Meeting the productivity and sustainability challenges to Australian agriculture

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Global challenges

• Raising agricultural productivity to ensure global food security

• Reducing greenhouse gas emissions to ensure climate security

• Adapting to unavoidable climate change

• Protecting the environment
Demand for global food production - 8 billion people in 2050

Food production demand in 2000-2050 as % of food production during 1500-2000

The demand for global food production over the period 1500 to 2050 for additive scenarios. Global food production demand is an estimate (in Petacal) of the food production demand driven by population growth and consumption increases associated with economic development. Some scenarios also include a food production demand equivalent associated with either food or land diversion to biofuels and post-harvest wastage. Citation: C beating et al 2010 (in review).
Demand for global food production
- 9 billion people in 2050

The demand for global food production over the period 1500 to 2050 for additive scenarios.

Global food production demand is an estimate (in Petacal) of the food production demand driven by population growth and consumption increases associated with economic development. Some scenarios also include a food production demand equivalent associated with either food or land diversion to biofuels and post-harvest wastage. Citation: Keating et al. 2010 (in review).
Demand for global food production
- Increased consumption in developing countries

The demand for global food production over the period 1500 to 2050 for additive scenarios.

- UN current population growth (8 B)
- UN medium population growth (9 B)
- Consumption increase in developing countries

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Demand for global food production - 6% biofuel diversion by 2050

The demand for global food production over the period 1500 to 2050 for additive scenarios. Global food production demand is an estimate (in Petacal) of the food production demand driven by population growth and consumption increases associated with economic development. Some scenarios also include a food production demand equivalent associated with either food or land diversion to biofuels and post-harvest wastage. Citation: Keating et al. 2010 (in review).
Demand for global food production - 12% biofuel diversion by 2050

The demand for global food production over the period 1500 to 2050 for additive scenarios. Global food production demand is an estimate (in Petacal) of the food production demand driven by population growth and consumption increases associated with economic development. Some scenarios also include a food production demand equivalent associated with either food or land diversion to biofuels and post-harvest wastage. Citation: Keating et al. 2010 (in review).
Demand for global food production - 20% post-harvest losses

The demand for global food production over the period 1500 to 2050 for additive scenarios. Global food production demand is an estimate (in Petacal) of the food production demand driven by population growth and consumption increases associated with economic development. Some scenarios also include a food production demand equivalent associated with either food or land diversion to biofuels and post-harvest wastage. Citation: Keating et al 2010 (in review).
Demand for global food production
Global yield and agricultural productivity growth rates, percent per year for 1961 to 2007. Yield is measured as metric tons per hectare. Labour and land productivity are total agricultural output per agricultural worker and agricultural area.
Total factor productivity growth in Australia’s cropping industries (ABARE)

Nossal and Sheng, 2010. ABARE
Food price index

World Food Situation

Food Price Indices

June 2010

FAO Food Price Index

Food Commodity Price Indices

For a world without hunger

National Research Flagships
Sustainable Agriculture

CSIRO

FAO Home
World Food Situation
FAO Initiative on Soaring Food Prices
How will increased production be achieved?

• Protecting existing productivity against emerging threats
  • Land degradations
  • Pests and disease

• Closing the yield gap in existing farming systems?

• Increasing intensity of cropping on existing arable lands?

• Creating new arable lands on existing grasslands or forestlands?

• Raising yield potential through “break-through” technologies?

Percent of obtainable yield estimated for selected African, Asian and Middle Eastern countries (CAWMA, 2007).
Crop intensification in southern Bangladesh

- Lands fallow because few tube wells for irrigation; hot & saline environment
- But some surface water at start of rabi (dry) season
- 5 yrs trials show irrigated wheat yields = 4t/ha; dryland yields 2t/ha
- Modelling suggests good prospects but with agronomy changes
- Widespread adoption of wheat
Investment framework

Production v’s investment ($)

Production – input responses


Developed by CSIRO & GRDC

Investment framework map current grower performance

- **H** = Environmental potential
- **G** = Maximum marginal return
- **A** = Region’s best growers
- **B** = Underperforming growers
- **C** = Risk-adverse growers

Efficiency Frontier

Current frontier
Pathway 1: Improve the agronomic performance of growers

- Increase the number of growers performing close to industry best practices
- Source of traditional productivity improvement for industry over many years
- Better uptake and exploitation of technology that are currently available
- Requires both confronting with evidence of inefficiencies and access to better agronomic advice

Diagram:
- Point A: Current frontier of productivity improvement
- Point B: Potential for increased productivity
- Point C: Current expenditure on inputs

Expenditure on inputs ($) vs. Production ($)
Pathway 2: Encourage growers to adopt risk management practices

- Encourage growers to move along the current efficiency frontier to higher returns whilst addressing the added risks.
- Need to be convinced that the increased investment justifies higher risk exposure.
- Achieved through growers accessing farm business management.
- Decision support for managing climate variability and risk.
Pathway 3: Increase efficiencies of resource use

- Create new efficiency frontiers which generate similar returns for less investment and risk.
- Increasingly more efficient resource use is a mainstay of agriculture’s response to the cost-price squeeze.
- Technologies can be both agronomic (eg. precision agriculture) or varietial (eg. phosphorus-efficient cultivars).
Pathway 4: Create new production frontiers

- Agricultural productivity continues to rise as new genetics and technologies are adopted.
- Discover the practices that will result in the next step-change in productivity and profitability.
- Create new efficiency frontiers by increasing the production potential (Point H → I).
- Likely evolve from the synergies between novel plant genetics and innovative management technologies.
- Requires strong investment in Research.

The graph shows a relationship between expenditure on inputs ($\text{Expenditure on inputs ($)}$) and production ($\text{Production ($)}$) with two curves: current frontier and yield increasing. The points D, A, H, and I indicate different stages of productivity and profitability.
Pathway 5: Maintain current production potential

- Protect against any loss of current production systems
- Preventing any breakdown in existing disease, weed or pest management strategies
- Maintaining facilities to rapidly respond to future outbreaks of exotic disease, weeds or pest
- Avoid practices which threaten the natural resource base for agriculture eg. soil salinity, acidification and nutrient rundown
Performance of Yield Prophet farmers

www.yieldprophet.com.au

- Internet-based subscriber system to predict current wheat yields and management response using APSIM

- Observed data for 334 commercial wheat crops monitored nationally between 2004-07
Yield Prophet crops (334) – relative yield v’s relative input investment

![Graph showing relative yield versus relative input investment with percentages marked at 16%, 48%, 23%, and 13%.]
Increase production through improved practices
New technologies needed to improve performance

64%
Australian national wheat yield trends

Angus (2009); Fischer (2009)
Conservation agriculture

Glenn Fretwell, Lake Varley, Western Australia 2003
No-till adoption across Australian cropping regions

Llewellyn et al 2009
Future technologies

Climate risk management
Canopy management
Precision agriculture
Dual purpose crops
Automation & robotics
ICT in agriculture

2010 - 2030

GM crops
Harnessing GxE
Value chain dividends
New commodities

Output

Risk

Soil biology
Farm rationalisation
Efficient irrigated agriculture
GM crops

- The adoptions of transgenics is on the rise, except in Europe and Africa.

- Bt cotton is having a positive impact on yields, profits and reduced chemical inputs in India, China, Argentina, Mexico.

- Impacts on global food security less clear.
Understanding

Synergies of new genetics in modern farming systems

- Soil structure and rhizosphere biology can limit yield in modern intensive no-till wheat by 20%.
- Varieties differ in sensitivity to these factors.
- New root genetics related to vigour and exudates can minimise these effects.
- Synergies of new root genetics with precision placement of root systems and inputs offer efficiency and productivity gains.

Farming systems

Lab Tilled No-till

Productivity constraints in modern, no-till intensive wheat of 20% are related to structural and biological constraints to roots in these systems.
Adoption of PA by Australian grain growers

- Use of guidance widespread and growing rapidly
- Adoption of VRT 20% (up from 5% in 5 years)
- Appreciate and manage paddock variability (2/3 growers)
- Adopters - educated, have consultant, large farm, more crop
- 70% yield monitor but < half of these map
- Few other data sources are used

Robertson et al 2010
### What is holding you back in PA? (WA Study)

<table>
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<th>Central</th>
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<td>Inexperienced workers</td>
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<tr>
<td>Reliability</td>
<td>-</td>
<td>4</td>
<td>-</td>
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</tbody>
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*Robertson et al 2010*
Climate risk management

www.yieldprophet.com.au
ICT in Agriculture – “virtual fencing”

Sensor networks:
- Gather information about an environment or system at a level of spatial and temporal detail not previously available
- Provide industry tools e.g. virtual fencing
- Link science and application
- Built around multi-disciplinary teams
- Address system goals e.g. nutrient fluxes

System control e.g. virtual fencing

Remote sensing linked to ground based sensors

Low bandwidth cameras

Soil sensors

Integrated sensors enabling systems optimisation
Improved irrigation water use efficiency

- Returns on use of irrigation water supplies can be increased significantly
- Whole farm decision making – managing in face of uncertainty in allocations
- Research at the paddock scale
  - Measuring devices and systems to help
  - Infrastructure investment decisions
  - Simple water balance programs
  - Control of storage evaporation
  - Improved rainfall infiltration
  - Soil characterisation for PAWC
- Degradable polymer film
New commodities or regions – high rainfall zone (HRZ)

Growing season: > 9 months
Total area: 32 Mha
Area for farming: 20 Mha
Arable area: 2-6 Mha

Requires adapted varieties and soil management techniques

<table>
<thead>
<tr>
<th>Region</th>
<th>Area (ha)</th>
<th>Average Yield (t/ha)</th>
<th>Potential Yield (t/ha)</th>
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<tbody>
<tr>
<td>NSW</td>
<td>900,000 +</td>
<td>2.5</td>
<td>5-10</td>
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<td>2.5</td>
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<td>Tas</td>
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<td>2.5</td>
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<tr>
<td>SA</td>
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<tr>
<td>WA</td>
<td>1,400,000 +</td>
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<td>4-10</td>
</tr>
</tbody>
</table>
Soil carbon sequestration

- Reviewed available trial data on soil C change in response to management
  - Reports data for 96 trials and/or treatments across Australia
- Rates of soil C change with “C friendly” management
  - Within cropping or grazing management in range 0.1 to 0.3 Mg C ha\(^{-1}\) yr\(^{-1}\)
  - Conversion of cultivation to permanent pasture in range 0.5 to 0.6 Mg C ha\(^{-1}\) yr\(^{-1}\)
- Many current systems are still running soil C down so some “C friendly” practices simply reduce this rundown rate

Available at http://www.csiro.au/resources/Soil-Carbon-Sequestration-Potential-Key-Findings.html
Our track record is impressive …. 

- Agriculture developed over 10,000 years ago
  - Domestication of crops & livestock

- 1st Agricultural Revolution 1750 to 1850
  - Co-evolved with the industrial revolution in Europe
  - Development of animal traction and improved agronomy

- 2nd Agricultural Revolution 1950 to 2000
  - Doubling of global production
  - Underpinned by cheap fossil fuels for mechanisation and fertilisation
  - Rapid gains due to systematic plant breeding combined with expansion of land, water, nutrient and energy usage
  - BUT - Massive greenhouse load on atmosphere
….. our task ahead is critical.

- **3rd Agricultural Revolution 2000 to 2050 ??**
  - To double food and fibre production from current land, water, nutrient and energy inputs with much reduced greenhouse gas outputs
  - Will need a revolution in “resource use efficiency”

- **21st Century Agronomy will be;**
  - Integrative and predictive systems science
  - Linked to climate and atmospheric science, ecological science, social and economic science
  - Delivered through policy development for government alongside traditional links with landholders and industry
Thank you