

Applications of Agricultural Biotechnology

'what the Australian Grains Industry is looking for'

Juan Juttner, GRDC
AusBiotech 2011 National Conference



Australian Government
Grains Research and Development Corporation



Grains Research &
Development Corporation

Rural Research and Development Corporations

GRDC

- statutory corporation
- founded 1990 under PIERD act
- research investment body in partnership with growers and Government
- funding from grain grower levy and matching Government \$
- invest approx \$150M/pa



GRDC – 25 crops

Cereals

- *wheat*
- *barley*
- *oats*
- *sorghum*
- *maize*
- *triticale*
- *millets/panicum*
- *cereal rye*
- *canary seed*

Pulses

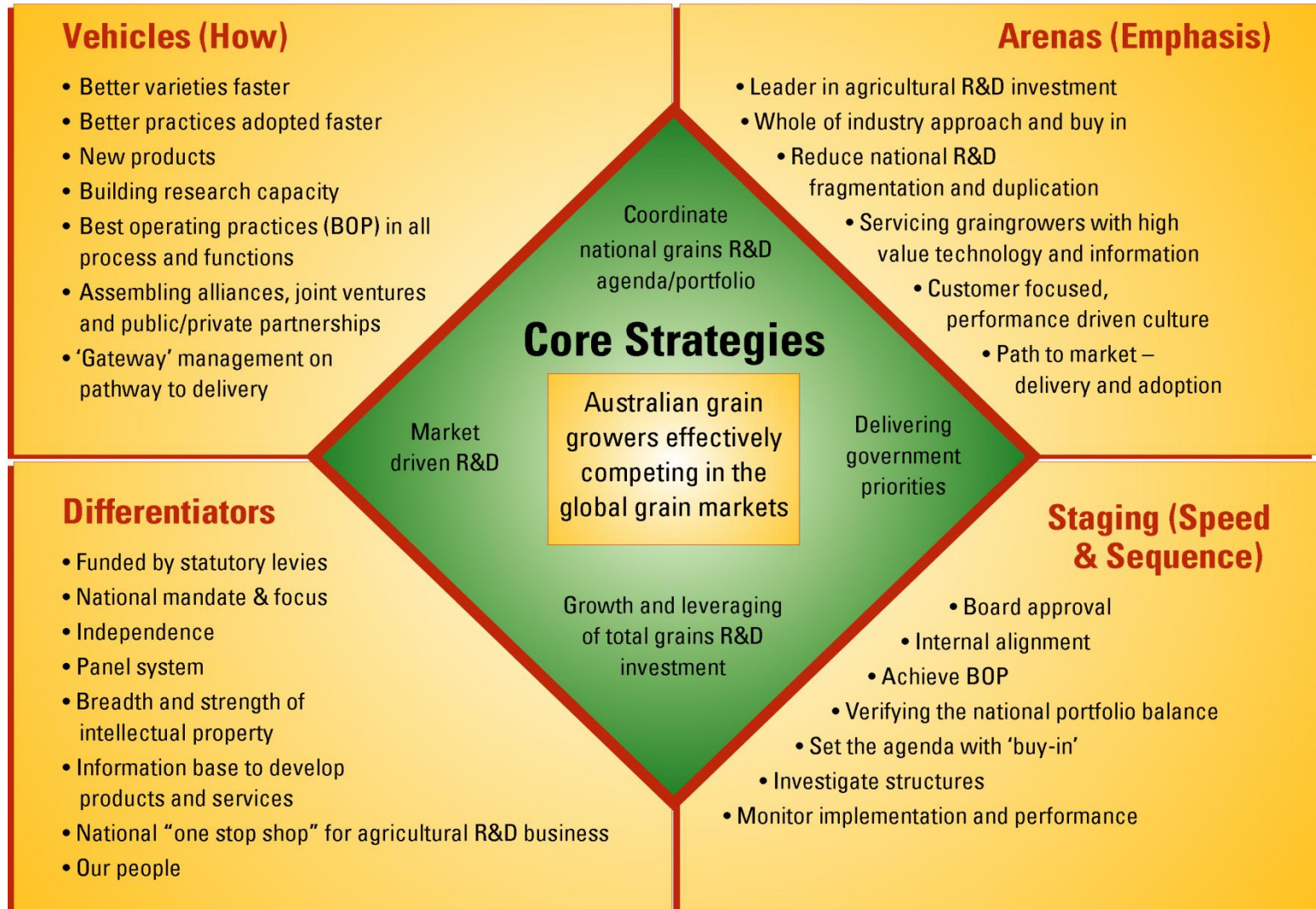
- *lupins*
- *field peas*
- *chickpeas*
- *faba beans*
- *vetch*
- *peanuts*
- *mung beans*
- *navy beans*
- *pigeon peas*
- *cowpeas*
- *lentils*

Oilseeds

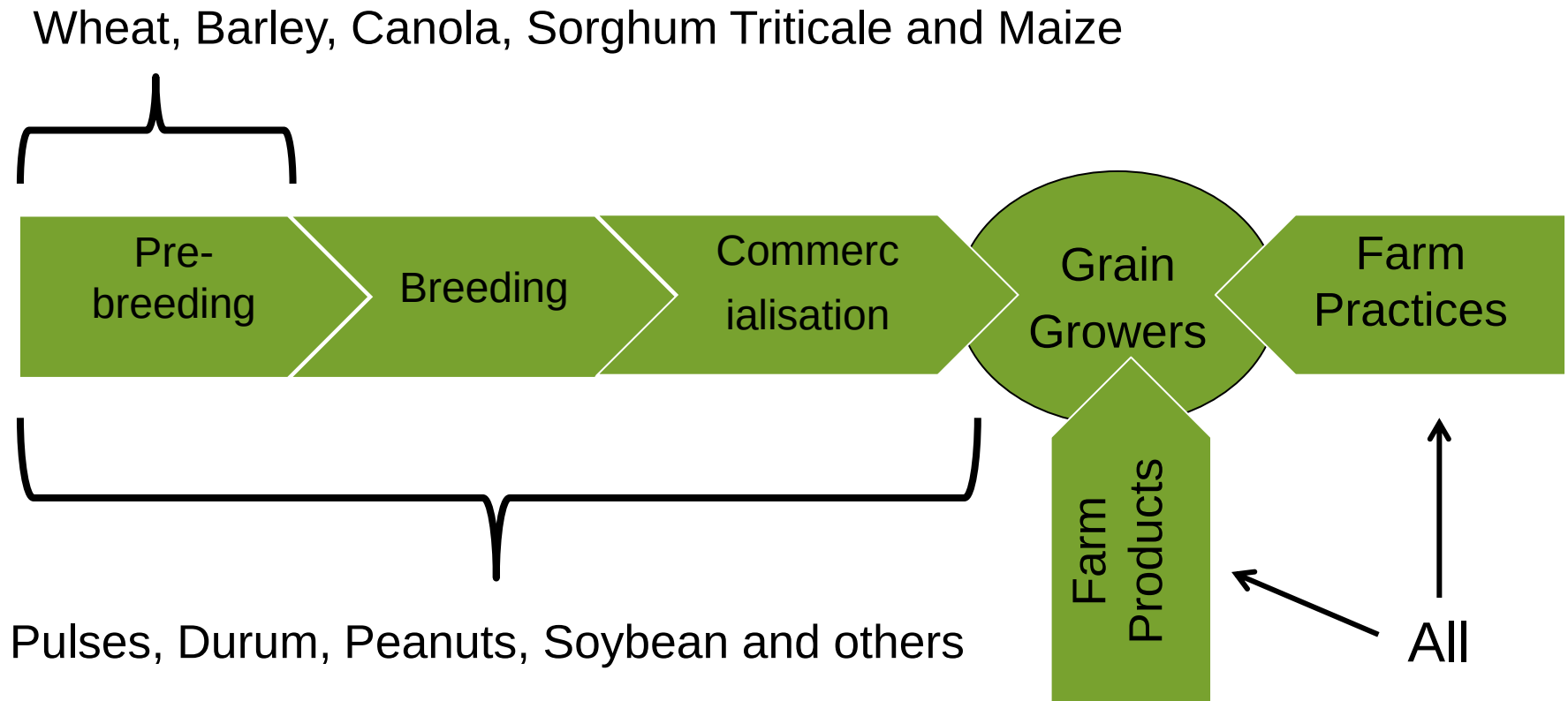
- *canola*
- *sunflower*
- *soybean*
- *safflower*
- *linseed*

0.99% levy

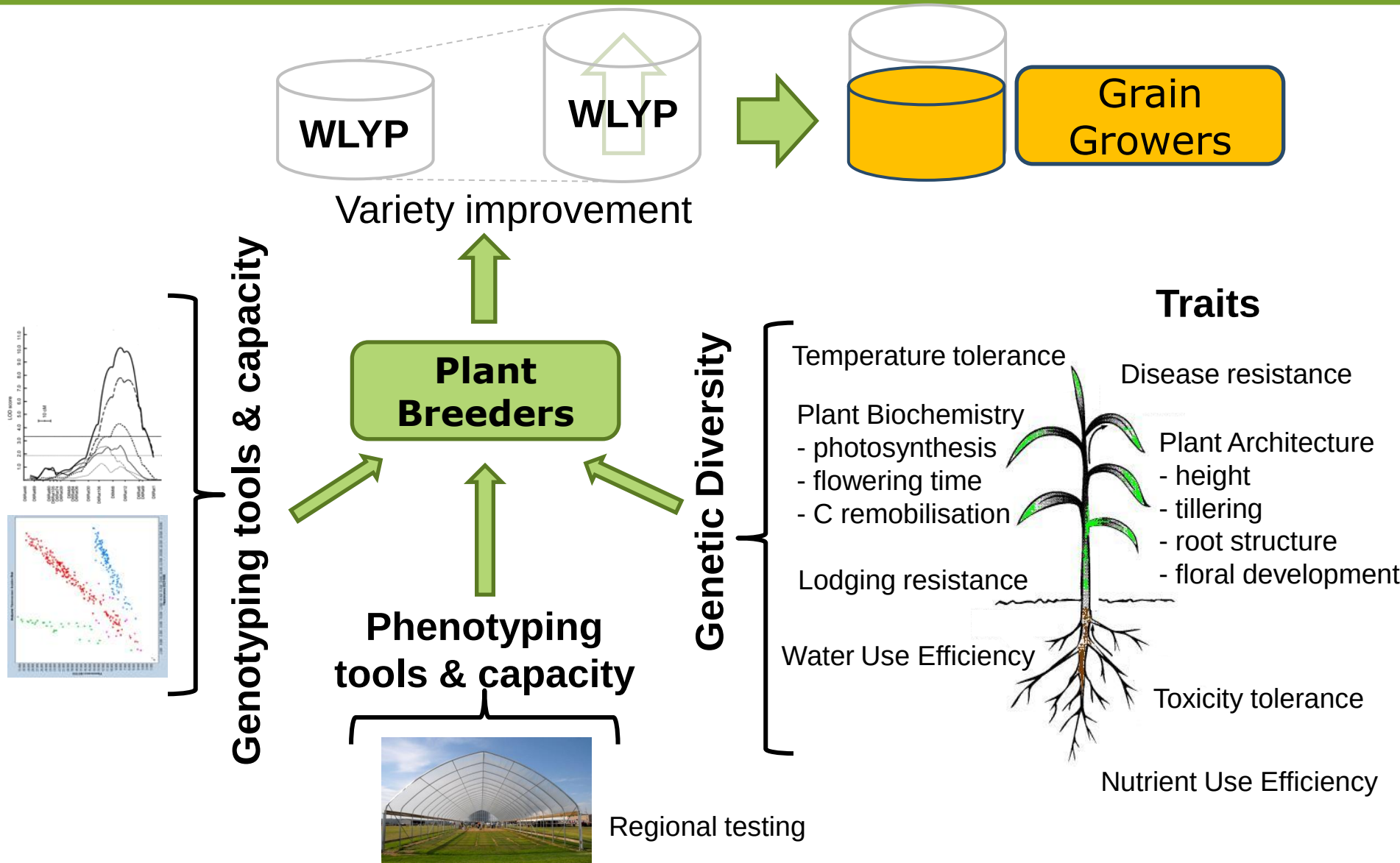
GRDC Mandate



Investment area is crop dependant



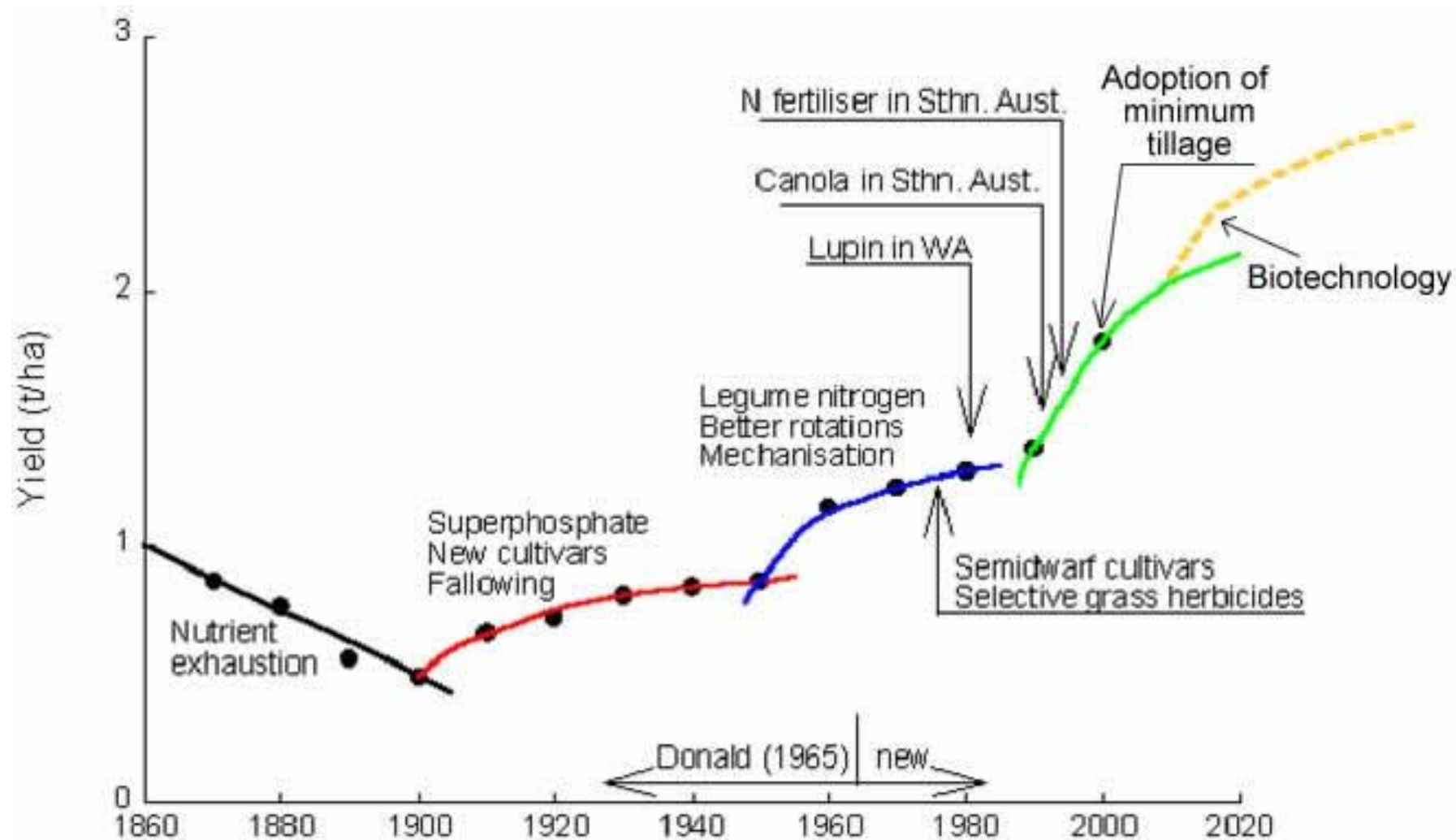
Biotech investment = breeding support



Expectations

What does the grains industry expect from biotech R&D?

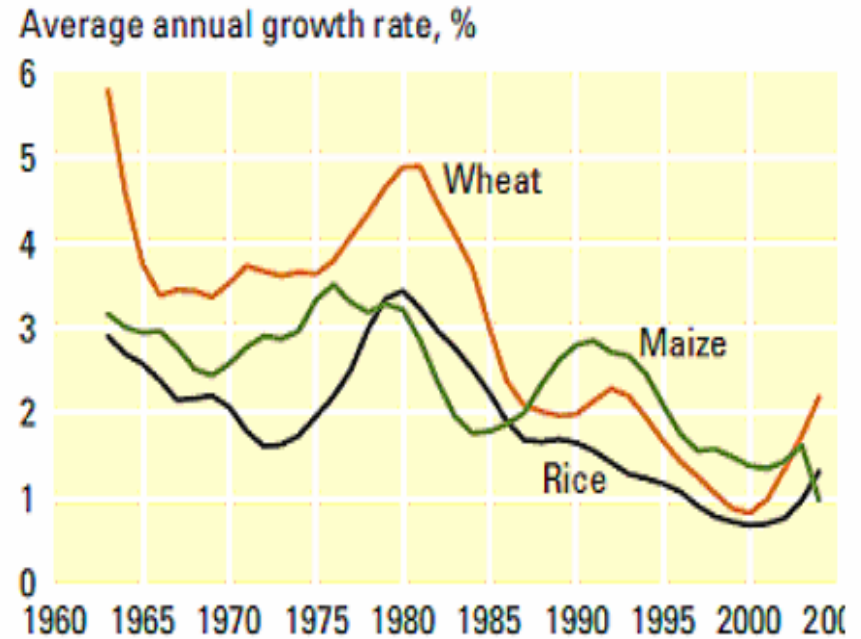
For most crops – the next step!



More Food

World Population

- 2011: 6.9 Billion
- **2050: 9 Billion**
  - Food +70%
  - Cereal Production +43%(FAO Report "How to feed to world 2050")
- 2100: 10.1 Billion
(UN "World Population Prospects", May 2011)



Wanted: 80% of production increases come from increases in yield

Facts: Annual yield increases for major cereals declining globally from 3.2% (1960) to 1.5 % (2000)

Solutions: including R&D investment, Technology

(FAO Report "How to feed to world 2050")

More Food

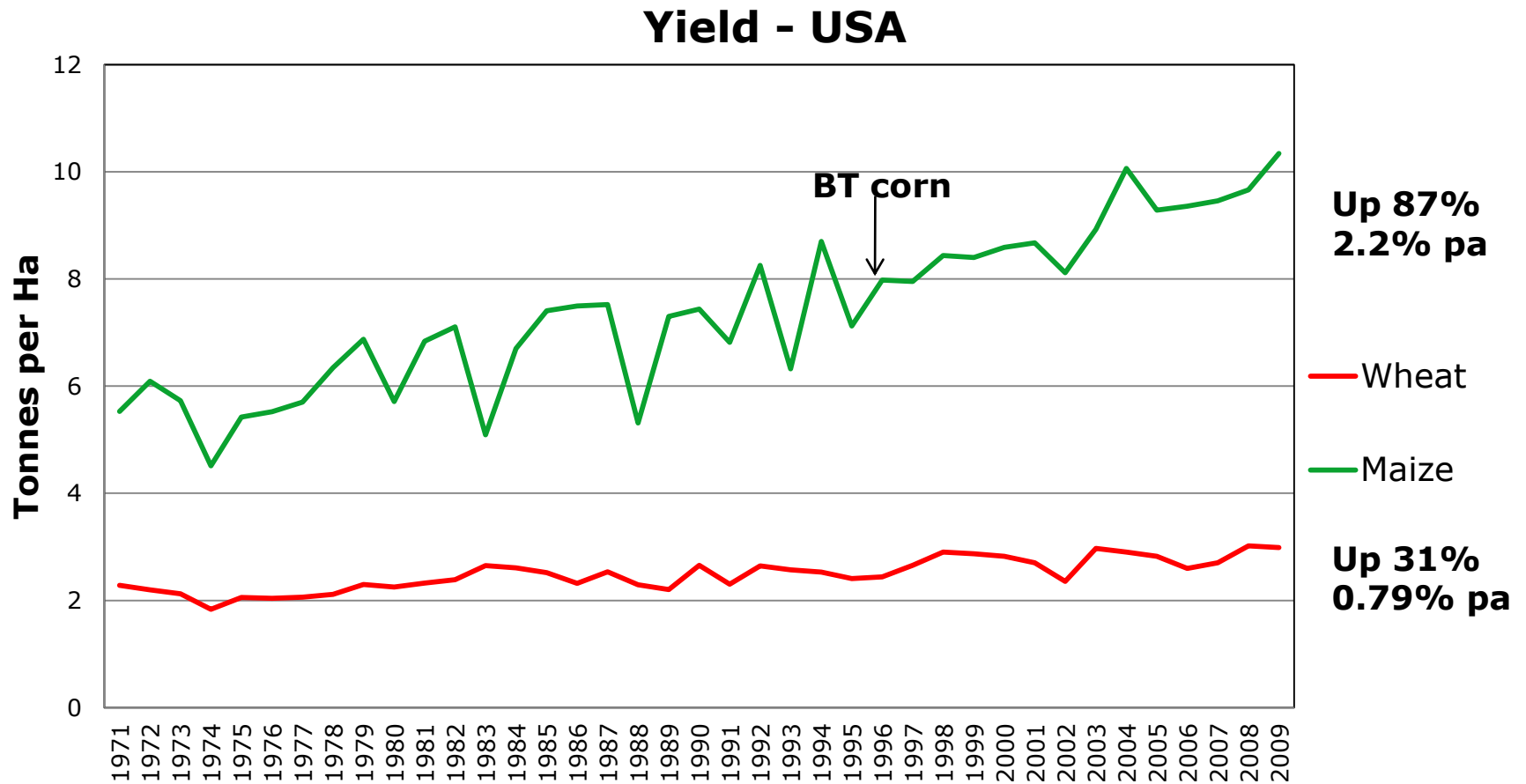
Globally

- 70% increase in global food production
- 1 billion additional tonnes of cereals
- 200 million additional tonnes of meat

Australia

- Increase in wheat production 22Mt to 29Mt p.a.
- On same land area
- Need 1.4% yld gain p.a.

Higher yield gains



Existing partnerships

Australia is well placed to support the development and delivery GM traits in wheat

- Research partnerships
  - Australian Centre for Plant Functional Genomics (ACPFG): Pioneer-Dupont
  - CSIRO: Bayer CropScience
  - Victorian Department of Primary Industries: Dow AgroSciences
- Breeding partnerships
  - Australian Grain Technologies: Groupe Limagrain
  - InterGrain: Monsanto
  - Longreach Plant Breeders: Syngenta & Pacific Seeds
  - Bayer CropScience (since 2010)

Path to Market

Stepping Stones (Alan Green, CSIRO)	Requirements	AU Strength	AU Weakness	AU Opportunity
Incentive To Operate	• Market • Expertise		X X	Partnership Partnership
Permission To Operate	• Regulatory Approval • Finance • Expertise		X X X	Partnership Partnership Partnership
Freedom To Operate	• Elite Germplasm (breeding) • Transformation Event ○ Enabling Technologies ○ Foundation Traits ○ Trait of Interest	X X	 X X	Partnership In Licence In Licence Out Licence
Ability To Operate	• Patent (Trait of Interest) • Proof of Concept • Proof of Function • Discovery	X X X X		Out Licence Funding Funding Funding

GM traits – need to partner

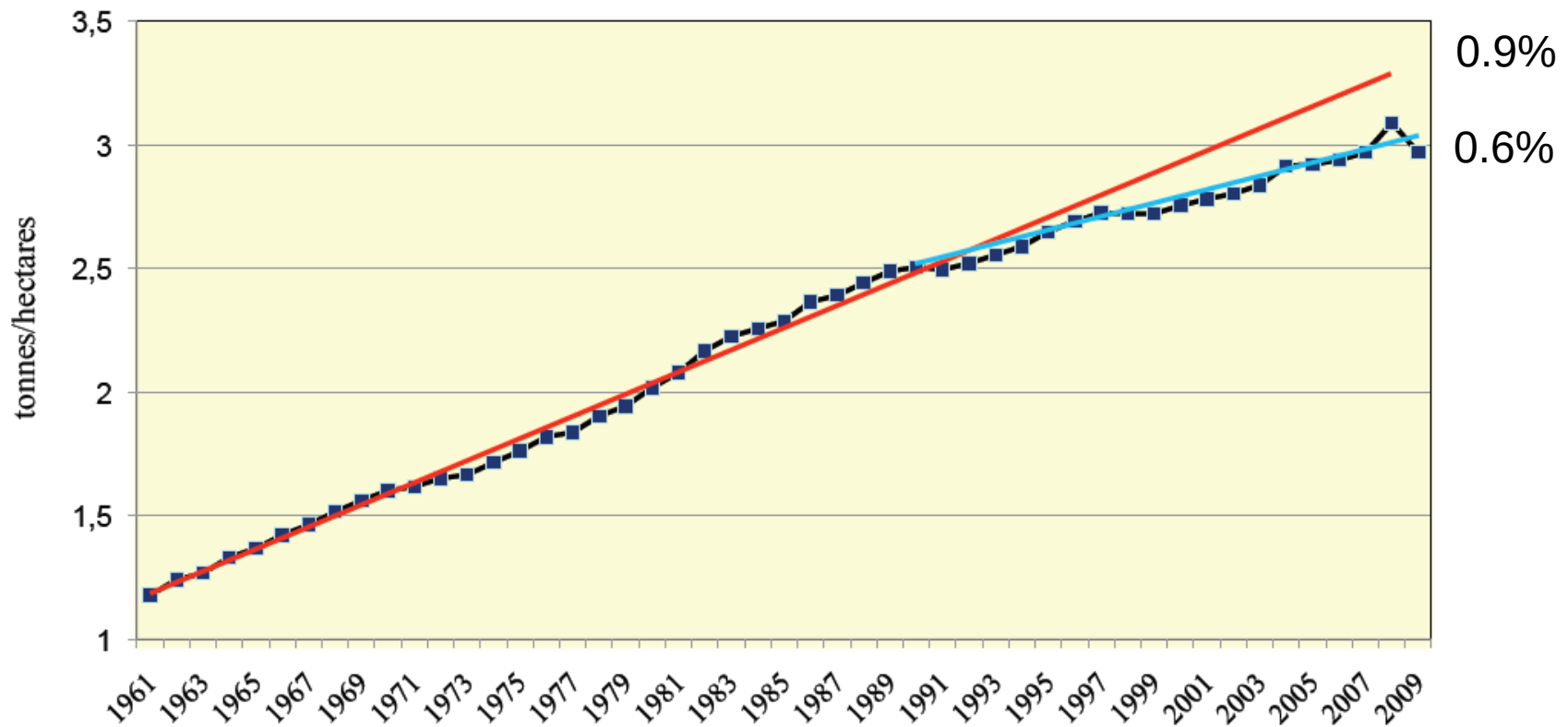
- Australia needs partnerships to take GM wheat to market
- GM events require global regulatory approval
  - Expensive :
    - AUD 11M-24M (2008) for GM corn
    - AUD 26M-41M (2008) for GM wheat
- GM traits require global markets
- Market acceptance
- Likely Traits:
  - Yield
  - Improved sustainability of production
  - Consumer benefits
- Timing: at least 7-10 years away

Kalaitzandonakes et al. (2006 & 2007)

Hoffman, Carr and McMullen (2008) “Delivery Platform and Supply Chain Infrastructure Requirements for GM Wheat and Barley Crops and Products in the Australian Grains Industry”

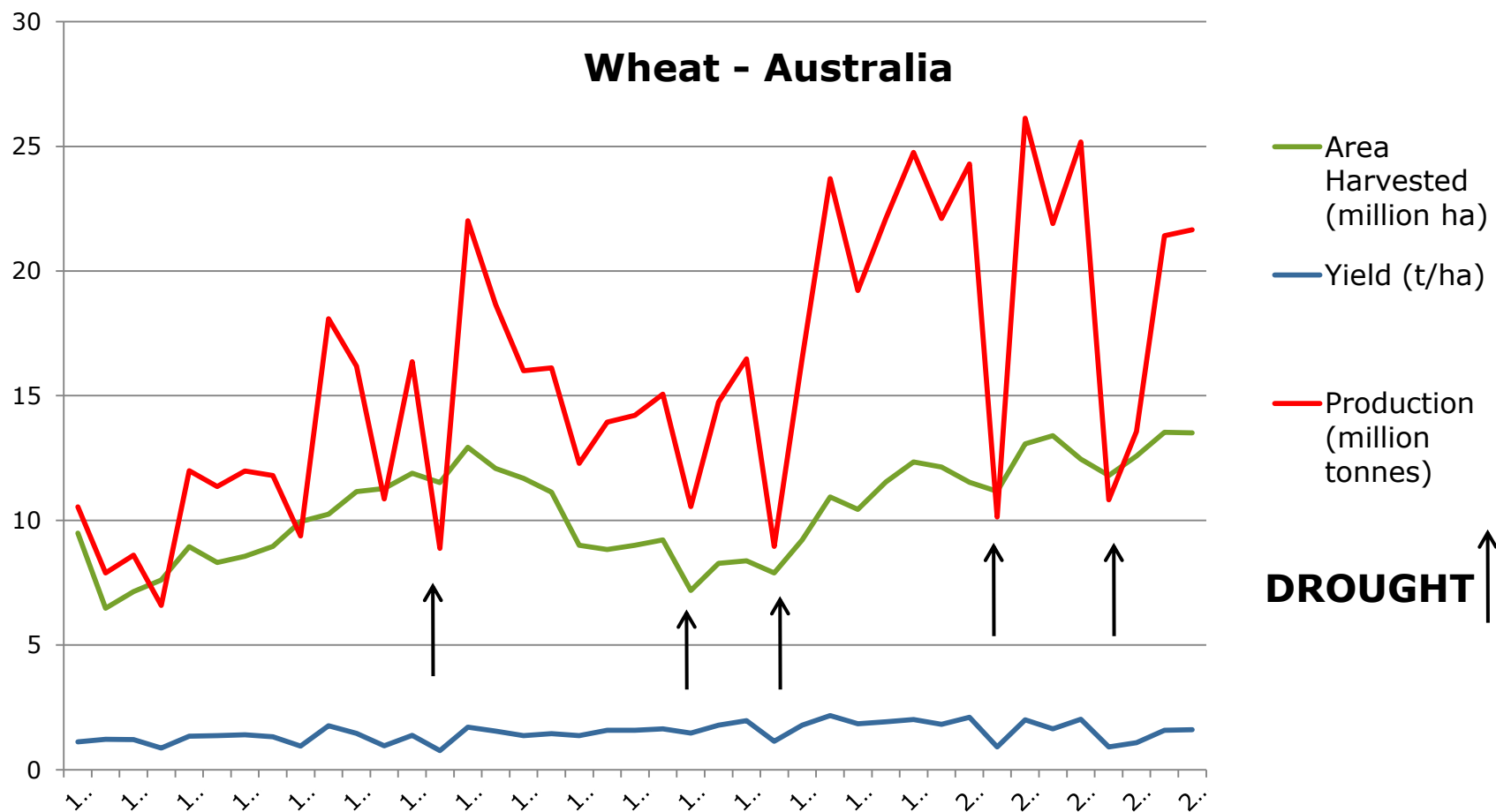
Australian wheat production currently

WORLD WHEAT YIELD TRENDS (5 Year Moving Average – tons/ha)



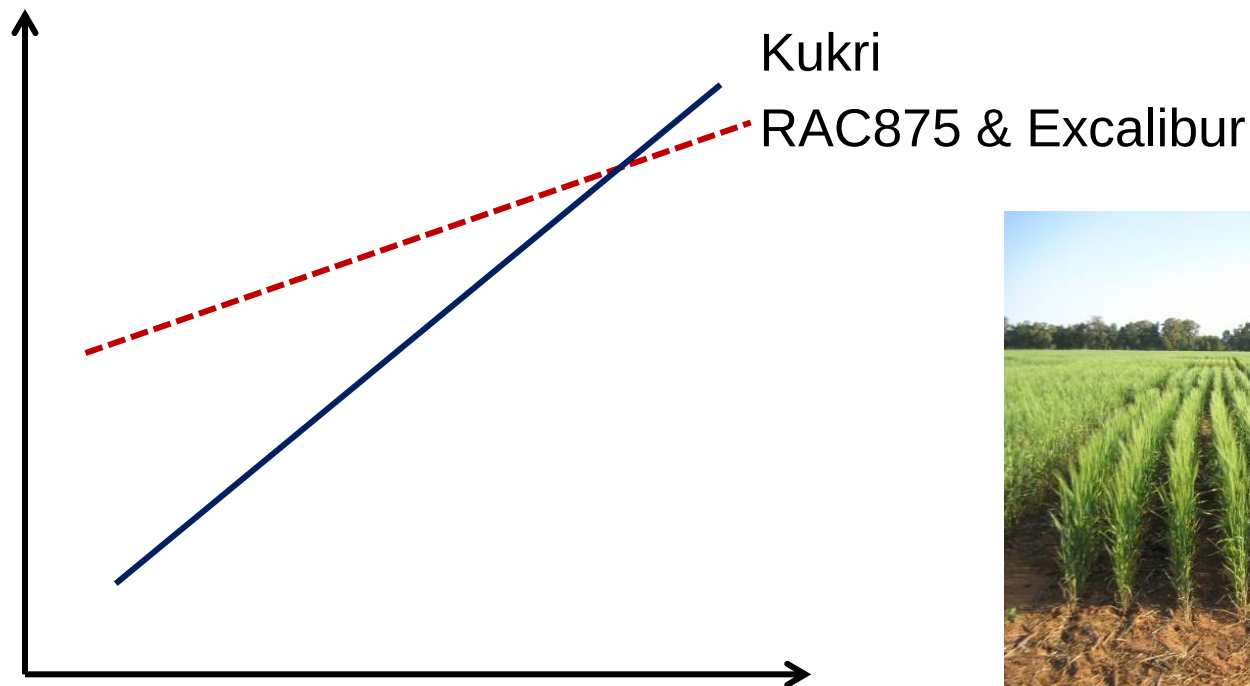
Fischer, R.A.: 2008. Agric. Science (Australia) 21: 6-18.

Yield stability

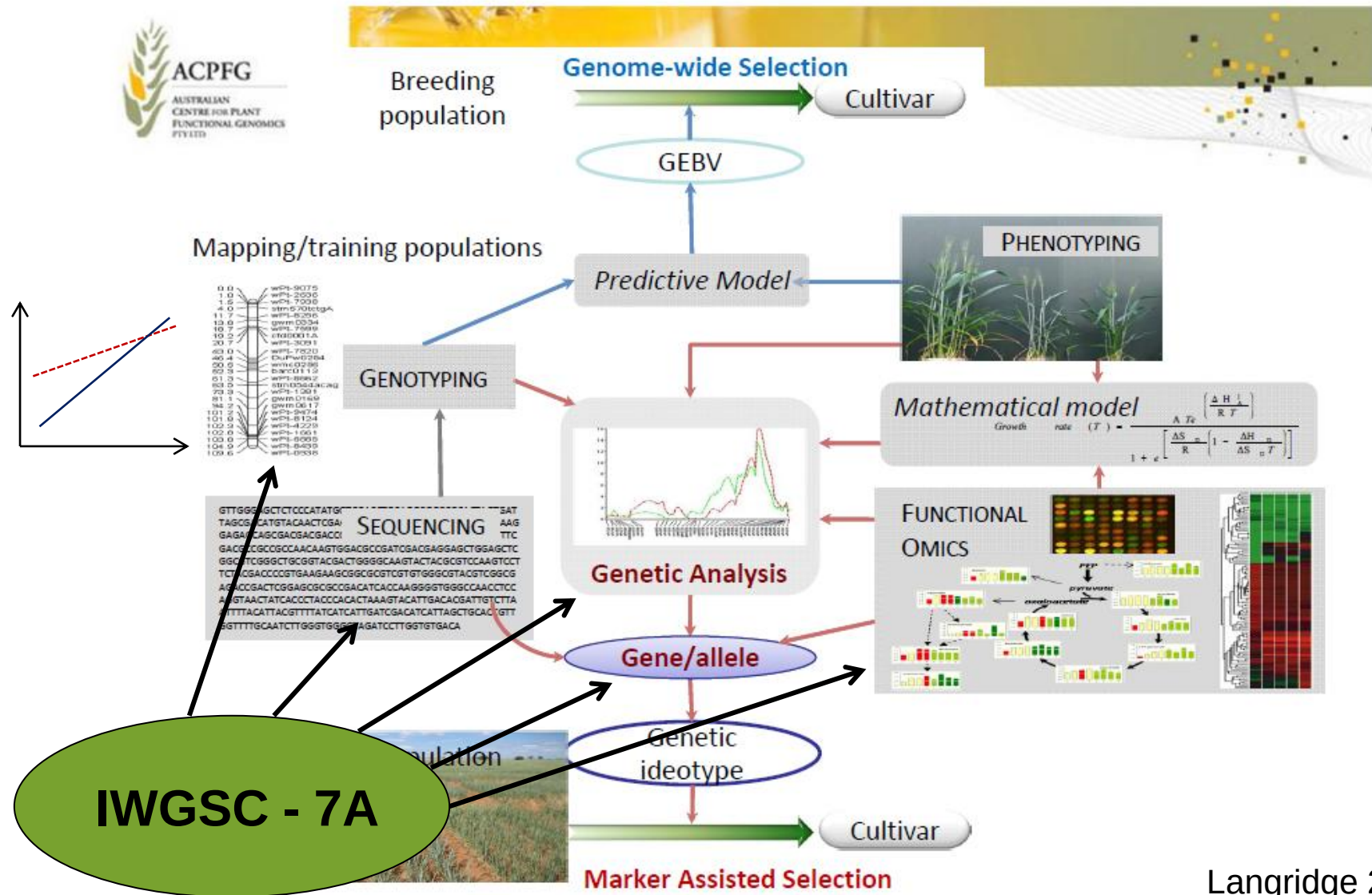


Yield stability under drought stress - ACPFG

Australian Grain Technologies – field observations



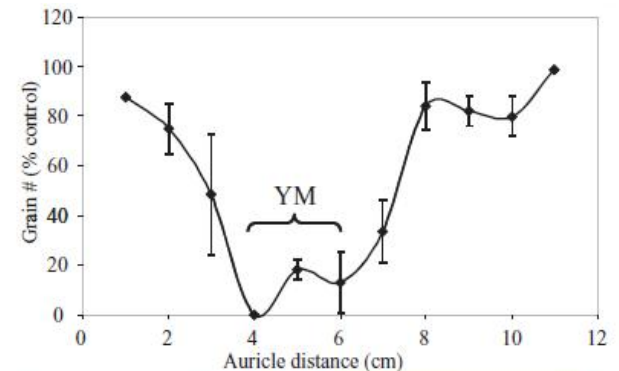
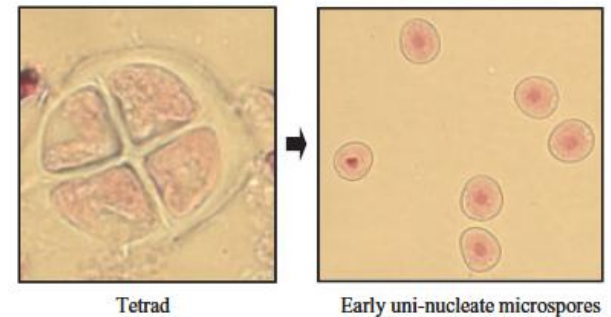
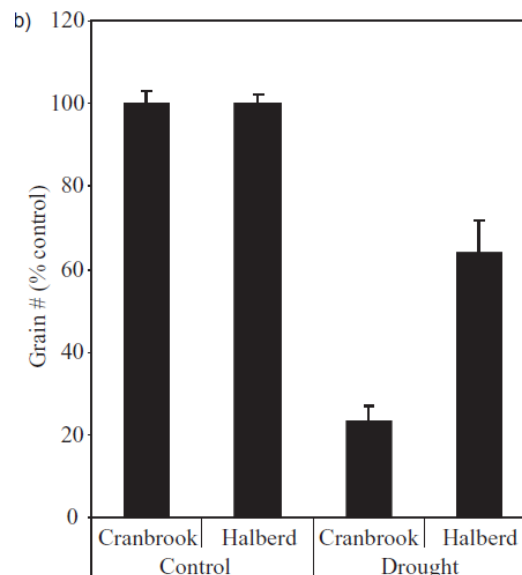
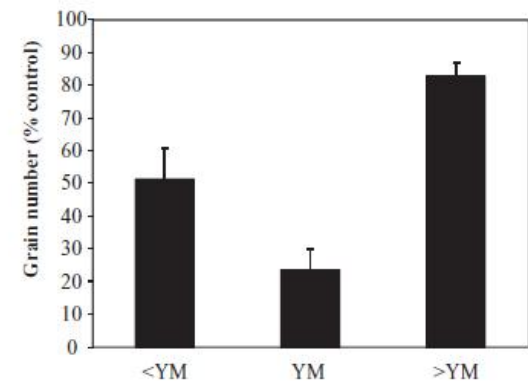
Yield stability under drought stress - ACPFG



Langridge 2011

Yield stability – maintenance of grain number

- Drought stress at anthesis = reduced grain size
- Drought stress at meiosis = abortion of pollen and reduced grain number
- Genetic variation for tolerance at YM stage exists



CSIRO PI

Ji et al 2010

Yield stability – maintenance of grain number

- Starch depletion in sensitive cultivar
  - ovary – reversible
  - anthers – irreversible

Tolerance =

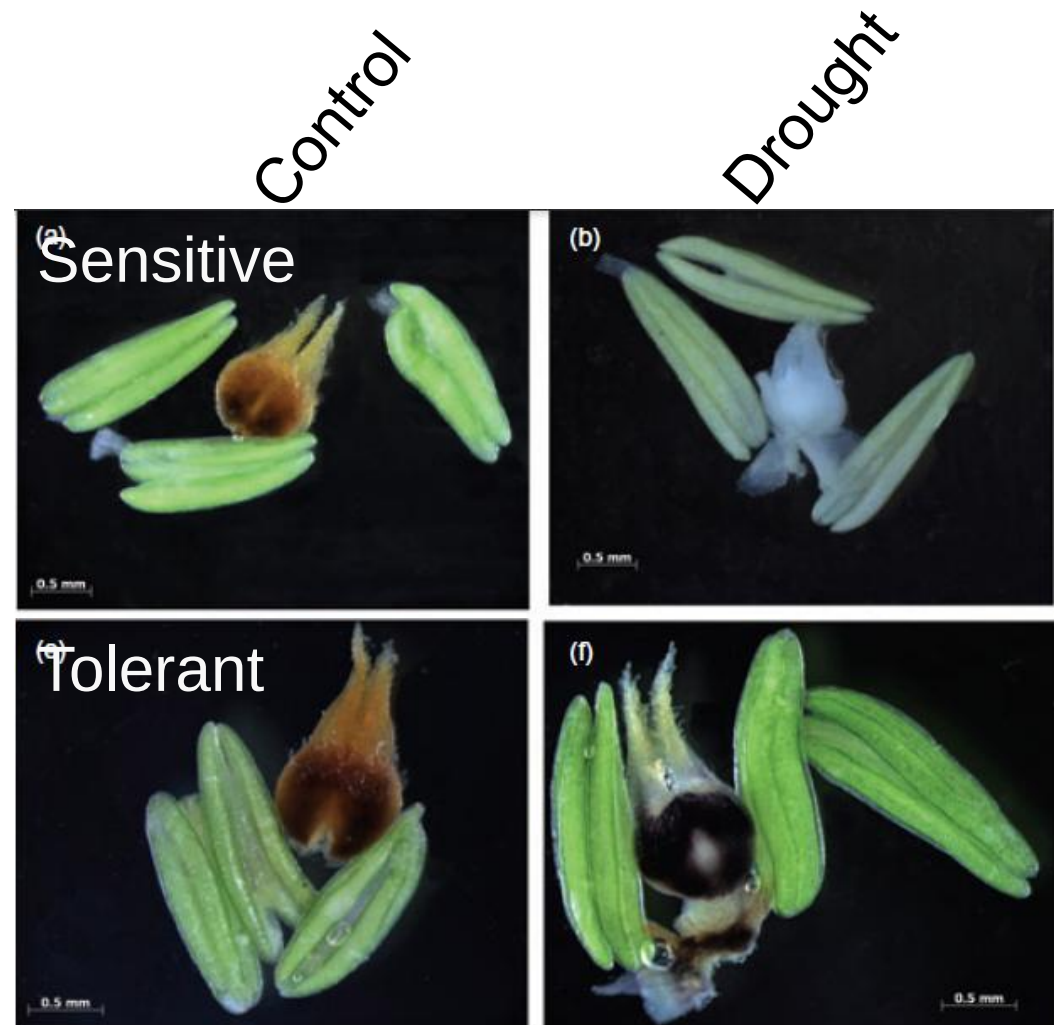
cell wall invertase gene
expression

fructan biosynthesis gene
expression

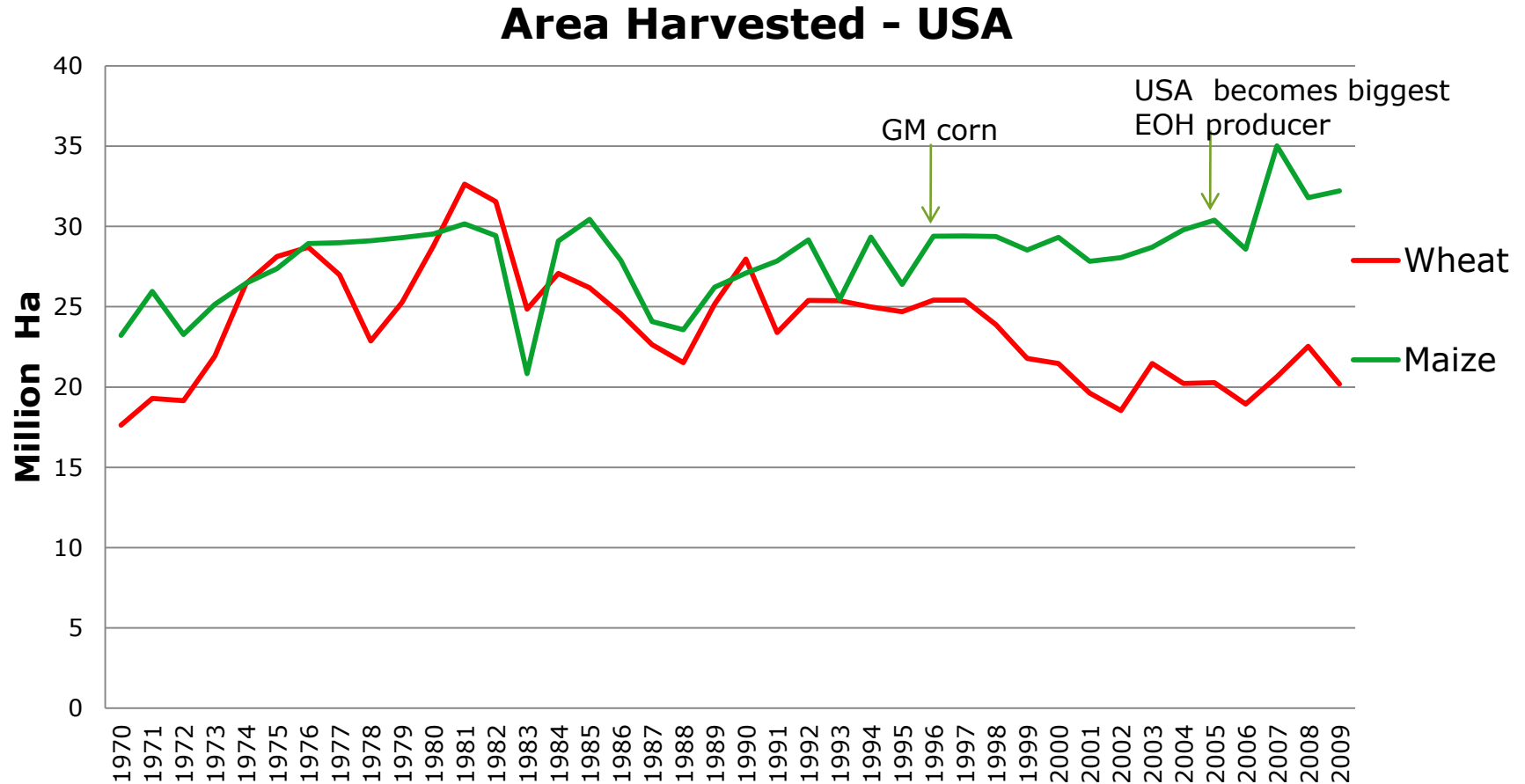
ability to maintain C supply to
anthers

**Similar results for salt and
cold**

**Broad abiotic stress
tolerance?**



More attractive cropping options



Attractive cropping options – disease resistance

➤ Wheat

- map-based cloning of wheat adult plant rust resistance genes
- reverse genetics development of *Rhizoctonia* resistance
- identification/map-based cloning of *Stagonospora nodorum* effectors genes and mapping of host receptor loci – sequencing fungal genome
- identification/map-based cloning of *Pyrenophora tritici-repentis* effectors genes and mapping of host receptor loci – sequencing fungal genome
- reverse genetics for identification of *Fusarium pseudograminearum* susceptibility genes – comparison of genomes of *Fusarium* strains

Attractive cropping options – disease resistance

➤ Barley

- map-based cloning of the scald *Rs1* resistance gene
- reverse genetics development of *Rhizoctonia* resistance
- Identification of the *P. teres teres* (net-form) and *P. teres maculata* (spot form) net-blotch pathogens and mapping of host receptor loci

➤ Canola

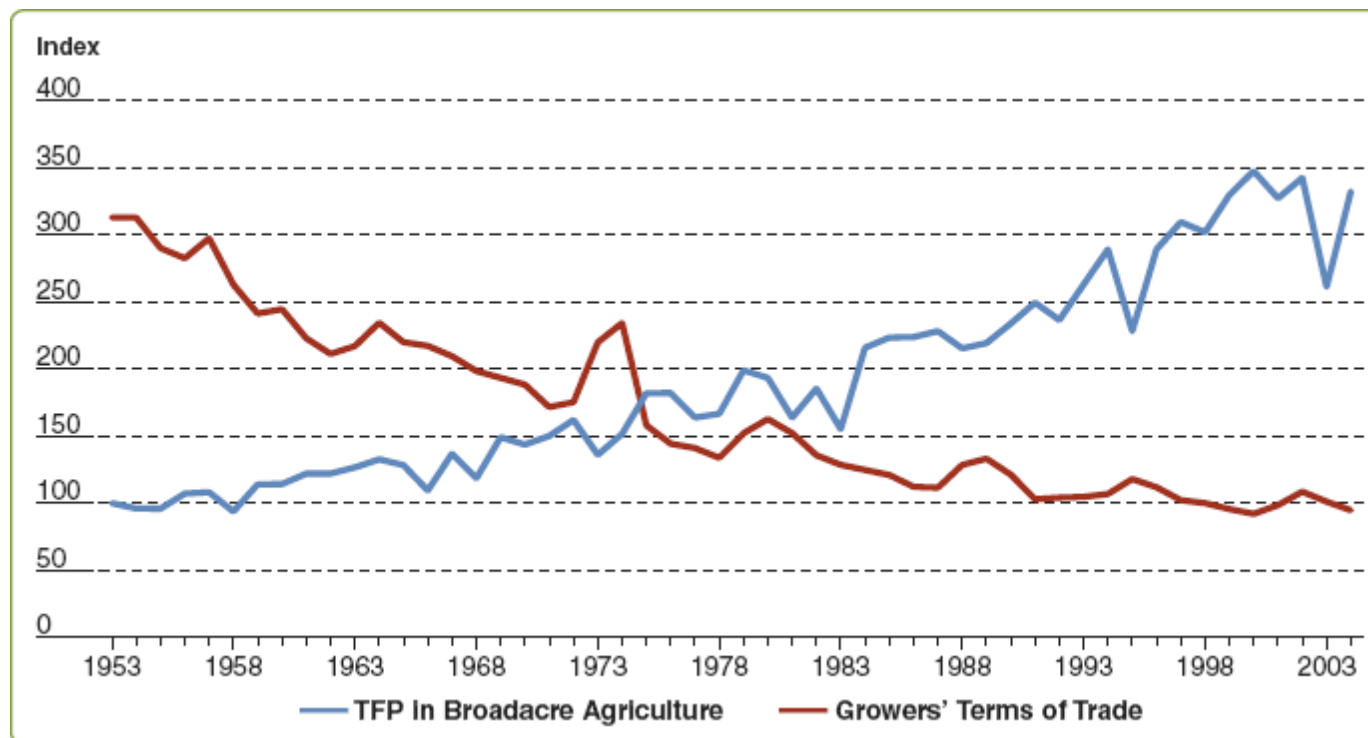
- Identification and cloning of the Blackleg resistance genes

➤ Lupin

- Identification/map-based cloning of anthracnose resistance genes (NLL genome sequencing)

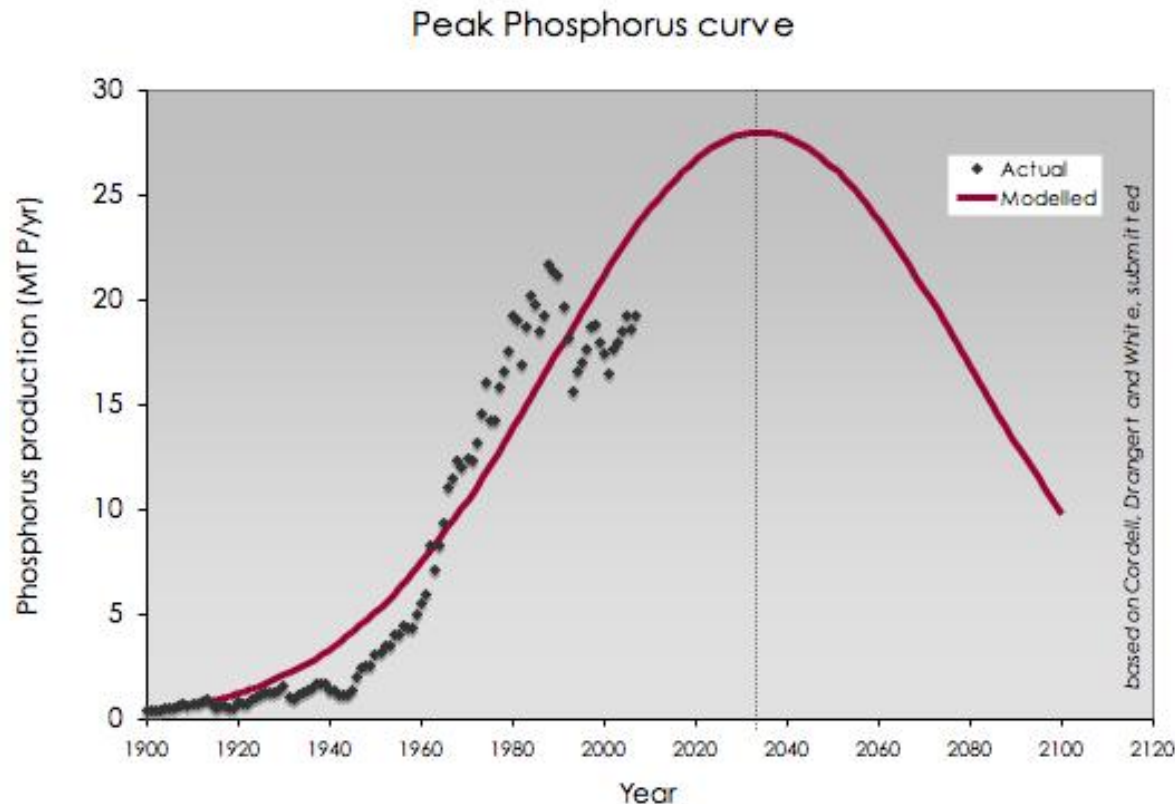
Reduced input costs

Total Factor Productivity (TFP) in Australian broadacre agriculture and growers' terms of trade, 1953-2003



Source: Mullen, JD & Crean, J 2007, *Productivity Growth in Australian Agriculture: Trends, Sources and Performance*, Research Report, Australian Farm Institute, Surry Hills, Australia.

Better use of fertilisers



- Global peak in phosphate rock reserves, estimated to occur in the next 30 years.
- Price for phosphate rock increased 700% within 14 months to June 2008

Source: Professor Stuart White¹ and Dr Dana Cordell "Peak Phosphorus: the sequel to Peak Oil", <http://phosphorusfutures.net/peak-phosphorus>, 2010

Better use of fertilisers - examples

Wheat and Barley

- GM

Nitrogen Use Efficiency (ACPFPG) – Alanine aminotransferase – 2011 field trials SA, WA, NSW and ACT

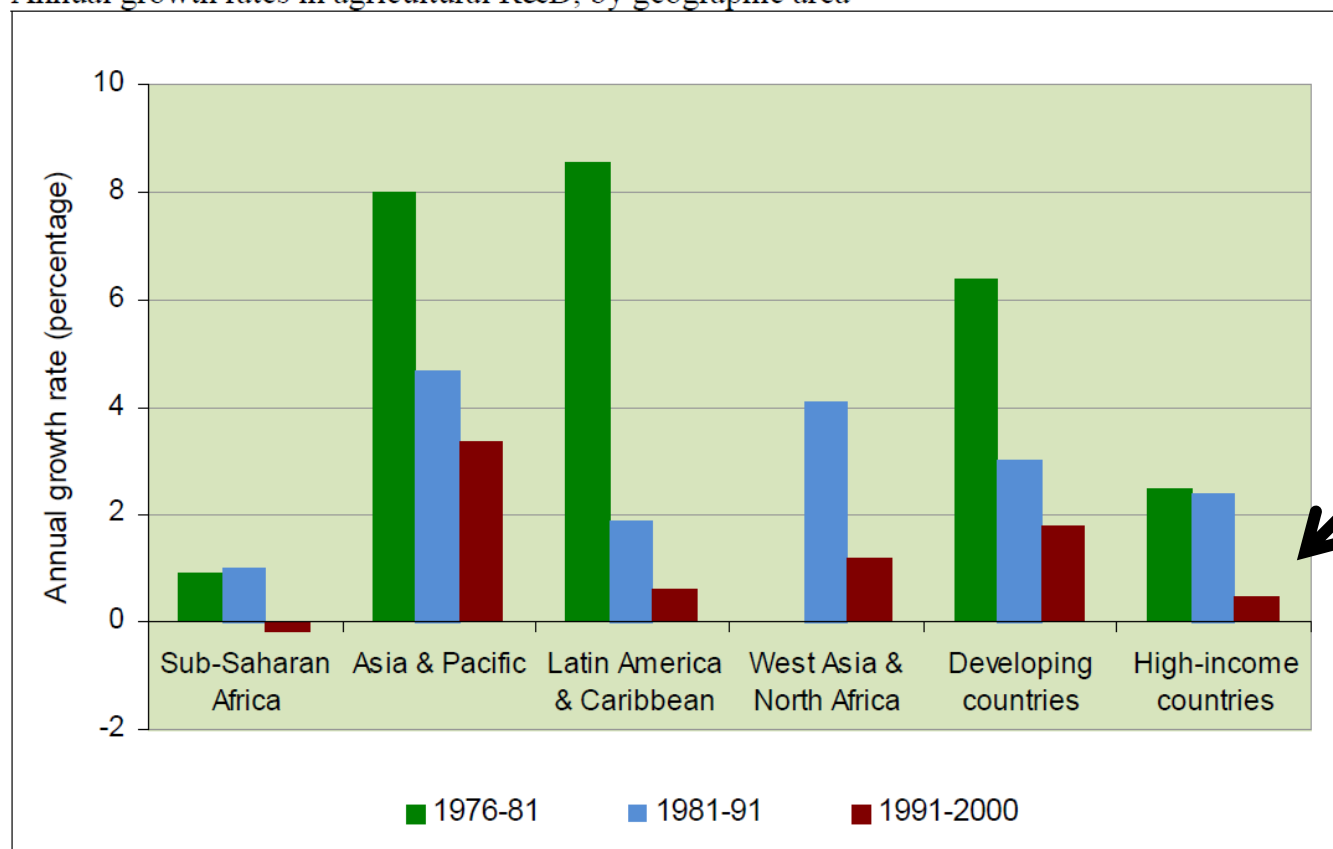
- Conventional

NUE and PUE (University of Adelaide and University of WA) – identification of genetic diversity for nutrient use efficiency in wheat and barley field screening - precursor to mapping population development, mapping and map-based cloning of NUE loci.

Agricultural R&D Investment

Globally investment in Agricultural R&D targeting productivity increases has been in decline for the past 20 years – Australia is no exception!

Annual growth rates in agricultural R&D, by geographic area



Source: Beintema and Elliott, 2009

Summary

Increased global demand
+
Reduced total agricultural R&D funding
+
Easier production gains have already been exploited
+
Challenging production environment outlook
+
Data intensive new technologies
=
Industry must maximise effectiveness of its investment
and ensure fit to target production environment

**Ensure best experimental design, analysis and
interpretation of R&D outputs**

Drought – Managed Environment Facilities

