earlier sowing systems



Optimal flowering periods are changing



Contents lists available at ScienceDirect

Field Crops Research

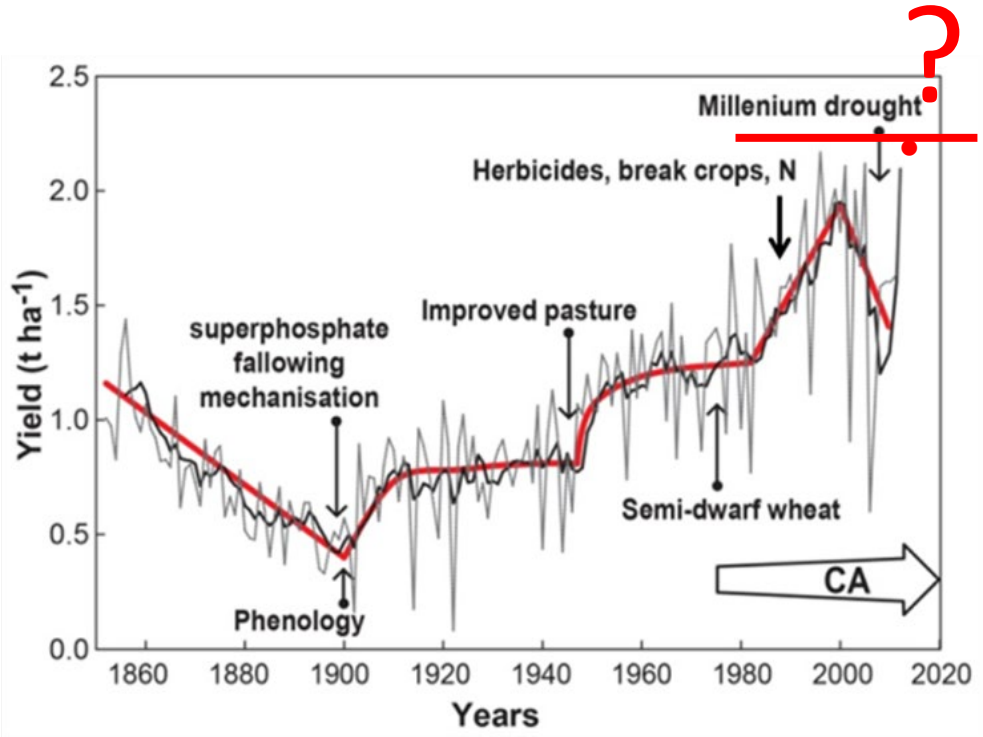
journal homepage: www.elsevier.com/locate/fcr

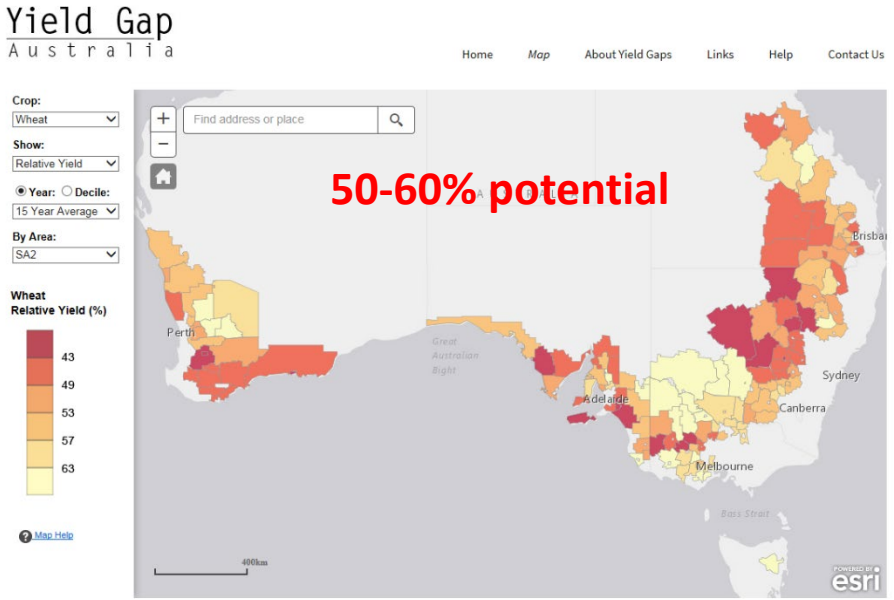
Water and temperature stress define the optimal flowering period for wheat in south-eastern Australia

B.M. Flohr[a,c,*], J.R. Hunt[b], J.A. Kirkegaard[a], J.R. Evans[c]

Flohr et al (2017) Field Crops Research 209, 108-119

National Yield Gaps (actual vs potential yield)





www.yieldgapaustralia

Kirkegaard et al., (2014) Agriculture, Ecosystem and Environment 187, 133-145

National Water Use Efficiency Initiative (2009 – 2013)

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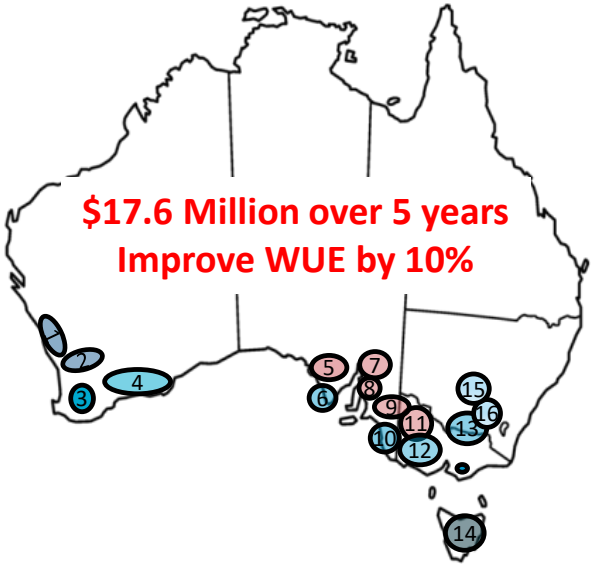
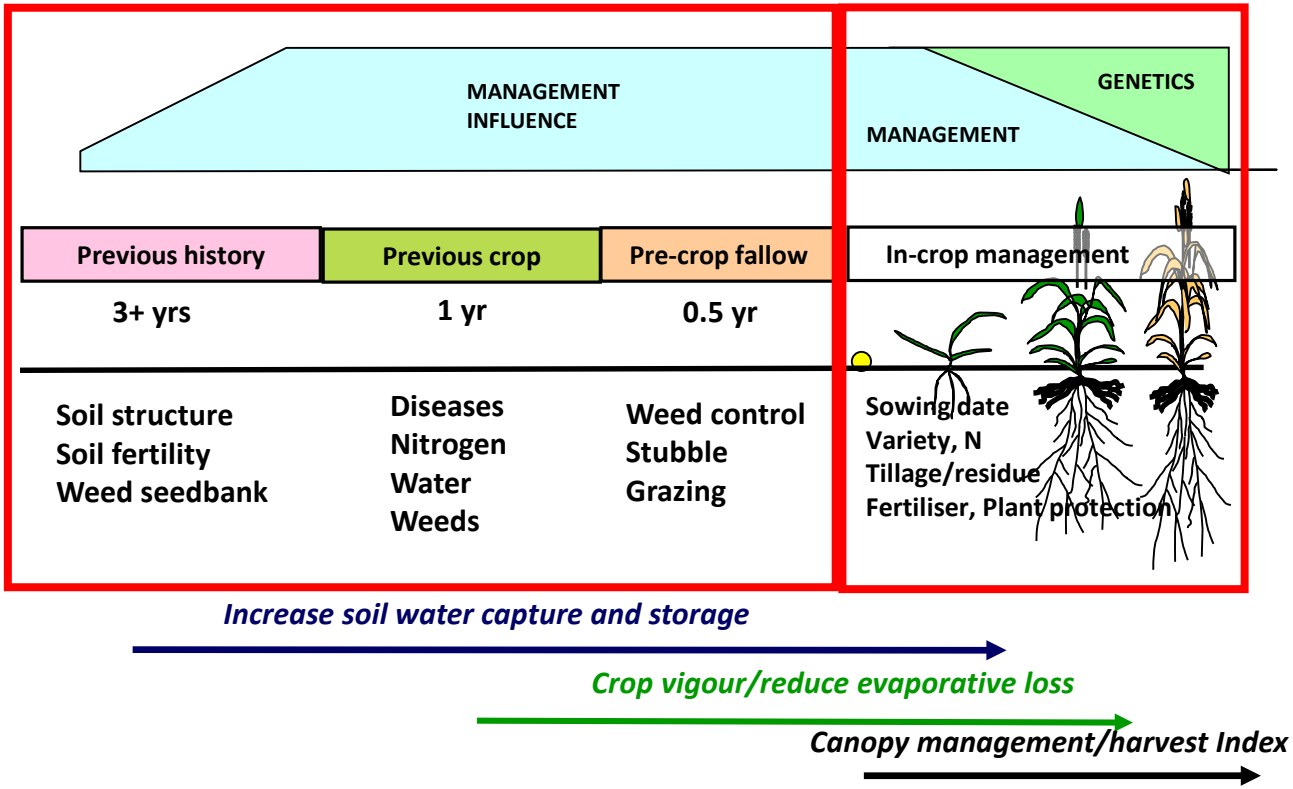


16 regional farmer groups

Systems science

Using rainfall more effectively (more crop per drop)



Research Themes

- Soil Management
- Crop Sequence
- Summer fallow
- In-crop management

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

Kirkegaard et al., (2014) Crop and Pasture Science 65, 583-601

Predicted effects of improved systems

Continuous wheat

Graze summer weeds

Burn/cultivate

Sow late May

Current spring variety

Old System

Mean Wheat Yield 1.6 t/ha

Better Rotation

Control summer weeds

No-till

Sow in April

New Variety (long coleoptile)

1.8 t/ha | **2.4 t/ha** | **1.8 t/ha** | **2.1 t/ha** | **1.5 t/ha**

New System

Mean Wheat Yield 4.5 t/ha

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

Experiments confirm simulated predictions

- Summer fallow management
  (20 Experiments, 6 regions)

Strict summer weed control
+
stubble >70% cover

- **extra 37 mm water + 44 kg N/ha**

6 : 1 return on investment

Earlier sowing, slow maturing wheat

(4 Experiments, 3 regions)

Grain yield (t/ha)	50 pl/m²	100 pl/m²
EGA Eaglehawk (18 April)	**5.9***	6.1
Bolac (26 April)	**5.8**	5.5
EGA Gregory (8 May)	5.1	**5.2**
Lincoln (17 May)	4.3	**4.0**

- Deeper roots, less evaporation, higher yield

- **Yield increase 0.6 to 1.9 t/ha**

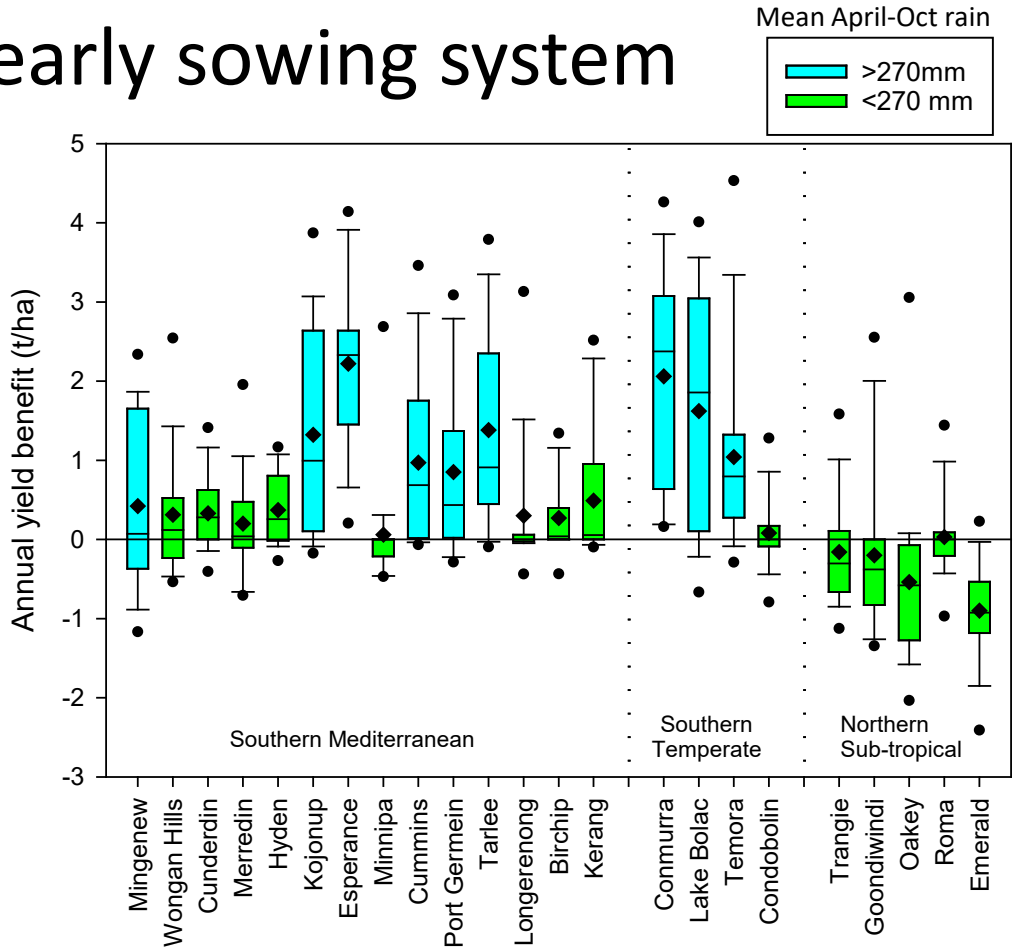
$562/ha increase

Whole-farm benefits of early sowing system

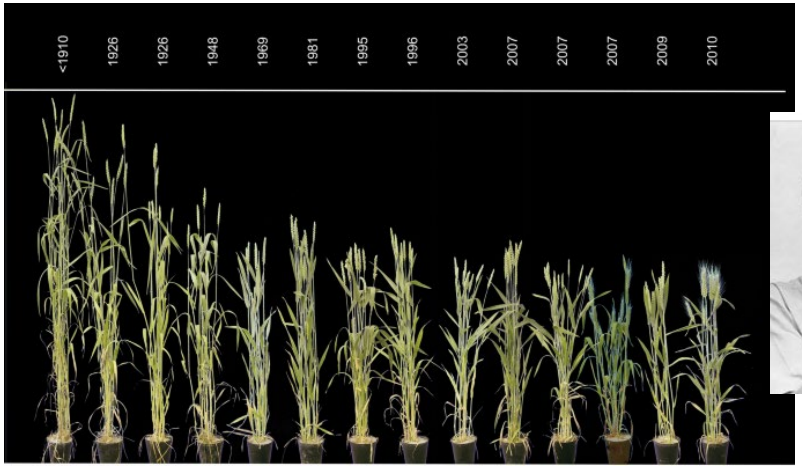
LETTERS
https://doi.org/10.1038/s41558-019-0417-9
nature climate change

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

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



Longer coleoptiles in wheat



nature climate change

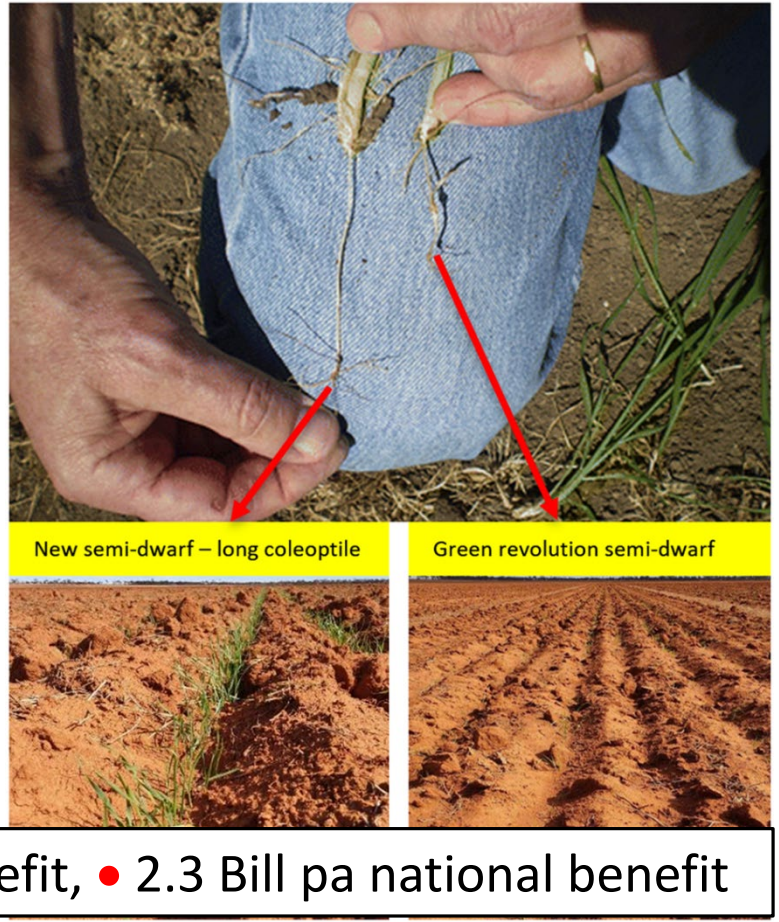
ARTICLES

https://doi.org/10.1038/s41558-022-01305-9

Check for updates

Novel wheat varieties facilitate deep sowing to beat the heat of changing climates

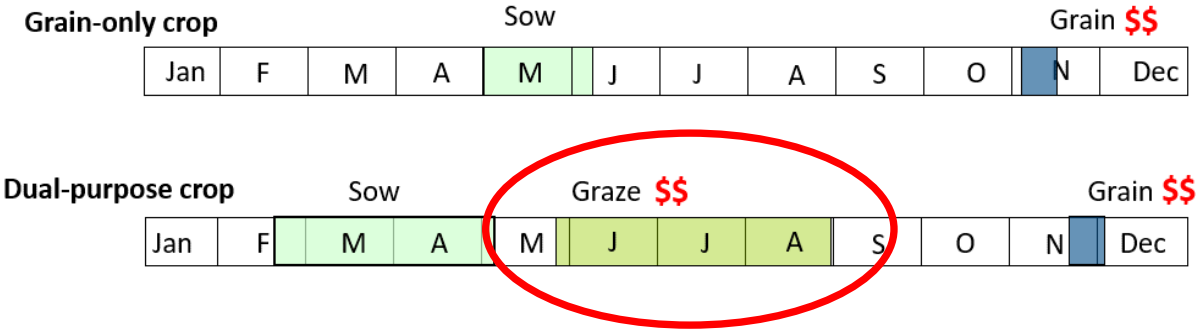
Zhigan Zhao, Enli Wang ✉, John A. Kirkegaard and Greg J. Rebetzke



- ~ 20% yield benefit,
- 2.3 Bill pa national benefit

Earlier sown crops can also be grazed in winter

Grazed wheat



Grazed canola

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

Summary

Synergies from small but targeted changes

to

Capture, store and use water more efficiently

are

Transformational in adaptation to climate change

Numerous colleagues, collaborators, farmers and friends

Thank you

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System resilience, not crop resistance

cv. Bale

Awnless, high fructan wheat for high-value hay
(when frost, heat or drought limits grain yield)

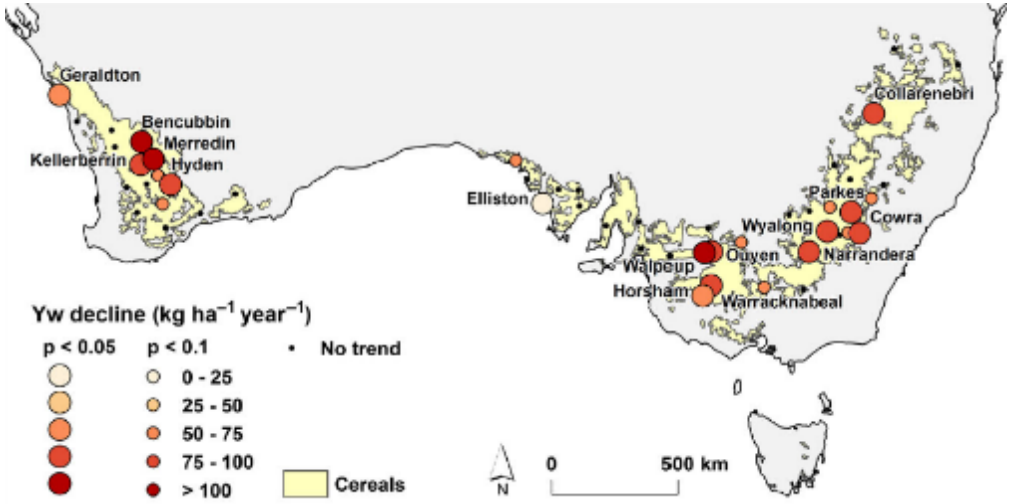
100-day Wheats

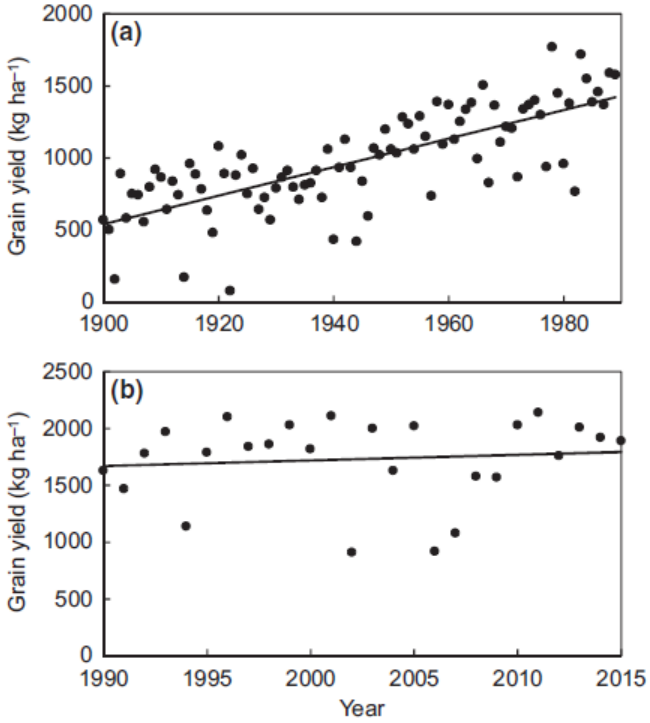
Fast, vigorous, 100-day wheats for late sowing.
(when autumn rain fails, or for weed control)

Hi-vigour selection (240-300g.m^{-2})

Current varieties 120-160g.m^{-2}

Climate induced stall in yield potential since 1990





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