Innovation in Australian agriculture benefits world agriculture … and vice versa

Peter Carberry
A rising perfect storm

Climate change
Land degradation
Loss of biodiversity
Food crisis
Energy crisis
Population explosion
Food aid will help buy peace

JOHN ANDERSON
The Australian  |  12:00AM February 23, 2017

The correlation between food security and national security is a direct one, as recent history shows. And agricultural aid is aid that works for the benefit of developing countries as well as Australia. Yet globally there has been a dangerous trend from overseas development assistance to agriculture.

One of the most important contributions to sustainability at a time of increased instability is to help to feed a world population set to hit 9.5 billion within 20 years. The key to increasing food security is food aid.

And when a government formulates its white paper on foreign policy, which it is doing now, it should take account of the impact of food security science. Beyond making us a good global citizen, supporting agricultural research for food security provides Australia with benefits worth more than we spend on it through our aid program.
A personal perspective

- Born on a farm at Narrabri, NSW
- Agricultural Science at Sydney Uni
- Decision point in 1982 … farmer or scientist?
- PhD study 1982-83 at ICRISAT, India
- Joined CSIRO in 1986
- Joined ICRISAT in 2015
ABOUT ICRISAT

We believe all people have a right to nutritious food and a better livelihood.

Our Vision
A prosperous, food secure and resilient dryland tropics

Our Mission

Overcoming Poverty  
Overcoming Hunger  
Reducing Malnutrition  
Preventing Environmental Degradation
Covers 6.5 million sq. km. of which 644 million are the poorest of the poor

Across 55 countries

2 billion people
ICRISAT’s mandate crops

Critical for SAT agriculture

- Chickpea
- Groundnut (Peanut)
- Pigeonpea
- Sorghum
- Pearl millet
- Finger millet
- Foxtail millet
- Kodo millet
- Little millet
- Proso millet
- Barnyard millet
- Little millet
- Proso millet
- Barnyard millet

Minor millets
Smart Food

Good for you - the planet - the farmer

✓ Highly nutritious
✓ Environmentally friendly
✓ Climate smart - resilient under extreme weather conditions
✓ Significant yield gap
✓ Good opportunities to diversify both diets and on-farm
✓ Untapped demand and uses
**Crop germplasm at ICRISAT genebank**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Conserved #</th>
<th>Conserved Countries</th>
<th>Distributed #</th>
<th>Distributed Countries</th>
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<tbody>
<tr>
<td>Sorghum</td>
<td>39,923</td>
<td>93</td>
<td>509,661</td>
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<tr>
<td>Pearl millet</td>
<td>23,092</td>
<td>52</td>
<td>155,534</td>
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<td>Chickpea</td>
<td>20,602</td>
<td>59</td>
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<td>Pigeonpea</td>
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<td>161,453</td>
<td>113</td>
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<td>Groundnut</td>
<td>15,446</td>
<td>92</td>
<td>200,576</td>
<td>96</td>
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<tr>
<td>Finger millet</td>
<td>7,186</td>
<td>25</td>
<td>43,713</td>
<td>54</td>
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<tr>
<td>Small millets</td>
<td>4,278</td>
<td>39</td>
<td>33,464</td>
<td>55</td>
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<td><strong>Total</strong></td>
<td><strong>124,305</strong></td>
<td><strong>144</strong></td>
<td><strong>1,451,587</strong></td>
<td><strong>148</strong></td>
</tr>
</tbody>
</table>
ICRISAT germplasm deposited at Global Seed Vault at Svalbard, Norway

- ICRISAT deposited 110,818 samples by 2015

- Total at Svalbard – 851,596 samples of 5,253 species from 233 countries and 66 institutes
ICRISAT germplasm and Australia

• The ICRISAT genebank collection includes
  – 279 accessions originating from Australia
  – 335 accessions donated by Australia

• A total of 3840 germplasm seed samples provided to various research organizations (92 shipments) in Australia

  – **Major users:** Australian Temperate Field Crops Collection, CSIRO, Queensland Department of Primary Industries, The University of Sydney, University of Queensland, University of Tasmania, SARDI, Pacific Seeds and Valley Seeds Australia.
ICRISAT-Australia partnership in chickpea breeding

- Three chickpea varieties (Heera, Sona, Genesis 836) directly released in Australia.
- ICRISAT has so far supplied 5528 breeding lines to Australia.
- ICRISAT made 279 crosses under this project and supplied 3137 ascochyta blight resistant promising lines to Australia.
- The breeding materials developed under this project also benefitted India and other developing countries, particularly in developing machine harvestable varieties.
95% of chickpea area under short-duration varieties developed from ICRISAT-bred lines in Southern India (AP & Telangana) and Myanmar.

During the period of 15 years (1999-2013), chickpea production increased 5.8-fold in southern India and 7.2-fold in Myanmar.
Harnessing variations through translational genomics approaches
Over 50 traits mapped

Drought tolerance
Root traits- root length density, root length, root surface area
Yield, harvest index, 100-seed weight, number pods per plant, biomass, specific leaf area, delta carbon ratio, days to flowering, days to maturity

Heat tolerance
Pods per plant, heat tolerance index, yield, biomass, harvest index, days to flowering, days to maturity

Salinity tolerance
Pod number, seed number, seed yield, Shoot dry weight, harvest index 100 seed weight

Ascochyta blight
Seedling resistance and adult plant resistance

Helicoverpa
Leaf damage rating (flowering), Unit larval weight, Helicoverpa larvae/10 plants, Days to first flowering

Fusarium wilt, Botrytis grey mould, Protein content
Climate variability makes dryland agriculture risky

Actual farm data – southern Mallee farm (5200ha), 80% crop and 20% livestock (by area)
Costs: Inputs, Machinery, Labour and Financial
Data courtesy of Harm van Rees (CropFacts)
Kenya: 20 seasons of crop yield

Maize grain (t/ha)

- Trt A: Bare fallow
- Trt B: Traditional (22K, 0N)
- Trt C: Intercrop (22K + beans)
- Trt D: 22K + 50% mulch
- Trt E: 53K, 70N & P + excess mulch
- Trt F: as E with reduced tillage
- Trt G: 53K, 100N & P + full mulch

Increasing investment
Drought ... but what can be done?
1. Breeding for drought

... attributes of plants that make them restrict water losses under high vapour-pressure deficits ... opens new possibilities for achieving genetic gains via breeding focused on this trait. Last but not least, small amounts of water used in specific periods of the crop cycle, such as during grain filling, may be critical.
Staygreen sorghum in Australia

Courtesy: David Jordan

4% per year
Plant traits – shift water extraction from pre- to post anthesis

Days after sowing
Less water extraction at vegetative stage, more for grain filling

Zaman-Allah et al 2011
Borrell et al 2014
Vadez et al 2013
Staygreen – post-rainy season sorghum in India

Test effects of a smaller leaf area (e.g.: Introgression of Stg3A / Stg3B QTLs)

Trade-off between grain and stover yield

Kholová et al. 2014 (FPB)
Conservation agriculture – a “new” energy, water and machinery system that took 40 years of development & adoption

Rick Llewellyn and Frank d’Emden (2009) Adoption of no-till cropping practices in Australian grain growing regions. GRDC report
3. Managing for drought – seasonal climate forecasting

Southern Oscillation Index (SOI) and global rainfall forecast


Climate outlooks – monthly and seasonal

Issued: 23 February 2017 – Next issue: 30 March 2017

Climate outlook overview

- Autumn (March to May) rainfall is likely to be below average over the southern two-thirds of Australia.
- March is likely to be hotter and drier than average across most of Australia, except the far north and west.
- Warmer autumn days and nights are likely across most of Australia, except northwest Australia where days and nights are likely to be cooler than average.
4. Managing for drought – soil water management

Effect of variations in PAW and seeding opportunity on percentage of modelled yields in Mallee, South Australia

- **At sowing**
  - Low SW
    - Low PAW (>38 mm)
    - Mod PAW (38-78 mm)
    - High PAW (>78 mm)
  - Moderate SW
    - Low PAW (>38 mm)
    - Mod PAW (38-78 mm)
    - High PAW (>78 mm)
  - High SW
    - Low PAW (>38 mm)
    - Mod PAW (38-78 mm)
    - High PAW (>78 mm)

- **Planting opportunity**: Early, Late

Upper tercile (white)
Middle tercile (grey)
Lower tercile (black)

Whitbread et al
5. Managing for drought – Decision support

Yield Prophet

- Joint initiative of BCG and CSIRO
- Commercial subscription service
- Provides reports on yield probability, crop & soil status, impacts of management

Yield Prophet is based on yield probability functions as simulated in the APSIM computer model (www.APSIM.info). For these modelled outputs APSIM uses the conditions which were entered in the paddock-specific Yield Prophet data entry screens. The Yield Prophet can not take into account weed competition, disease/mosquito pressure, pesticide damage or adverse weather conditions such as frost. The Yield Prophet assumes good agronomic management in relation to outside influences on crop growth.
Mallee farmers invested in their crops in 2011 despite a decile 2 (very dry) season

- Characterisation of soils for water holding capacity
- Regular monitoring to determine the state of soil water and nitrogen
- Conserving soil moisture through conservation tillage and weed control
- Use of decision support to help make investment decisions
- Seasonal climate forecasting
Agricultural Production Systems Simulator (APSIM)  www.apsim.info

The soil provides a central focus, crops, seasons and managers come and go, finding the soil in one state and leaving it in another

Simulates:

✓ mechanistic growth of crops, pastures, trees, weeds ...
✓ dynamics of populations (eg. weed seedbank)
✓ key soil processes (water, solutes, N, P, carbon, pH)
✓ surface residue dynamics & erosion
✓ dryland or irrigated systems
✓ range of management options
✓ crop rotations + fallowing + mixtures
✓ short or long term effects
✓ one or two (multi-point) dimensions
✓ high software engineering standards
✓ language independent (VENSIM™ module maker)
✓ now includes pests nor diseases
✓ links to livestock modules
What next for Australian farmers?

Smart Farm Enterprise

Remote Expert Services
- Agronomist
- Modeling

Remote Sensing / Weather Services
- MODIS
- BOM

Market / Transport Services
- Futures
- Logistics

Cloud Provider

Internet

Farm Enterprise
- Crop sensing
- Animal sensing
- Pasture Mapping
- Soil Carbon Monitor
- Ag Robotics

Alex Zelinsky, CSIRO
Digital technologies have the power to overcome physical barriers and democratize information.

Mobile Phones are ubiquitous devices that are entry points for farmers to digital services.

Mobile devices provide the last mile connectivity and first mile of reconnaissance of information for farmers.
New App Promises to Tell Indian Farmers When to Sow Crops

Farmers in Andhra Pradesh can sign up for an app that shows them the weather and prime planting days

By Vibhuti Agarwal
Jun 17, 2016 5:00 pm IST

Monsoon season in India has just begun, but farmers in Andhra Pradesh, a southeastern coastal state of India, won’t need to look to the skies to know when to sow their crops. A new mobile application launch earlier this month and developed by a local agricultural research institute, Microsoft India and the state government...
Conclusions

• Australian dryland farming systems have evolved to address climate risks
• Australian farmers and Australian agricultural research are a major source of innovation in dryland farming
• The world’s poor smallholder farmers of the dryland semi-arid tropics need to also benefit from these innovations
• Agricultural science is a great career and an essential investment for our future