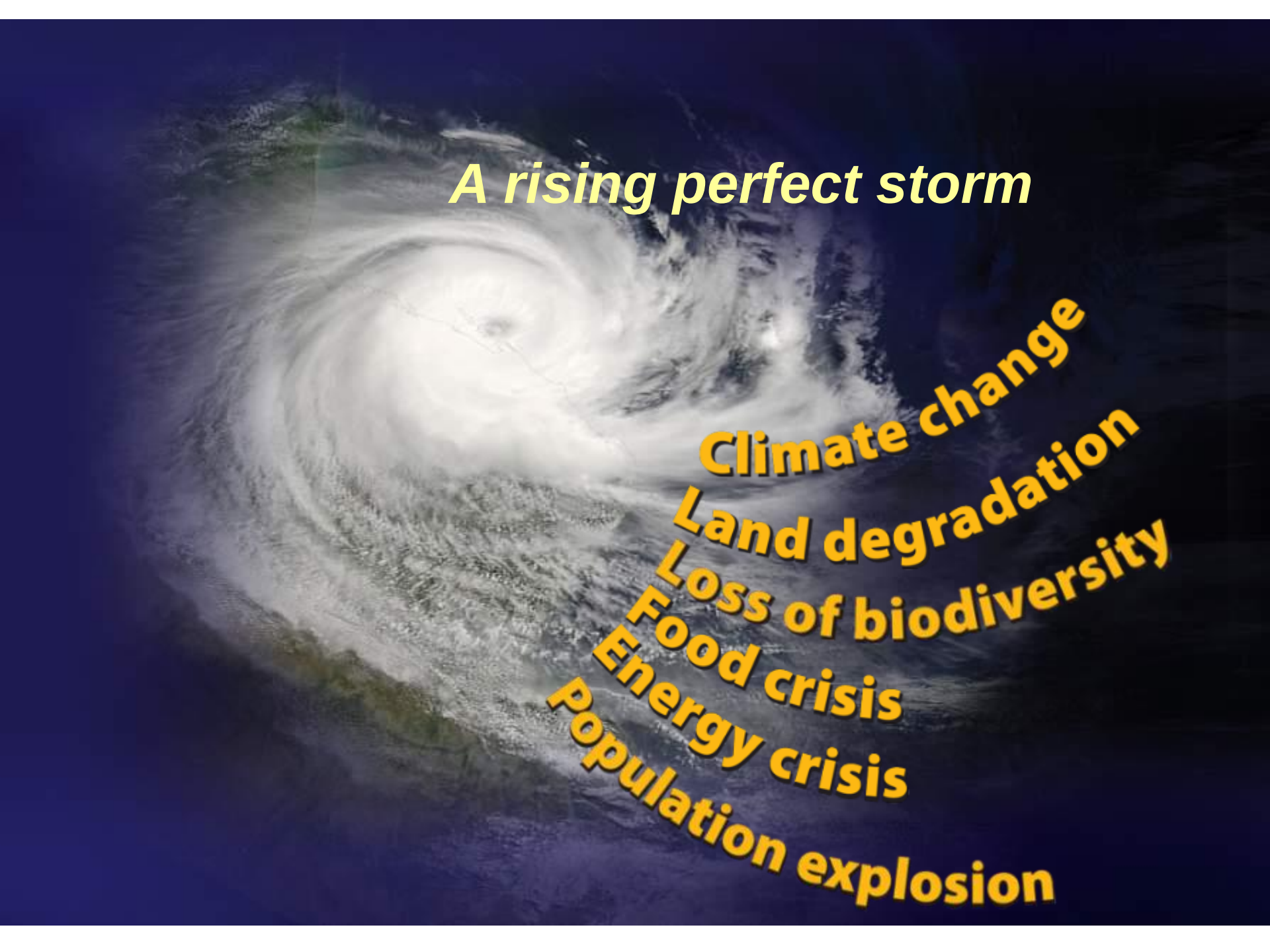
Innovation in Australian agriculture benefits world agriculture

… and vice versa

Peter Carberry

ICRISAT INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS


A rising perfect storm
Climate change
Land degradation
Loss of biodiversity
Food crisis
Energy crisis
Population explosion

THE AUSTRALIAN
FOR THE INFORMED AUSTRALIAN

OPINION

Food aid will help buy peace

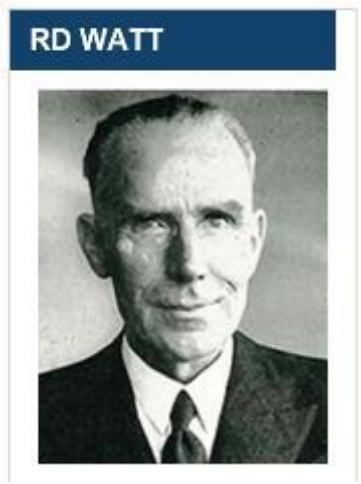
JOHN ANDERSON
The Australian | 12:00AM February 23, 2017

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 contribution sustainability at a time of help to feed

And account of the impact of food security scien ment formulating its white paper on foreign policy, which foreign aid. This is our opportunity to more sharply focus on food security and tap the skills, experience and expertise of the Australian agriculture

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.



The annual RD Watt Lecture commemorates the first lecture delivered to University of Sydney agriculture students in March 1911 by Australia's first Professor of Agriculture, Robert Dickie Watt

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

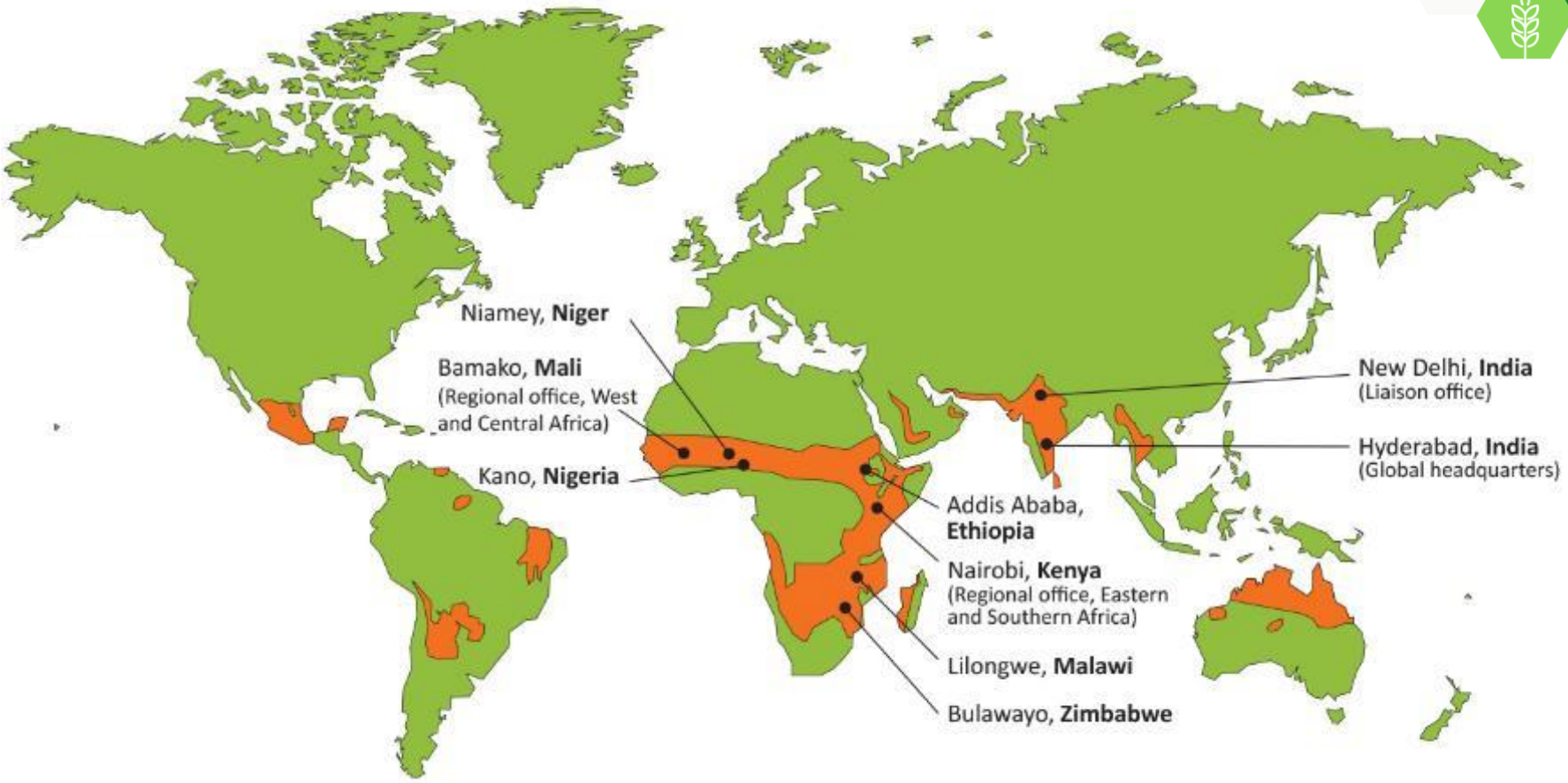
A prosperous, food secure and resilient dryland tropics

Our Mission

- Overcoming Poverty
- Overcoming Hunger
- Reducing Malnutrition
- Preventing Environmental Degradation

ICRISAT | International Crops Research Institute for the Semi-Arid Tropics

ICRISAT locations in the semi-arid tropics



Covers **6.5 million** sq. km.

Across **55** countries

2 billion people

of which **644 million**

are the poorest of the poor

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

Minor millets

smart food

Good for you - the planet - the farmer

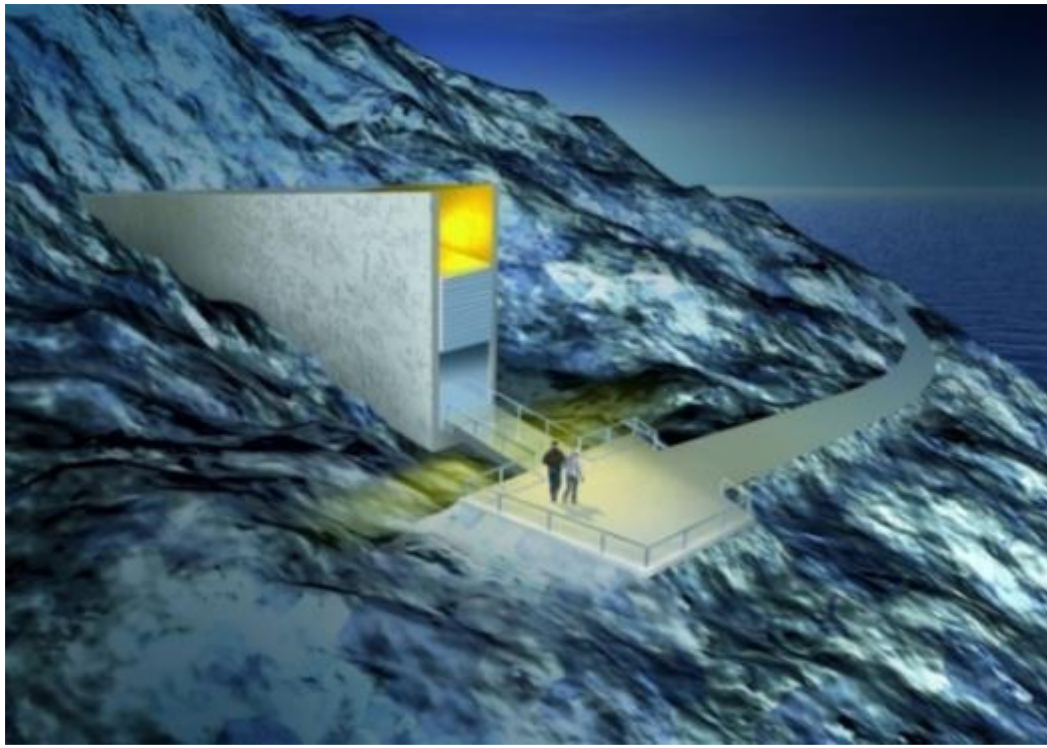
- ✓**Highly nutritious**
- ✓**Environmentally friendly**
- ✓**Climate smart** – resilient under extreme weather conditions
- ✓Significant **yield gap**
- ✓Good opportunities to **diversify** both diets and on-farm
- ✓**Untapped demand** and uses

Crop germplasm at ICRISAT genebank

Crop	Conserved		Distributed	
	#	Countries	#	Countries
Sorghum	39,923	93	509,661	110
Pearl millet	23,092	52	155,534	81
Chickpea	20,602	59	347,186	88
Pigeonpea	13,778	74	161,453	113
Groundnut	15,446	92	200,576	96
Finger millet	7,186	25	43,713	54
Small millets	4,278	39	33,464	55
Total	124,305	144	1,451,587	148

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

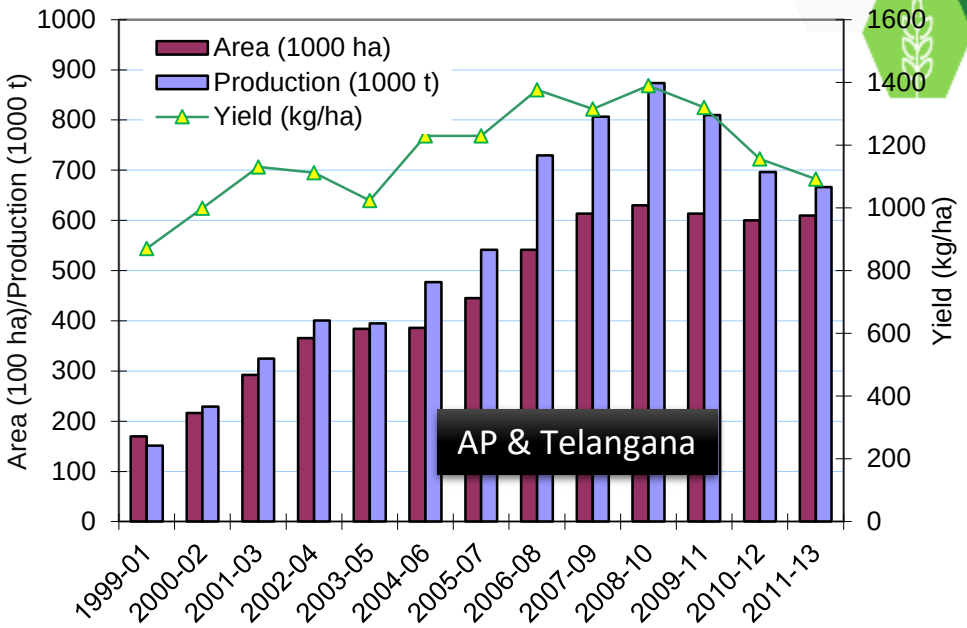
- The ICRISAT genebank collection includes
  - 279 accessions originating from Australia
  - 335 accessions donated by Australia
- A total of 3840 germplasm seed samples provided to various research organizations (92 shipments) in Australia
  - **Major users:** Australian Temperate Field Crops Collection, CSIRO, Queensland Department of Primary Industries, The University of Sydney, University of Queensland, University of Tasmania, SARDI, Pacific Seeds and Valley Seeds Australia.

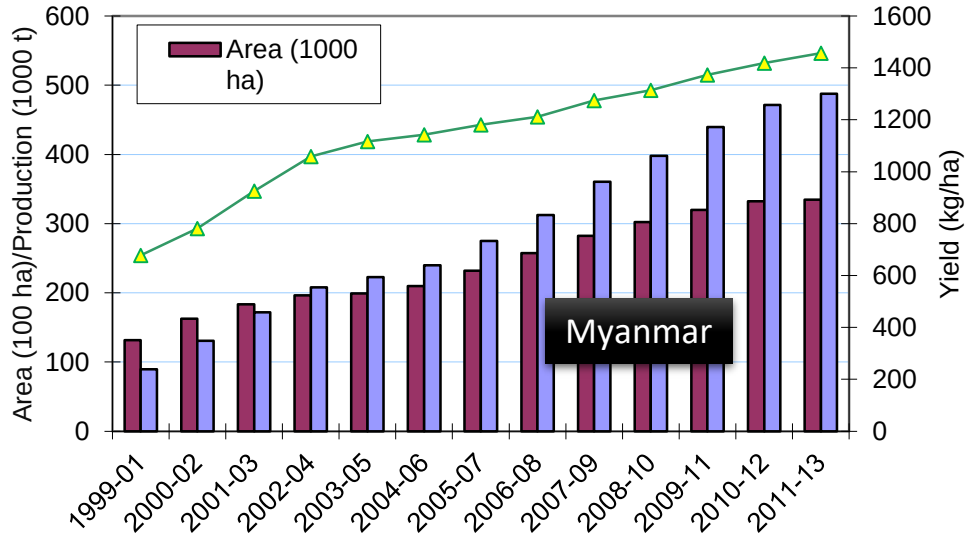
ICRISAT-Australia partnership in chickpea breeding

- Three chickpea varieties (Heera, Sona, Genesis 836) directly released in Australia
- ICRISAT has so far supplied 5528 breeding lines to Australia.
- ICRISAT, DAFWA, UWA/CLIMA workproject "**Accelerated Genetic Improvement of Chickpea**" during 2005 to 2010.
- 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.

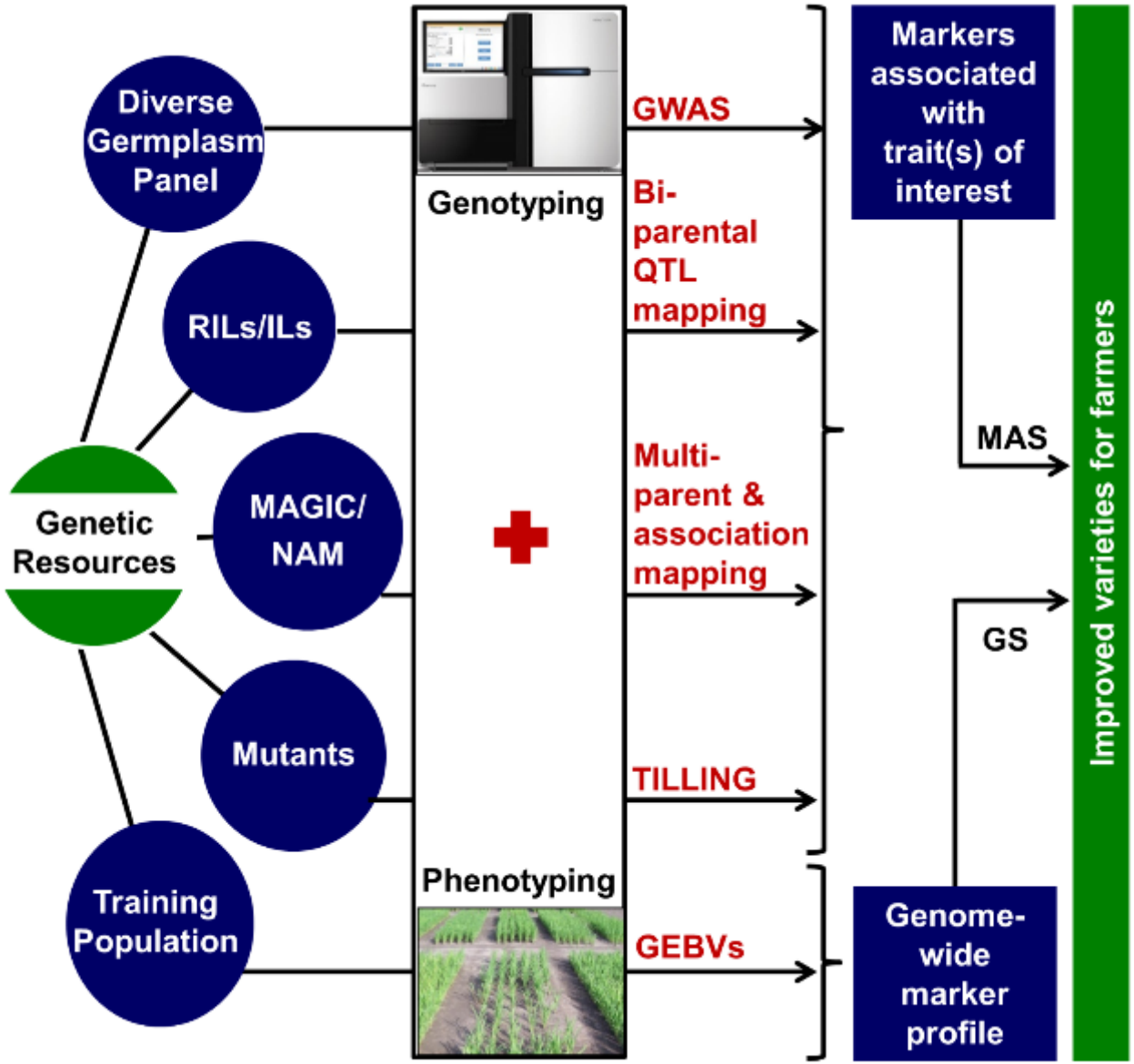
Impacts of short-duration chickpea varieties in Southern India & Myanmar

- 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





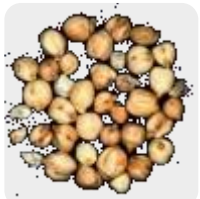
Harnessing variations through translational genomics approaches



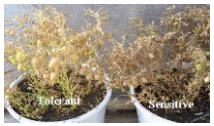
PLoS Biol 2014

Over 50 traits mapped

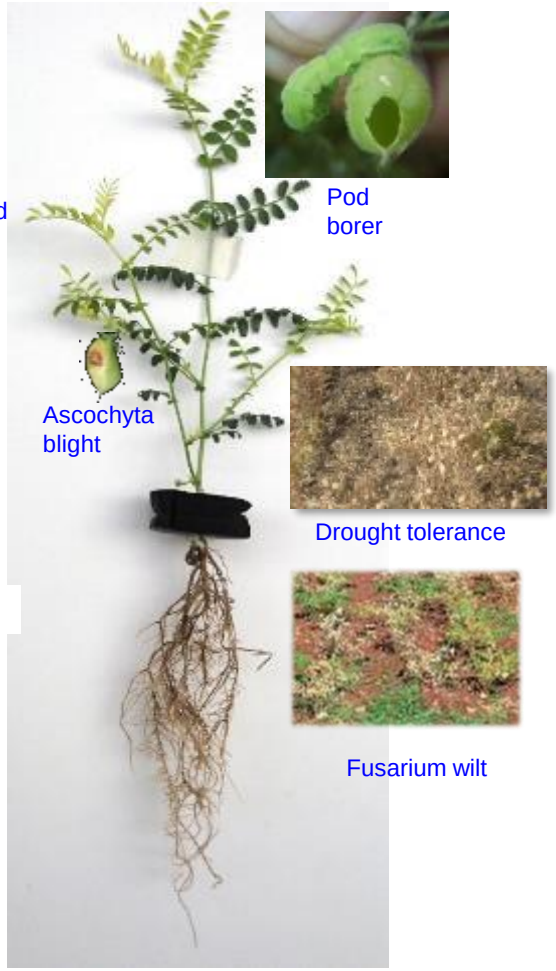
Chickpea


Botrytis grey mould


Heat tolerance



Salinity tolerance



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

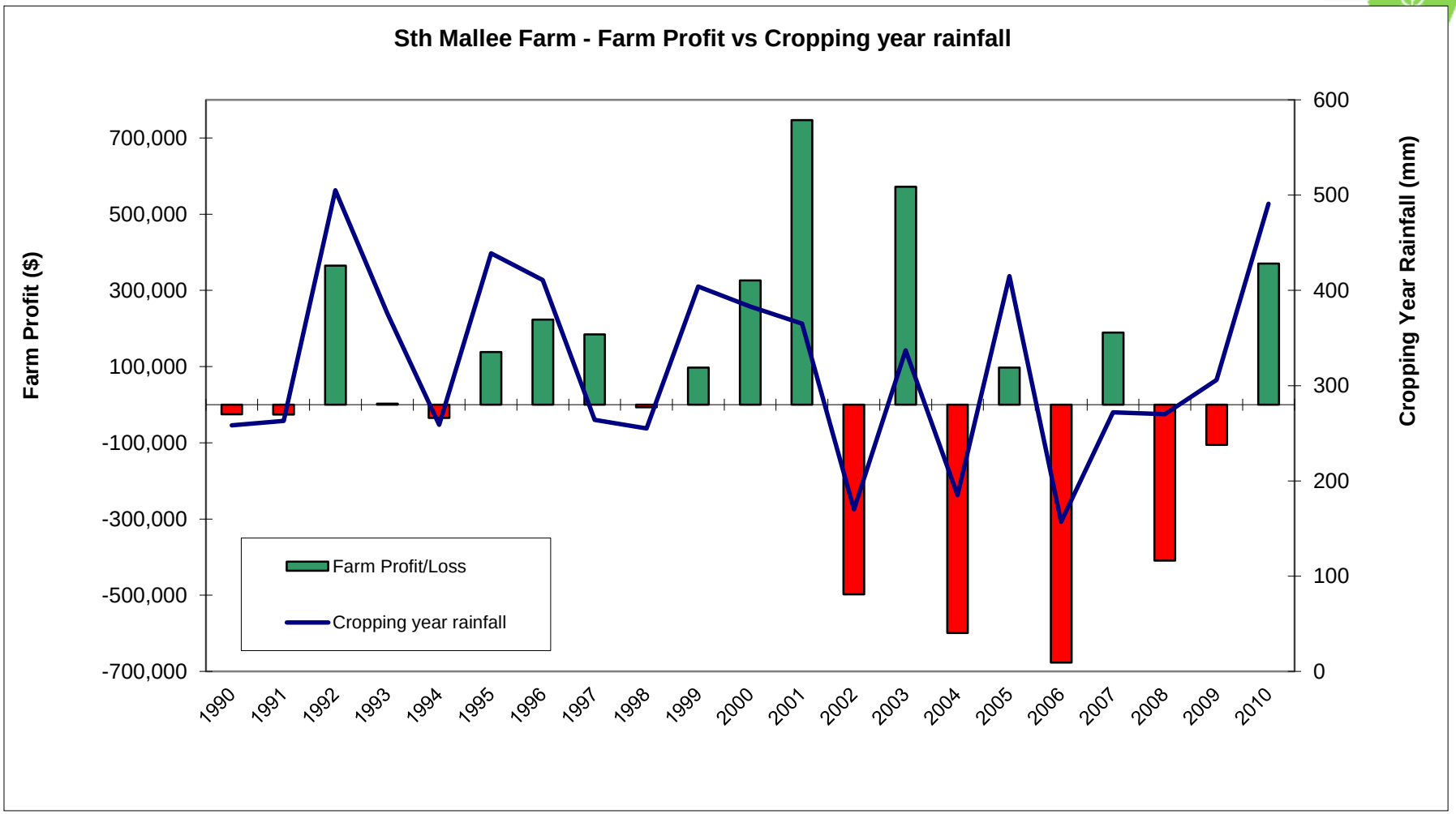
Seedling resistance and adult plant resistance

Helicoverpa

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

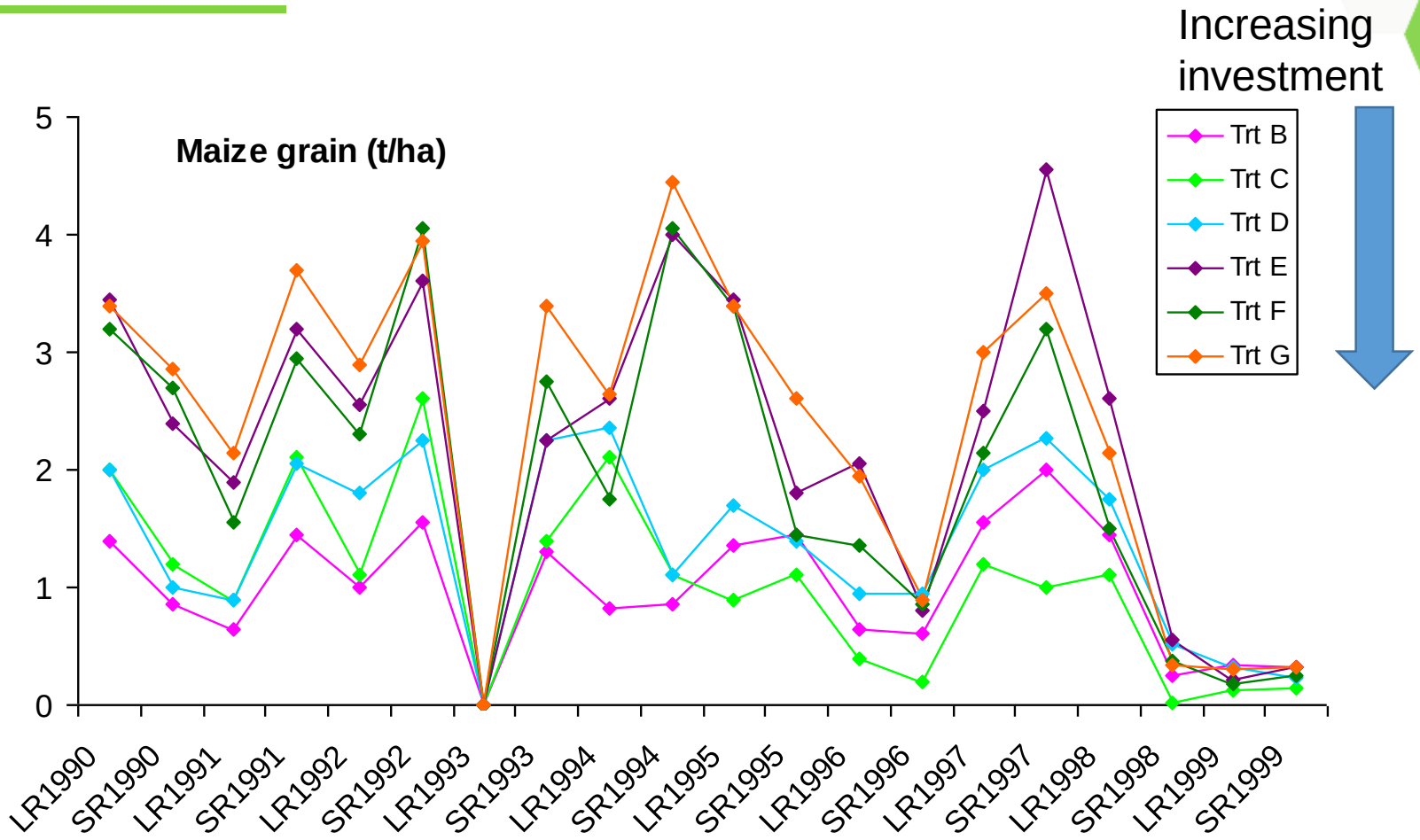
Fusarium wilt, Botrytis grey mould, Protein content

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



A	Bare fallow	12
B	Traditional (22K, 0N)	1 & 8
C	Intercrop (22K + beans)	7
D	22K + 50% mulch	3 & 6
E	53K, 70N & P + excess mulch	4 & 10
F	as E with reduced tillage	5 & 9
G	53K, 100N & P + full mulch	2 & 11

Drought … but what can be done?

1. Breeding for drought

Journal of Experimental Botany, Vol. 65, No. 21, pp. 6141–6153, 2014
doi:10.1093/jxb/eru040 Advance Access publication 5 March, 2014

Journal of Experimental Botany
www.jxb.oxfordjournals

REVIEW PAPER

Transpiration efficiency: new insights into an old st

Vincent Vadez[1,*], Jana Kholova[1], Susan Medina[1], Aparna Kakkera[1] and H

[1] International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Cro
Hyderabad, Andhra Pradesh, India
[2] Department of Biochemistry and Structural Biology, Center f

* To whom correspondence should be addres

Received 28 October 2013; Re

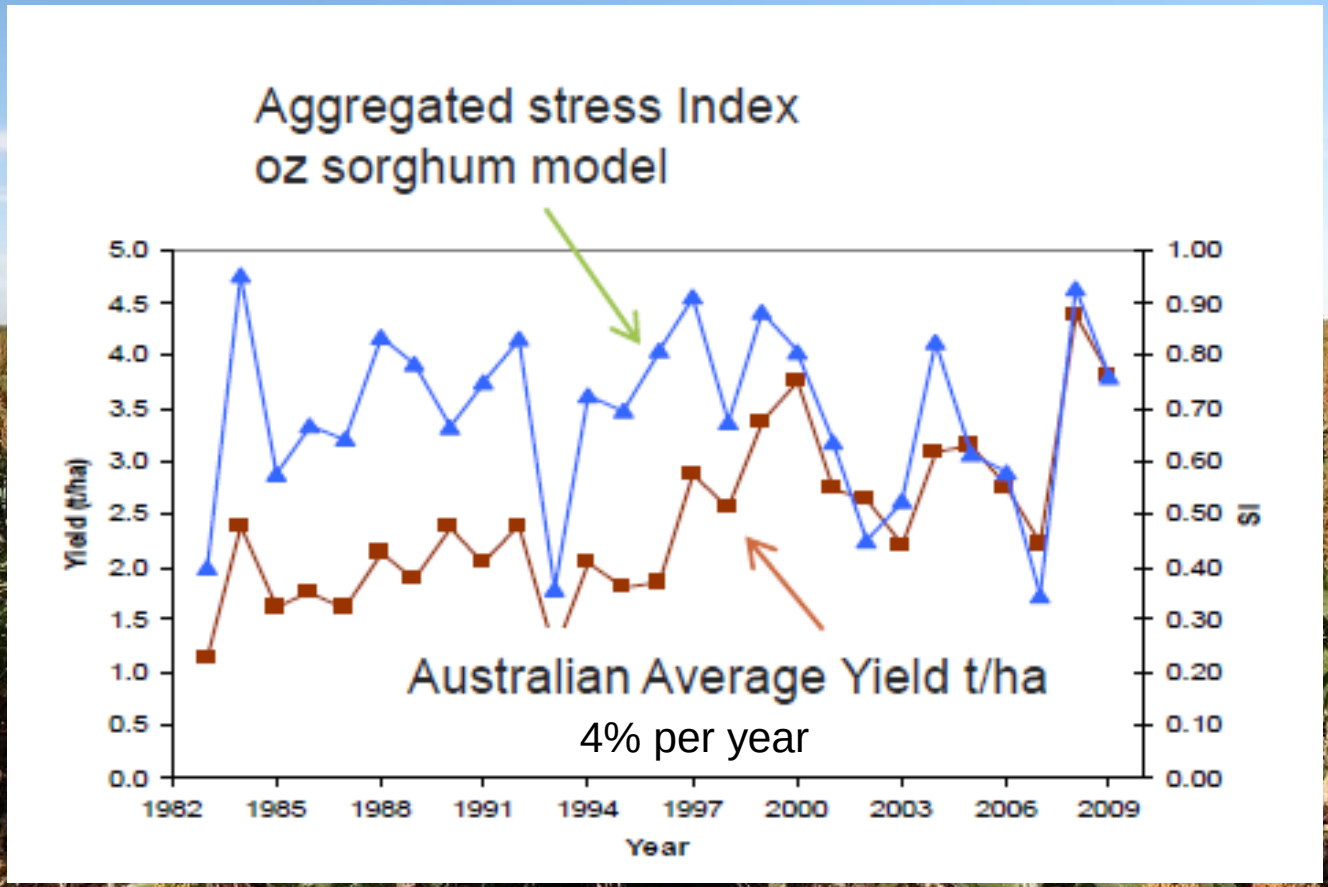
Ab

… 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

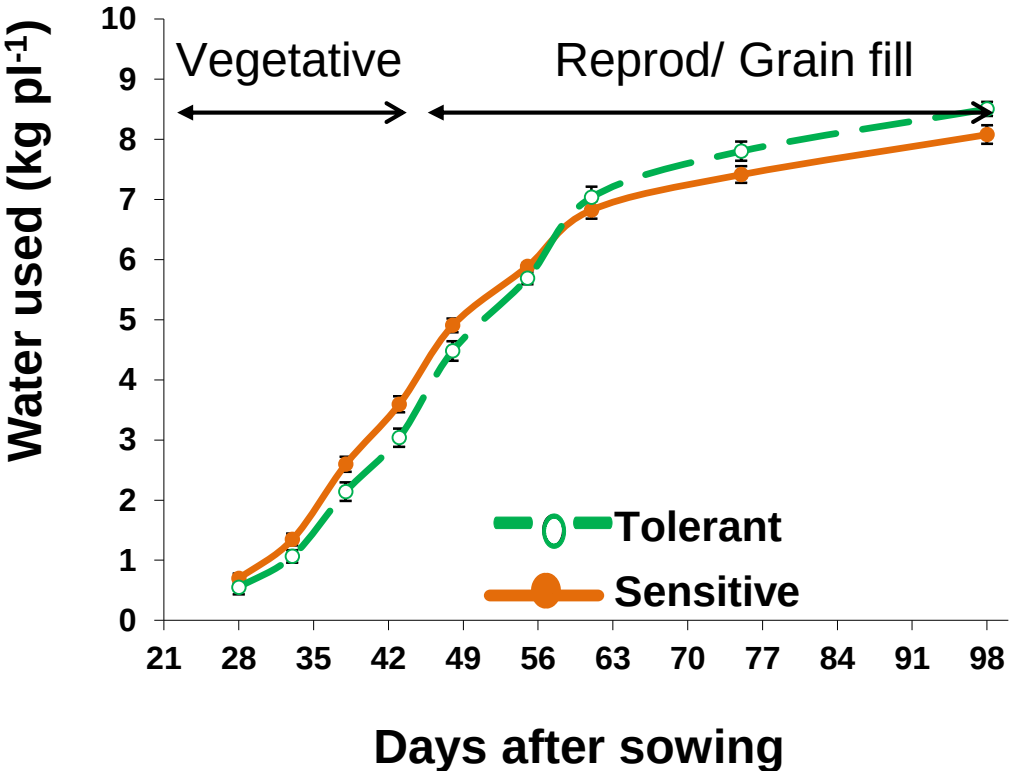
he demand for water by on a dwindling resource, leading been given high priority in the research cases, such as water-use-efficient wheat in accomplished. Here, we review the efforts to harness onent of water-use efficiency. As TE is difficult to measure, d mostly on surrogate traits, although this has most likely resulted in w lysimetric method for assessing TE gravimetrically throughout the entire genetic variation in different cereals and legumes. Across species, water regimes, ypes, this method has clearly established an absence of relationships between TE and total misses previous claims that high TE may lead to a lower production potential. More excitingly, s been found between these large differences in TE in several crops and attributes of plants that make restrict water losses under high vapour-pressure deficits. This trait provides new insight into the genetics of TE, especially from the perspective of plant hydraulics, probably with close involvement of aquaporins, and 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. We assessed the efficiency of water use at these critical stages.

Staygreen sorghum in Australia

Courtesy: David Jordan



Plant traits – shift water extraction from pre- to post anthesis

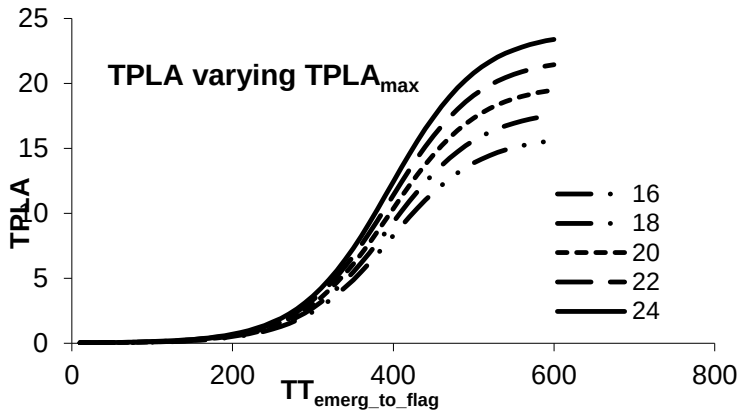


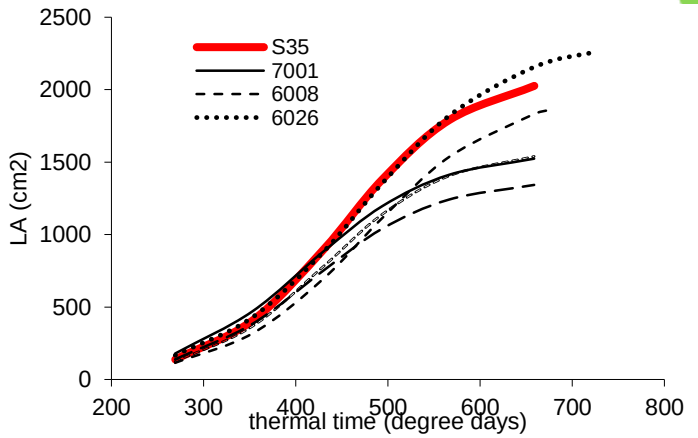
Less water extraction at vegetative stage, more for grain filling

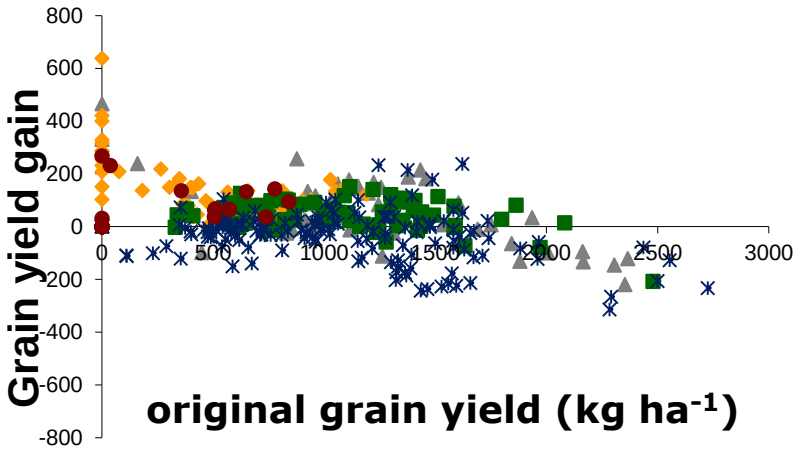
Zaman-Allah et al 2011
Borrell et al 2014
Vadez et al 2013

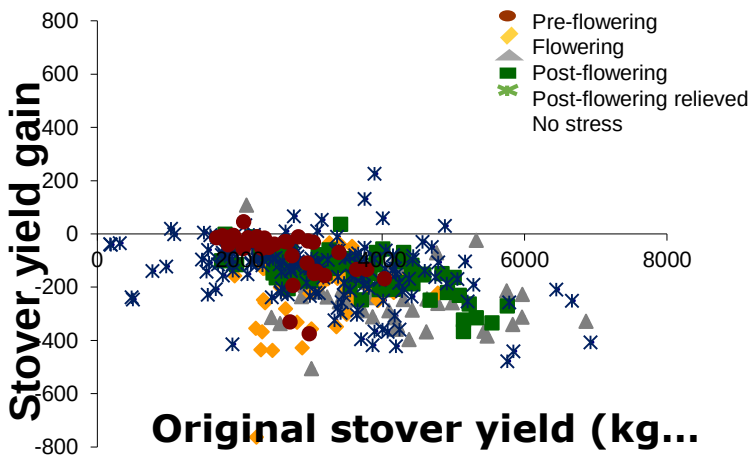
Staygreen – post-rainy season sorghum in India

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







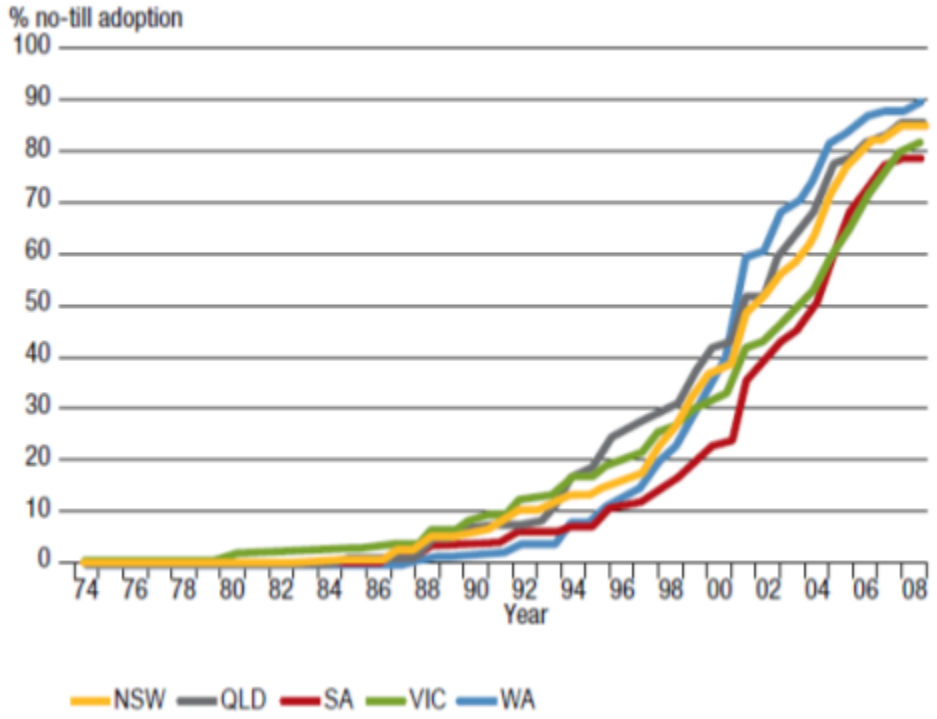


Trade-off between grain and stover yield

Kholová *et al.* 2014 (FPB)

Conservation agriculture – a “new” energy, water and machinery system that took 40 years of development & adoption

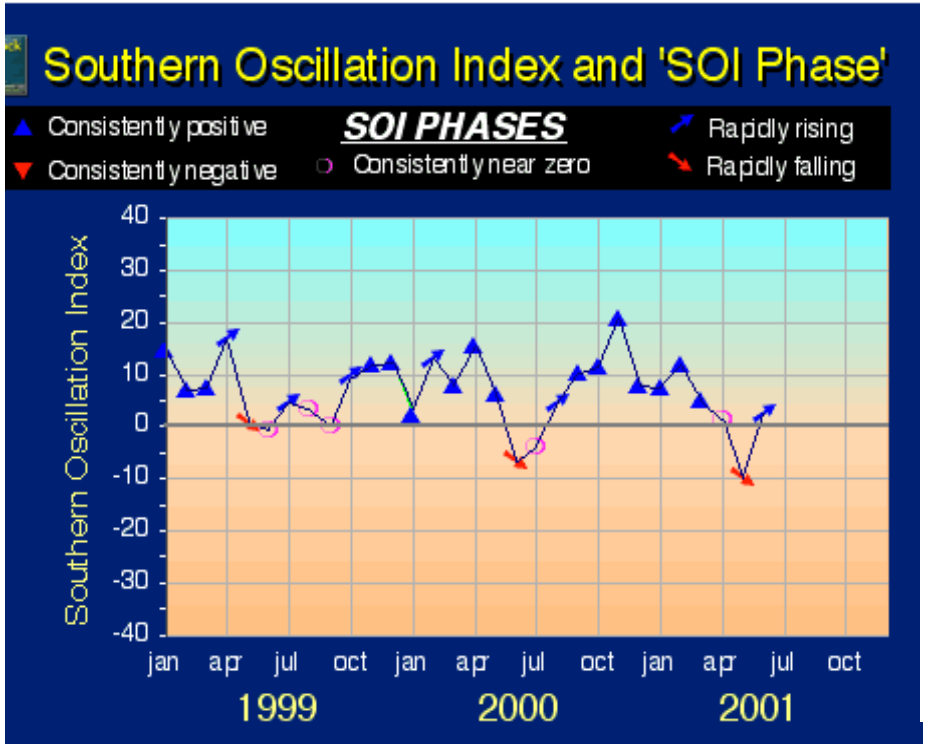
FIGURE 7 Cumulative adoption of no-till (decision to first use no-till) by respondents classified by state

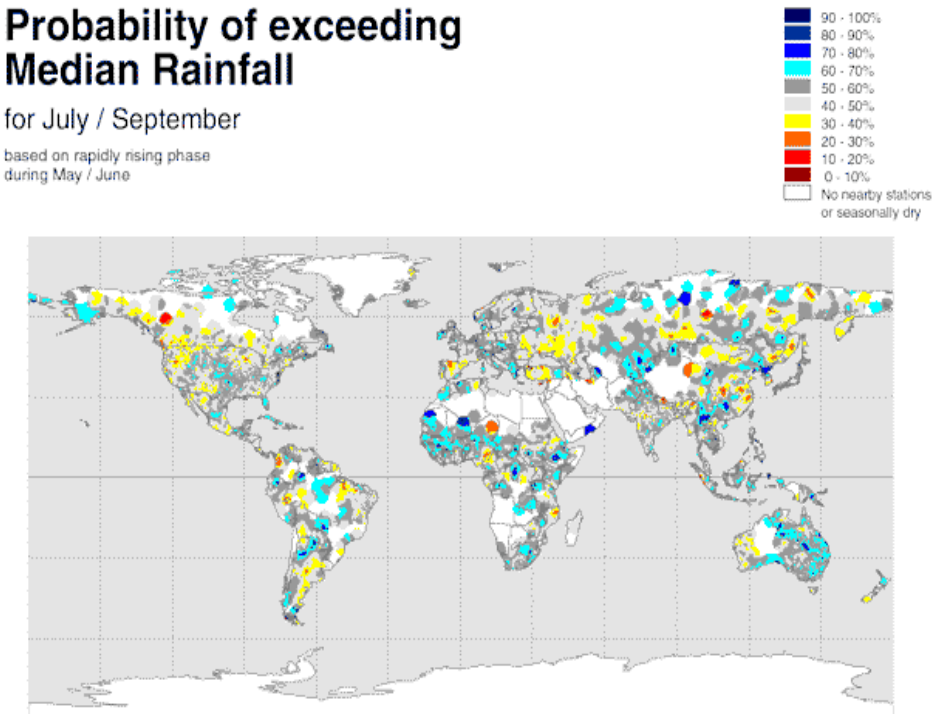


Rick Llewellyn and Frank d’Emden (2009) Adoption of no-till cropping practices in Australian grain growing regions. GRDC report

3. Managing for drought – seasonal climate forecasting

Southern Oscillation Index (SOI) and global rainfall forecast





Long Paddock web page www.dnr.qld.gov.au/longpdk/

Carberry, P.S., Hammer, G.L., Meinke, H. and Bange, M., 2000. The potential value of seasonal climate forecasting in managing cropping systems. In: Hammer, G.L., Nicholls, N. and Mitchell, C. (Eds.), Application of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems - The Australian Experience. Kluwer Academic Publishers. p. 167-181

Australian Government
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Bureau home » Climate » Outlooks

Climate outlooks – monthly and seasonal

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

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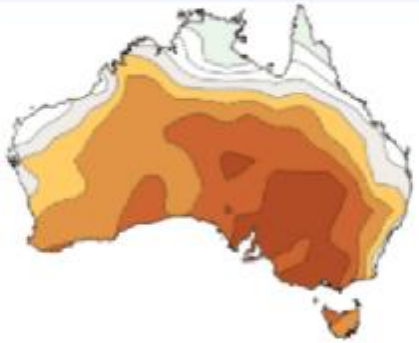
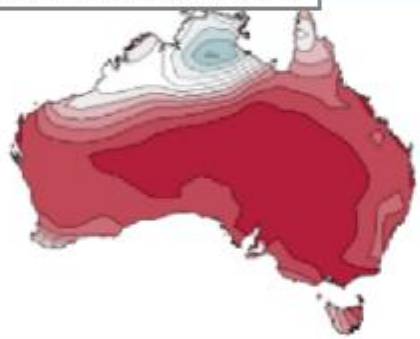
Overview - Summary

- Overview
  - Summary
  - Climate influences
  - Outlook video
- Rainfall
- Temperature

Rainfall



Maximum temperature outlook map



Outlook video

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.

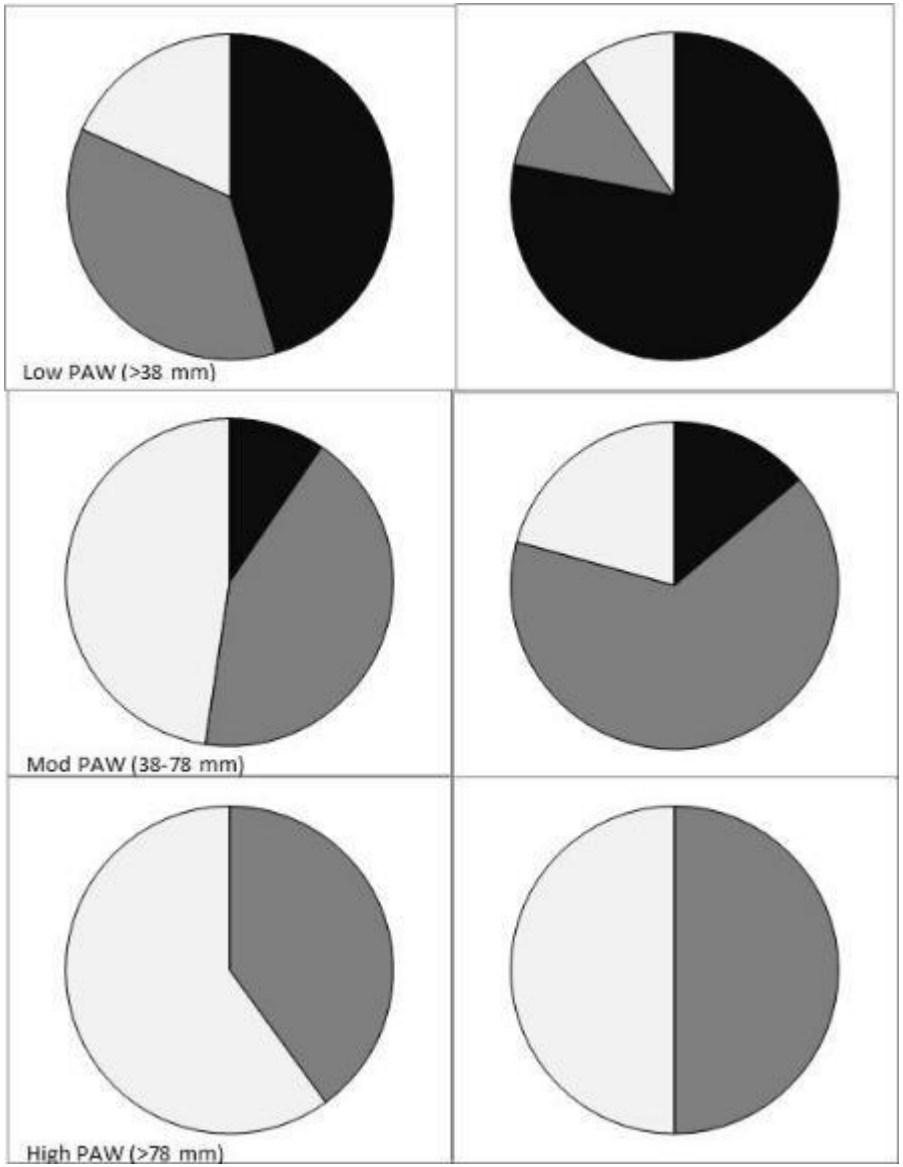
4. Managing for drought – soil water management

At sowing

Low SW

Moderate SW

High SW



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

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

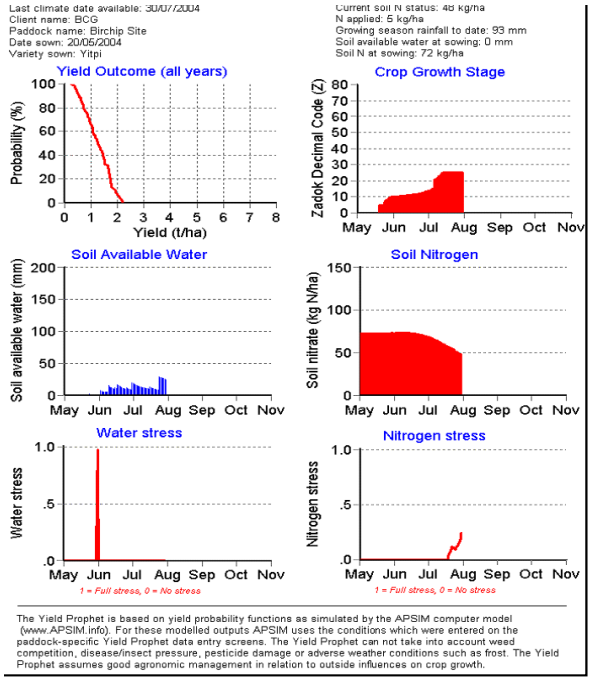
Planting opportunity: Early Late

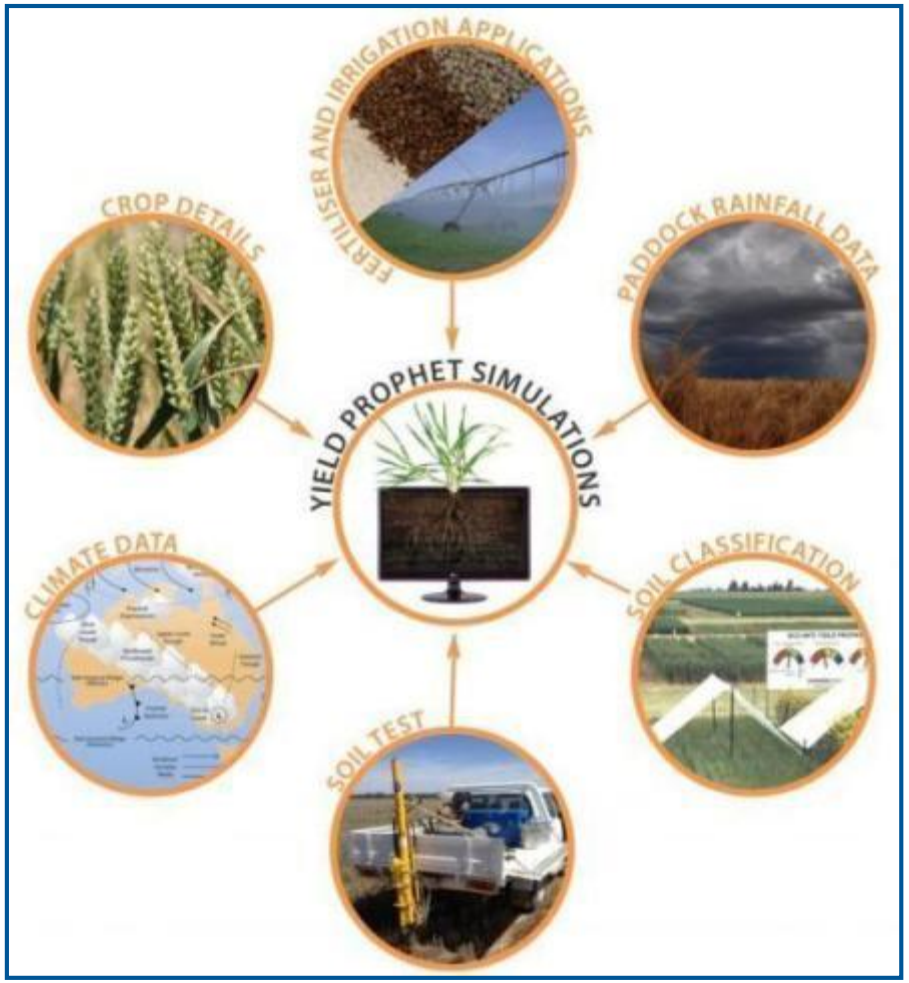
Whitbread et al

5. Managing for drought – Decision support

Yield Prophet www.yieldprophet.com.au

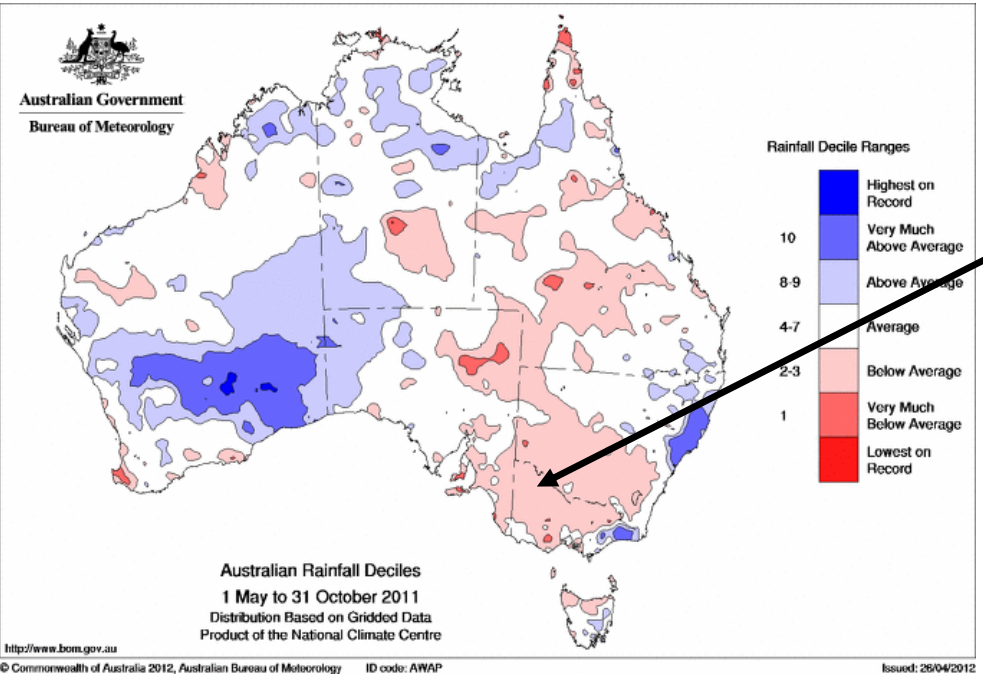
- Joint initiative of BCG and CSIRO
- Commercial subscription service
- Provides reports on yield probability, crop & soil status, impacts of management





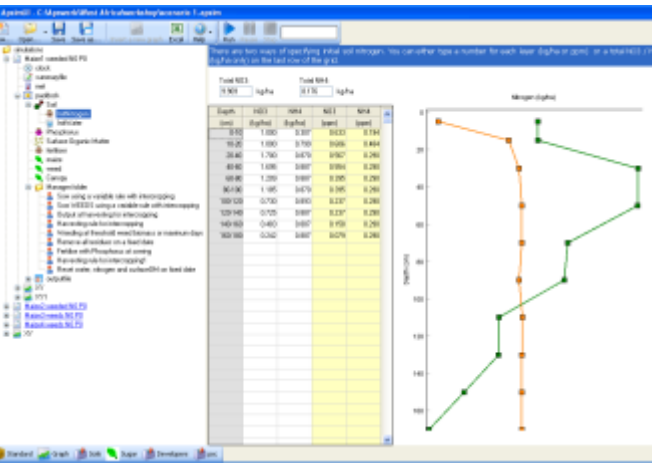
Mallee farmers invested in their crops in 2011 despite a decile 2 (very dry) season

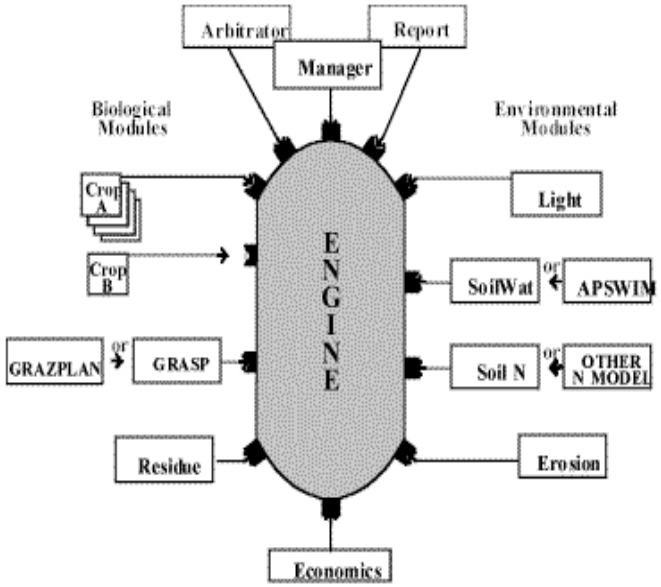
- Characterisation of soils for water holding capacity
- Regular monitoring to determine the state of soil water and nitrogen
- Conserving soil moisture through conservation tillage and weed control
- Use of decision support to help make investment decisions
- Seasonal climate forecasting



CLOSE EYE: John Ferrier, right, and his son David inspect a wheat crop on their Birchip farm. Birchip Cropping Group's Yield Prophet has predicted the crop will yield six tonnes to the hectare. Pictures: PAUL CARRACHER Wimmera Mail-Times

Agricultural Production Systems Simulator (APSIM) www.apsim.info



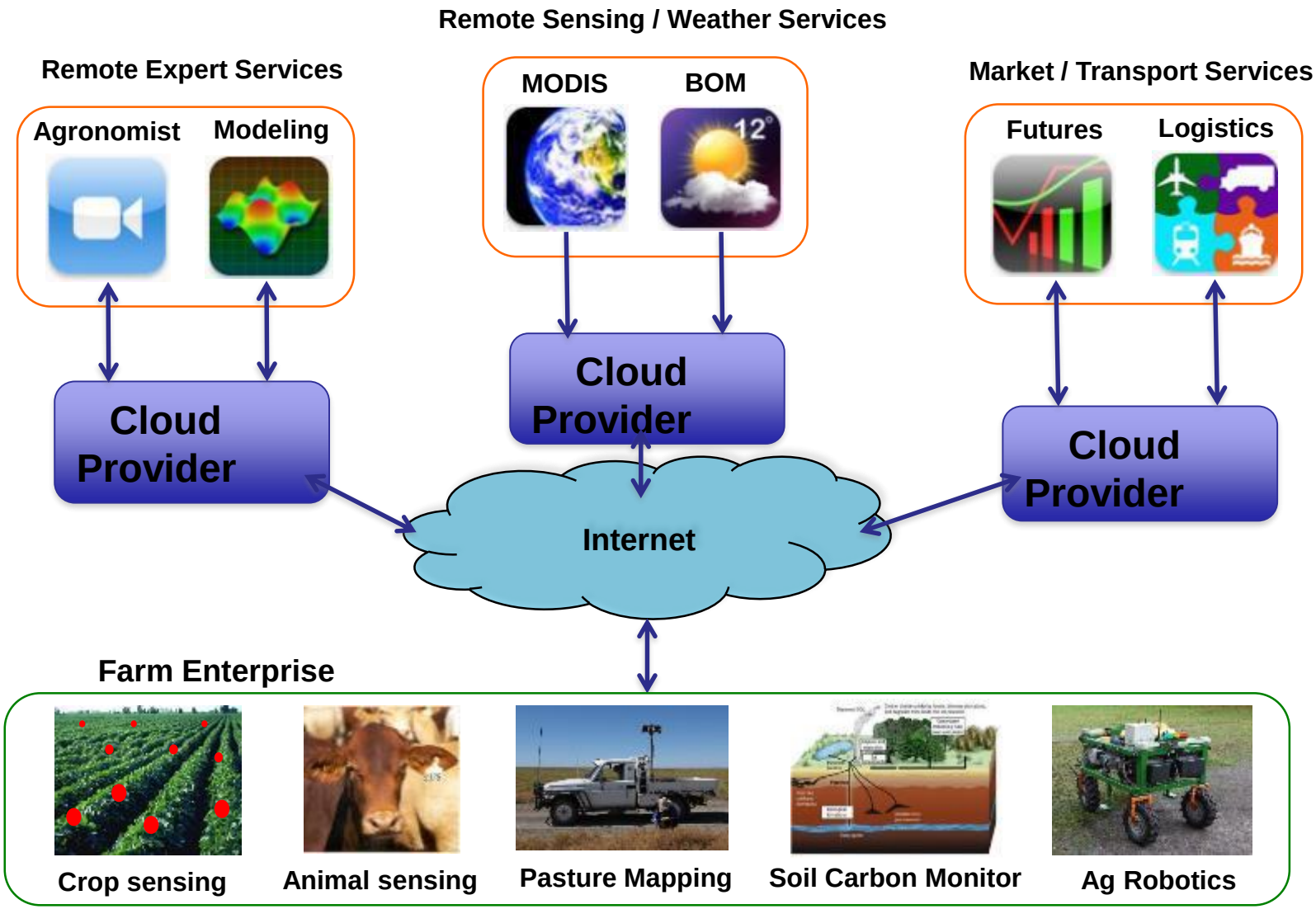


The soil provides a central focus, crops, seasons and managers come and go, finding the soil in one state and leaving it in another

Simulates:

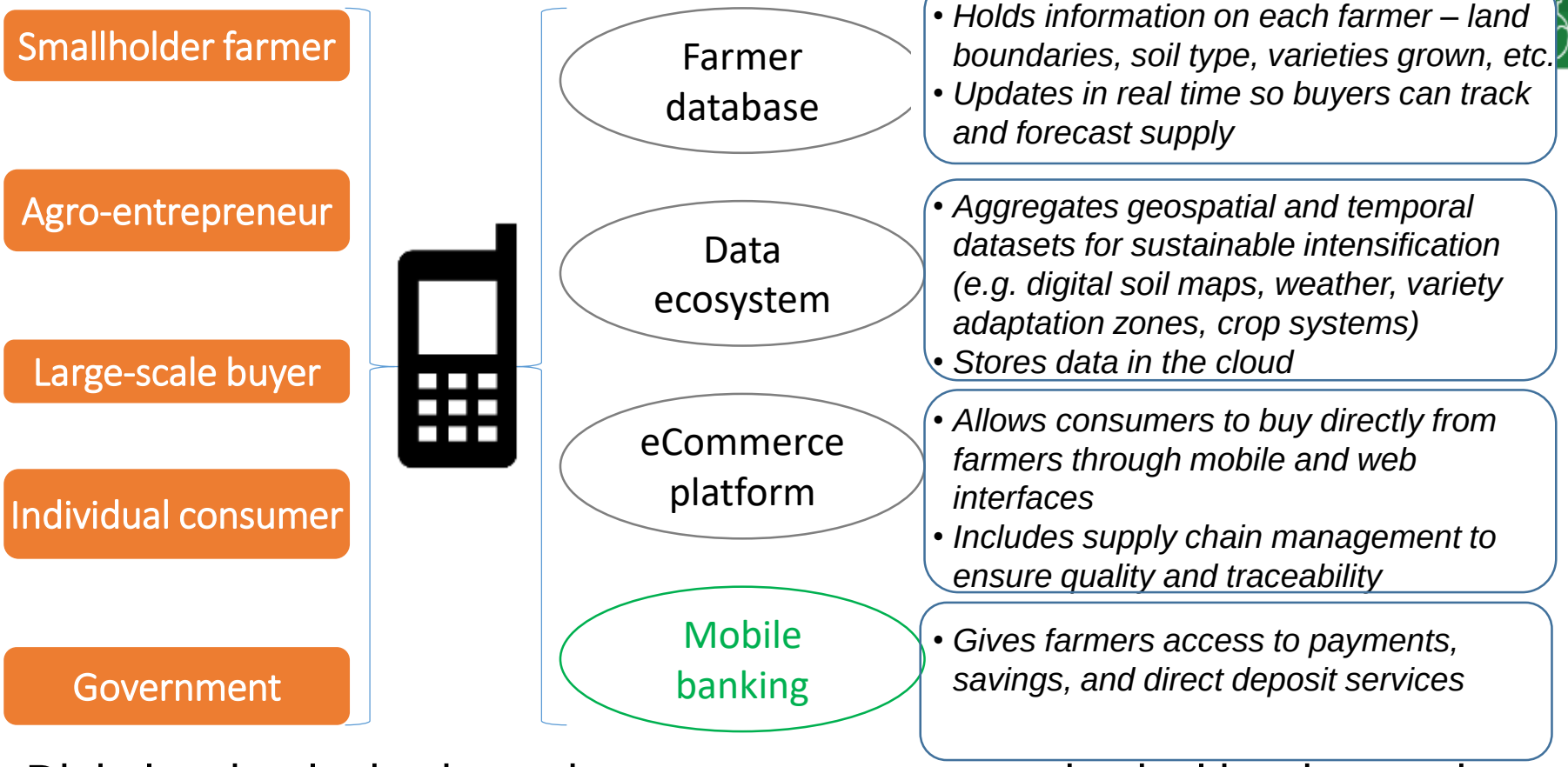
- ✓ mechanistic growth of crops, pastures, trees, weeds ...
- ✓ dynamics of populations (eg. weed seedbank)
- ✓ key soil processes (water, solutes, N, P, carbon, pH)
- ✓ surface residue dynamics & erosion
- ✓ dryland or irrigated systems
- ✓ range of management options
- ✓ crop rotations + fallowing + 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



Alex Zelinsky,

Opportunities for smallholder farmers?



- 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

THE WALL STREET JOURNAL.

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