Research achievements in the Australian cotton industry

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Overview

1. Challenges, opportunities and broad outcomes
2. Research areas (and extension)
3. Three examples of success
4. Outcomes and impacts

Challenges and opportunities for research

Issue	1970	1995	2018
Yield = $	Low (800 kg/ha)	Moderate (1750 kg/ha)	High (2600 kg/ha) ★★★★
Pests	Severe	Severe	Respectable ★★
Sustainability	Severe	Problematic	Respectable ★★
Soil health	Severe	Respectable	Respectable ★★★
Diseases	Bacterial blight, Verticillium wilt	Fusarium wilt, Bunchy Top	Verticillium wilt? ★★

RESEARCH AREAS in recent decades

1. Physiology, agronomy, farming systems
   - Water – irrigation, wue
   - Nutrition - fertilizer
   - **Soils**
   - Tillage
2. Crop protection
   - **Pests**
   - Diseases
   - Weeds
3. Genetic improvement
   - **Breeding**
   - Biotechnology
4. Processing
   - Ginning
   - Fibre measurement, Spinning
5. Other, eg Machinery

Note especially:
IPM – Integrated Pest Management
IWM – Integrated Weed Management
IDM – Integrated Disease Management
IFM – Integrated Fibre Management

Combined = ICM – Integrated Crop Management

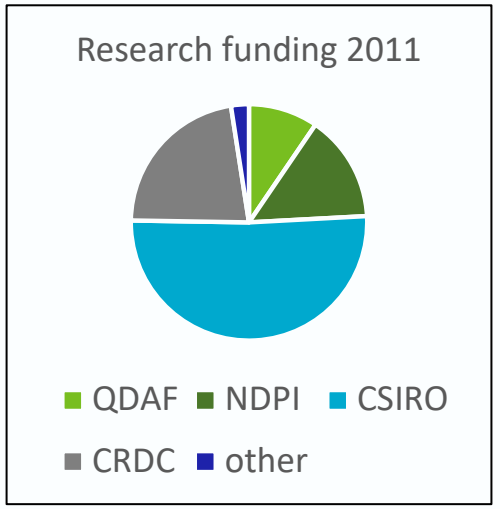
GM traits:
- Protein(s) from soil bacteria *Bacillus thuringiensis* (Bt) toxic to *Helicoverpa* and other lepidopterans. Released 1996.
- EPSPS enzyme confers resistance to glyphosate. Released 2000.
- Regulatory studies too (GMAC, OGTR).

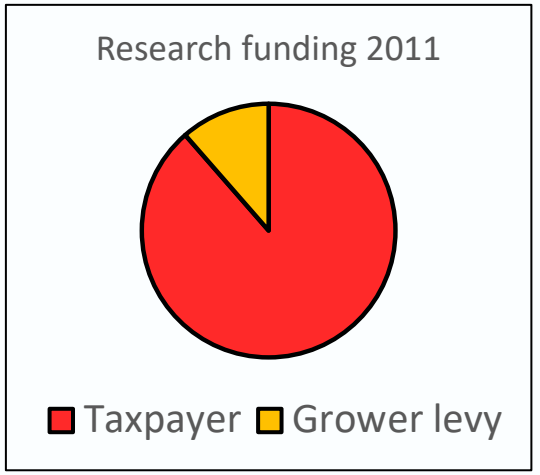
Research bodies

1. Public agencies
   - Federal – CSIRO
   - State – NSW, Qld, WA, NT
   - University – SU, UNSW, UWS, UNE, UQ, USQ, CQU, JCU, Deakin U.
   - Cooperative Research Centre (x3) 1994 to 2012 (~$2m pa).
2. Private/commercial
   - Growers (± researchers)
   - Chemical companies – Shell, Bayer, Monsanto, etc.
   - Machinery – JD, Case, local
   - Contract research – Kalyx, etc.

Research funding

- Prior to 1987, funding was via tax payer - through research agencies.
- In 1972, the Australian Cotton Growers Research Association (ACGRA) supported research focused on their needs, via voluntary 25 c/bale levy, full compliance demonstrated growers commitment.
- In 1987 the Cotton Research Council was established to collect grower levy ($2.25/bale) and matching Federal money and distribute research funds. This body was replaced by the Cotton Research and Development Corporation (CRDC) in 1990. $24m in 2016/17.
- ACGRA (later CA) play a role by assessing all CRDC research applications.
- External research funds are critical in an era of government budget cuts.





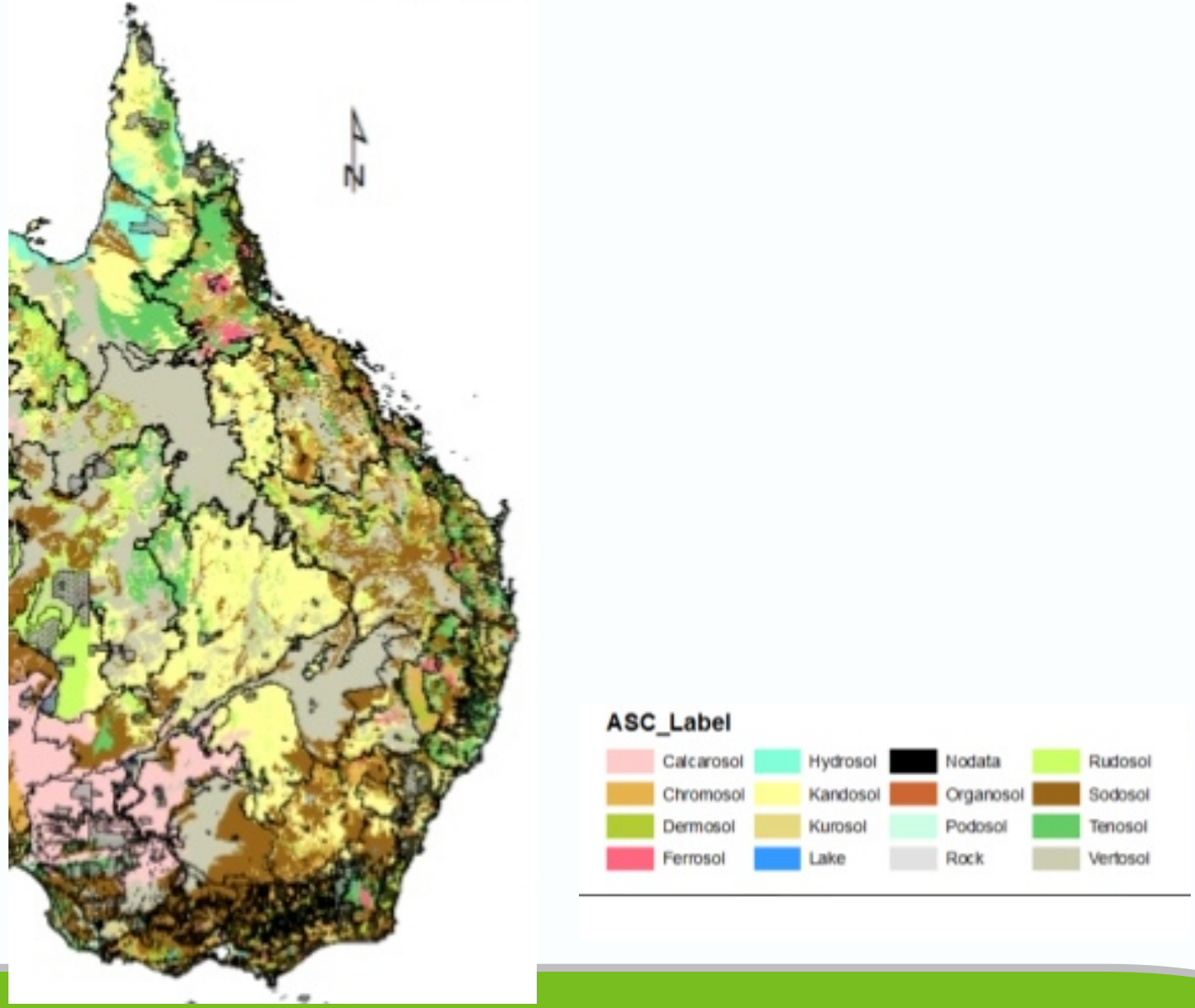
Three major research achievements

Soil management

Pest management

Plant breeding

SOIL MANAGEMENT



SOIL MANAGEMENT

A typical soil where cotton is grown:

Vertosol

High clay content

High water holding capacity

Cracks when dry

Alkaline

Sodic

Reasonable fertility – N, P, K, Zn

Resilient

So:

Drainage may be slow – waterlogging (N loss, stunting).

The soil is fragile when wet – prone to soil compaction from tillage or traffic.

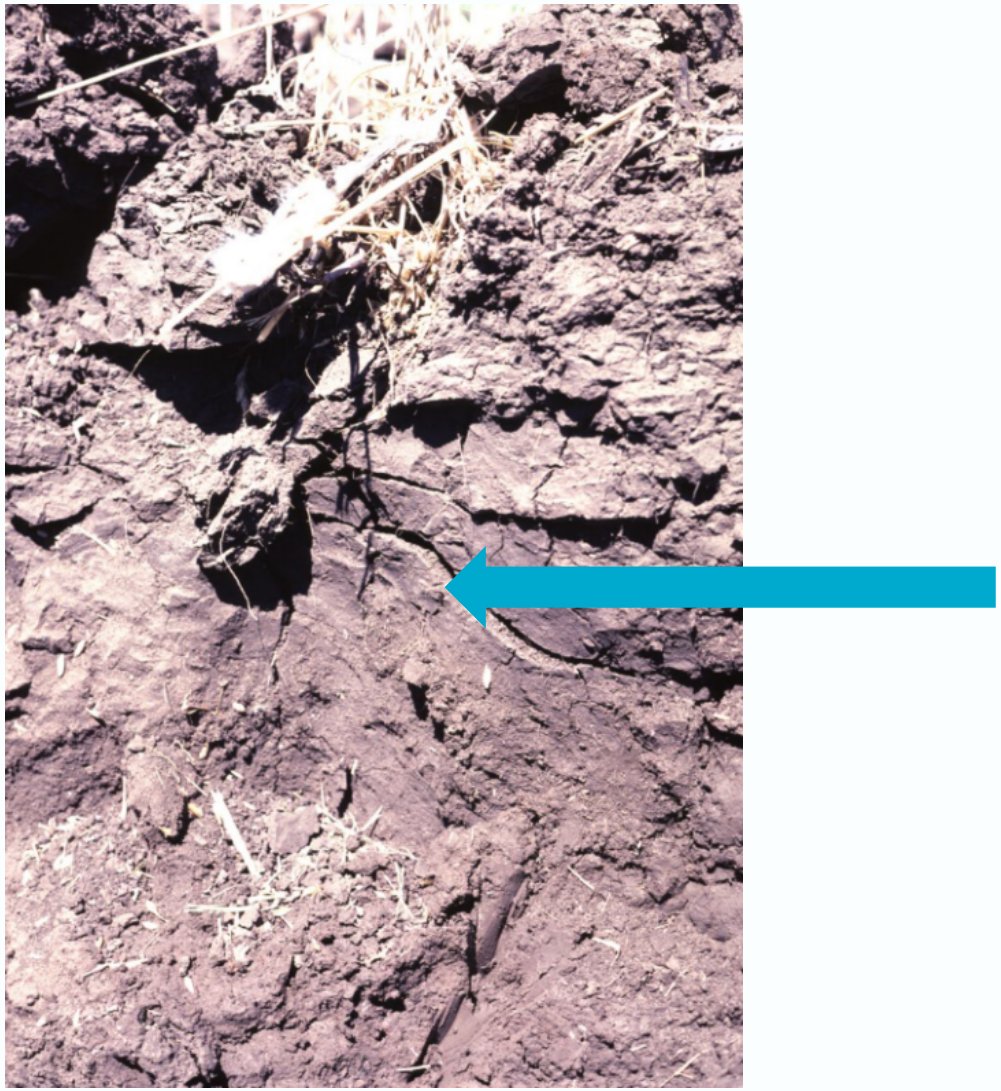
Appropriate tillage for soil type and moisture content is required.

It is sometimes necessary to consider a rotation crop to dry the profile.

Soil compaction

From Dave Anthony

Soil compaction

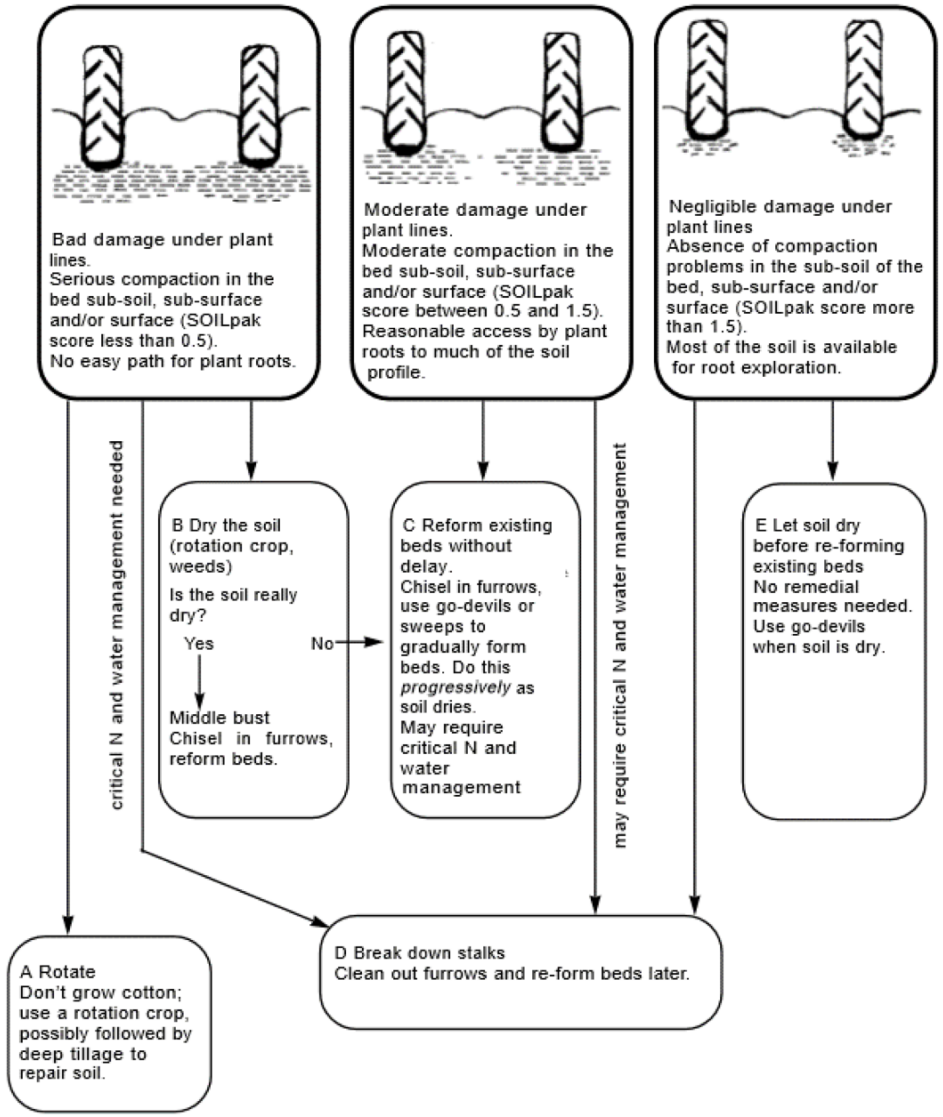


From Dave Anthony

SOILpak

Information to help decisions on soil management, particularly tillage

Figure B4-1. Tillage strategies after a wet harvest



Outcome: massive improvement in soil structure (=resilient) which facilitated better crop response to water and fertilizer.

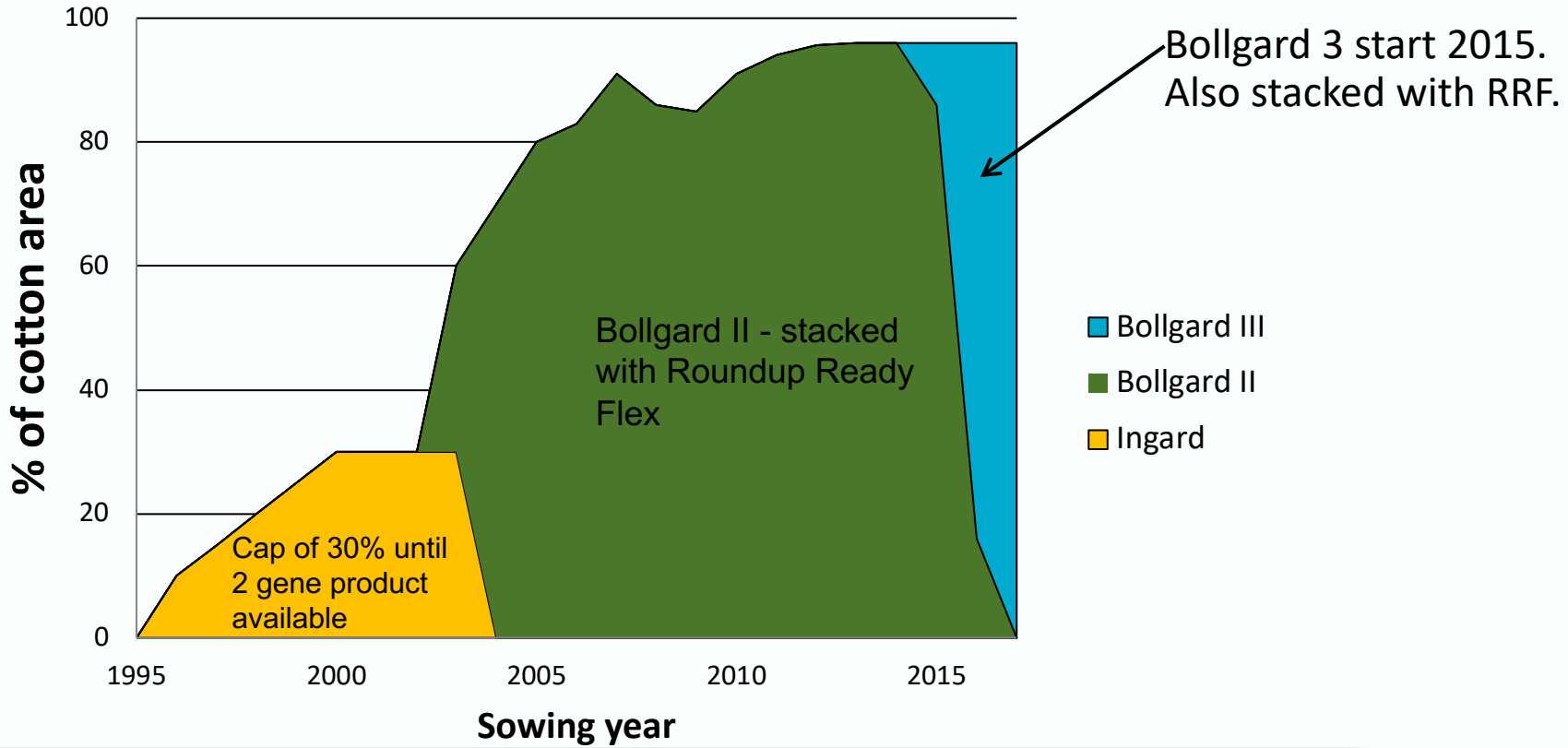
PEST MANAGEMENT

PEST MANAGEMENT

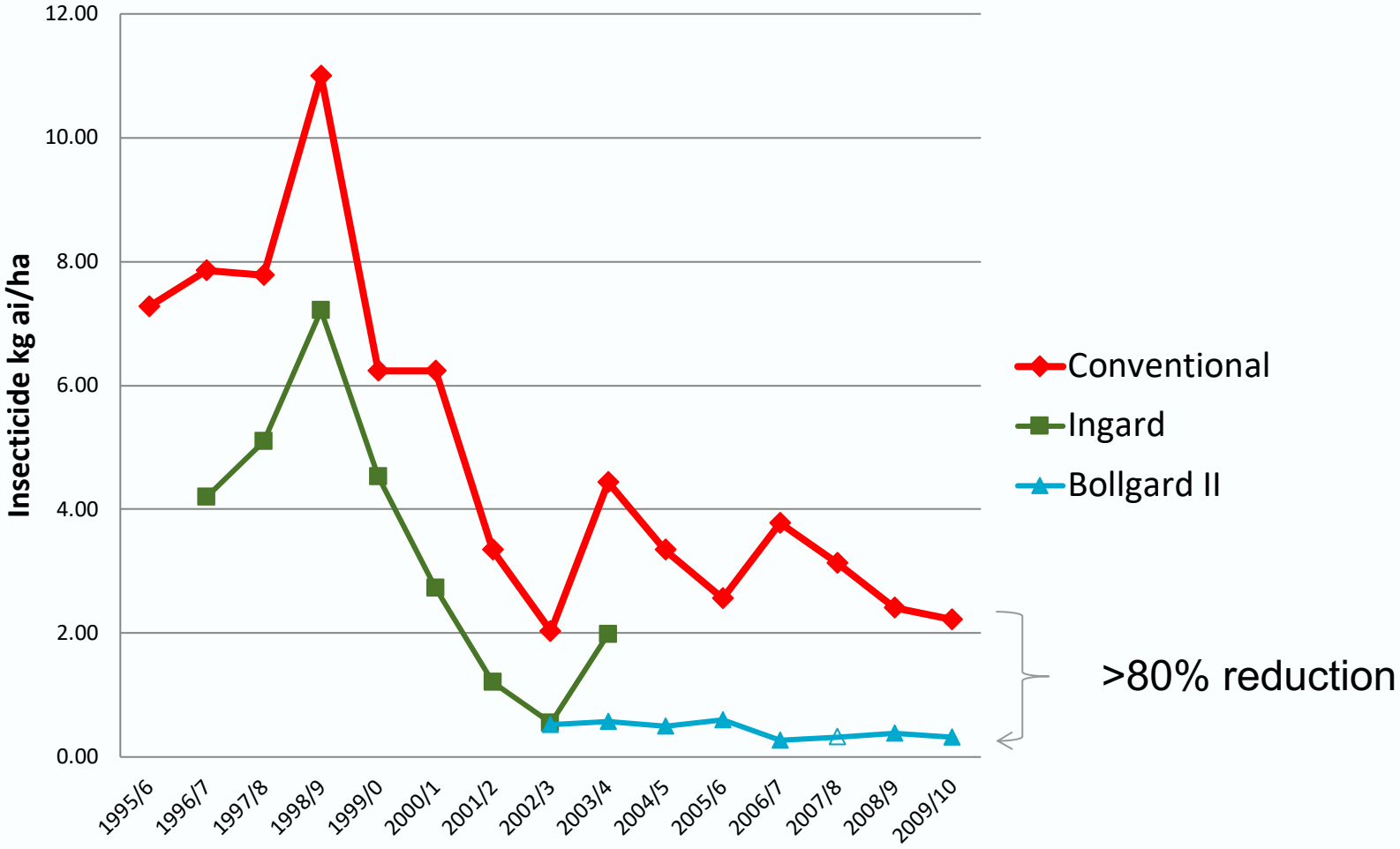
- Large numbers of pests (100) + cotton is attractive to pests.
  - Especially *Helicoverpa spp.*
  - Zero yield with high incidence of uncontrolled *Helicoverpa.*
- Regular control = Pesticide contamination: air, soil, water. +Resistance.
- Large number of beneficial predators and parasites of pests.
- However, insecticides can kill beneficials as well as pests.
- **Integrated Pest Management** was required
  - Damage thresholds (eg 2 v. small larvae/m); accurate scouting.
  - Understand insect ecology / movement of different species.
  - Pesticide resistance management. Reactive?
    - Chemistry rotation, defined windows, pupae destruction.
- Prevention of resistance to Bt GM traits. Preemptive!

Adoption of Bt cotton varieties in Australia

- Traits from Monsanto and Bayer used under research agreement with CSIRO (breeding) and commercial agreement with CSD (seed sales).
- Grower signs licence agreement with Monsanto to follow resistance management requirements. Compliance is audited.

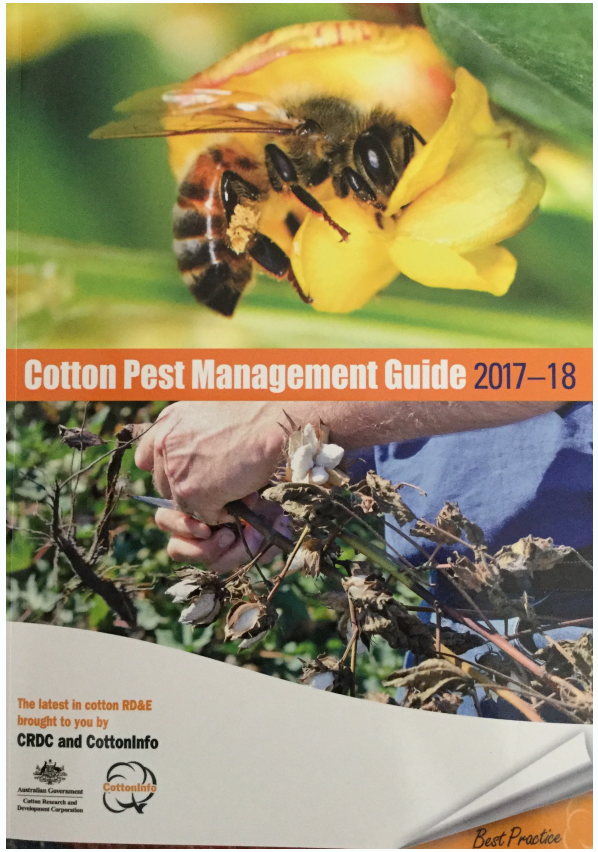


Insecticide (ai) use on cotton in Australia



Pest management outcomes

- Comprehensive recommendations on pest control options.
- The experience with insecticide resistance research enabled the development of pre-emptive resistance management for GM Bt technology before its widespread use:
  - Refuge crop (eg. pigeon pea, u/s cotton)
  - Planting windows x region ~
  - Pupae destruction (autumn, winter)
  - Different proteins stacked (Ingard → Bollgard II → Bollgard 3)
- With low levels of background resistance in *Helicoverpa* populations to Bt; it is still necessary to be vigilant in compliance with resistance management.
- IPM for all pests is facilitated by GM Bt use.



COTTON BREEDING

- Long history in Australia, particularly in Qld.
- Long term projects >>10 year breeding cycle.
- At the start of the modern cotton industry ~1960s, there were breeding and selection programs in Qld, NSW (2) and WA.
- Key event – 1972. Centralisation of CSIRO breeding program in main production area at Narrabri and staffed by experienced scientists. Other programs closed eventually.

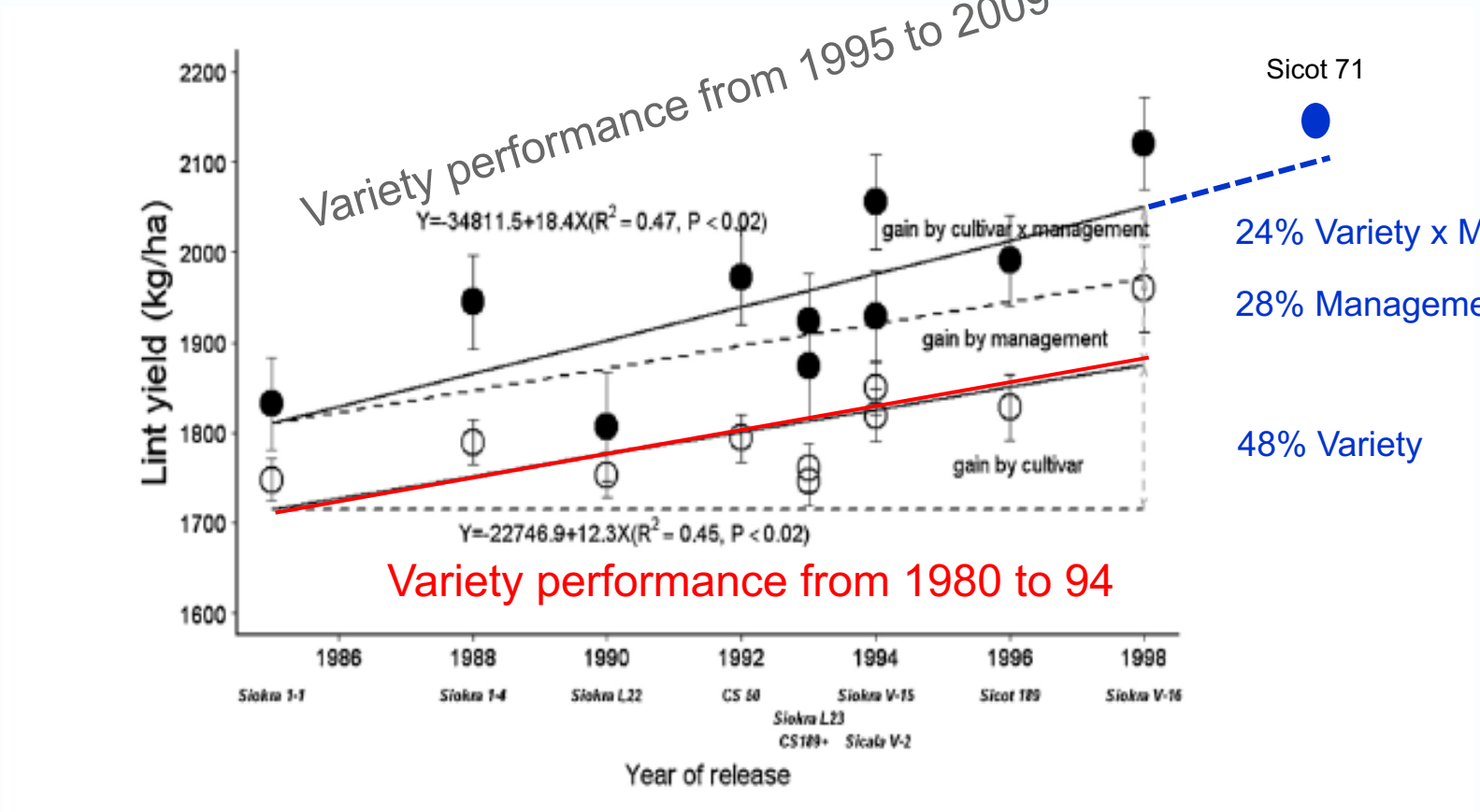
CSIRO breeding activities and objectives

2018: Team >20: 3 breeders; 3 PDF; ~15 technical staff.
Return On Investment is > 80: 1. NPV is $5b - $10b.

- **Yield** / local adaptation (soil, pests, climate, etc)
  - Irrigated and rainfed; heat and stress tolerance; tropical and temperate
- Disease resistance
  - Bacterial Blight, Verticillium Wilt, Fusarium Wilt, Cotton Bunchy Top
- Fibre quality
  - Especially length, strength, fineness - dictated by market preference

- Introgression of GM traits since 1991
  - Btx4, RRx3, LL and combinations; plant type = turnover.
  - Involves CSIRO biotechnology group in Canberra.

Yield gain due to Variety, Management & their interaction.
325 CSIRO experiments over 30 years.



Over the period 1980 to 2010, AUS yields increased by ~1000 kg lint/ha (from 1200 to 2200).
That is 480 kg/ha for variety (~$1,000/ha); 280 for management; and 240 kg/ha for VxM.

Liu et al FCR 2013

Varieties developed

CSIRO released the first varieties through CSD: Sicot 1 and 3 in 1983 (replaced imported US varieties)

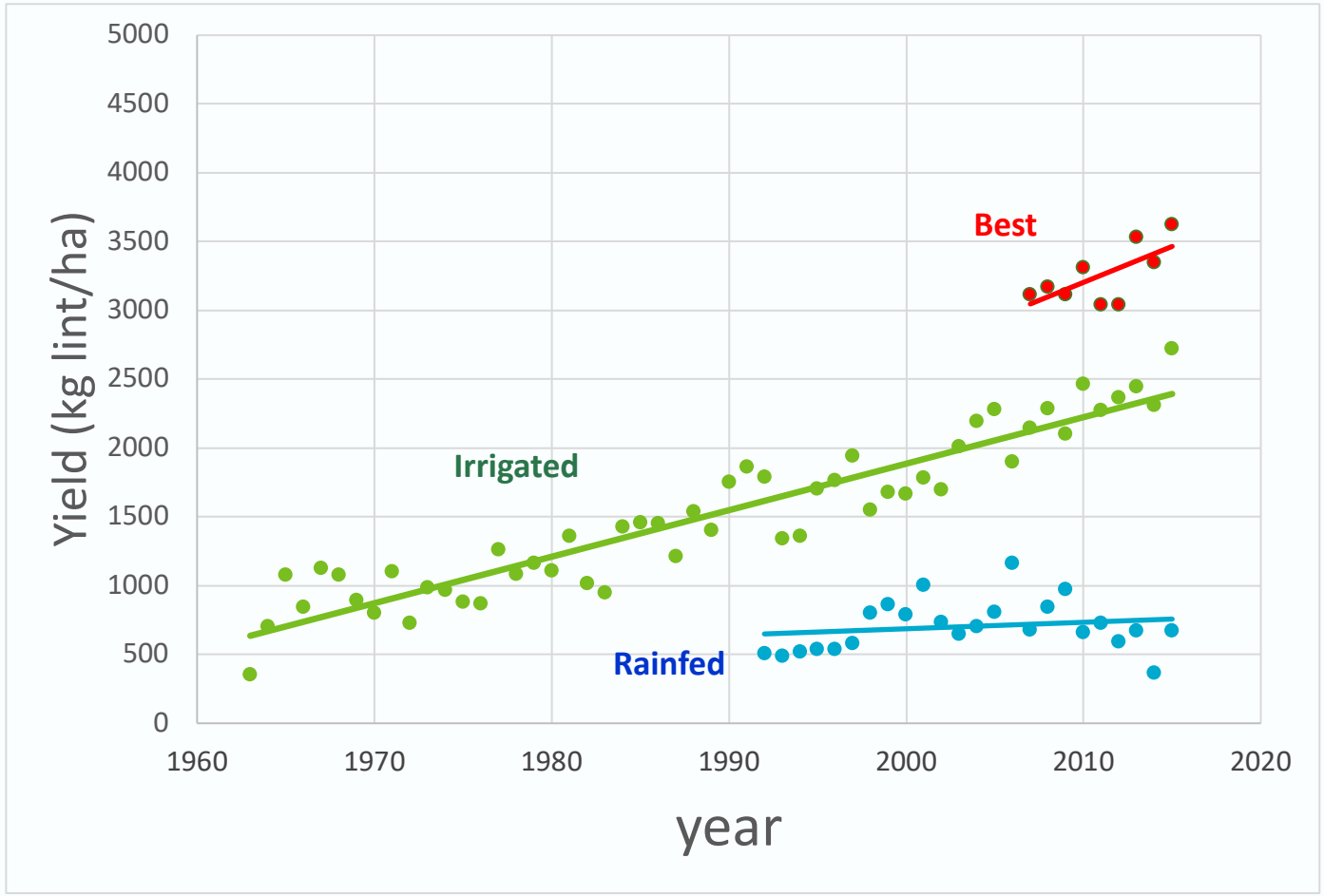
Then Siokra, Sicala and on .... (green or red are redundant)

In 35 years, there have been ~110 varieties released (trait turnover).

Conventional			Transgenic Bt/RR/LL			
Sicot 1	CS 7S	Sicot 70	Siokra V-15i	Siokra V-16RRi	Sicala 40B	Sicot 80L
Sicot 3	CS 50	Sicot 72	Siokra L-23i	Siokra V-17i	Siokra V-16B	Sicot 43L
Siokra 1-1	Siokra L23	Sicot 80	Sicala V-2i	Sicot 11B	Sicot 71B	Sicot 71BRF
Siokra 1-2	CS 189+	Siokra S-102	Sicot 50i	Sicot 12B	Sicot 71RR	Sicot 71RRF
Sicala 3-1	Siokra V-15	Sicala 43	Sicot S-8i	Sicot 13B	Sicot 43BR	Sicot 74BRF
Siokra 1-4	Sicala V-2	Sicot 71	Sicot 189i	Sicot 14B	Sicot 43B	Sicala 340BRF
Sicala 3-2	CS 8S	Sicala 45	Sicot 289i	Sicot 289RR	Sicot 43RR	Sicot 75BRF
Sicala 33	Siokra S-101	Siokra V-18	Siokra V-16i	Sicot 60RR	Sicot 80RR	Siokra V-18BL
Siokra S324	Sicot 189	Sicot F-1	Sicot 189RR	Sicot 289BR	Sicala 350B	**Sicot 75RRF**
Siokra L22	Siokra V-16	Sicot 73	Sicala V-2RR	Sicot 71BR	Sicala 60BRF	**Sicot 707B3F**
CS 6S	Sicala 40	Siokra 24	Sicala V-3i	Sicala 60BR	Sicot 80BRF	**Sicot 714B3F**
CS 189	Sicot 53	Sipima 280	Sicala V-3RRi	Sicala V-3BR	Sicot 43BRF	**Sicot 746B3F**
Sicala V-1	Siokra V-17	Sicot 75	Siokra 201i	Siokra V-16BR	Sicot 80RRF	**Sicot 748B3F**
Sicala 34		**Sicot 730**	Sicot 42i	Sicala 40BR	Sicot 43RRF	**Sicot 754B3F**
			Sicala 40i	Sicot 289B	Sicot 70BRF	**Sicot 812RRF**
			Sicala 40RRi	Sicot 80B	Sicot F-1B	**Sicot 711RRF**
			Sicot 289RRi	Siokra V-18B	Sicala 45B	

Closing comments to sum up

Australian cotton research outcomes: Better yield, better quality, more efficient.

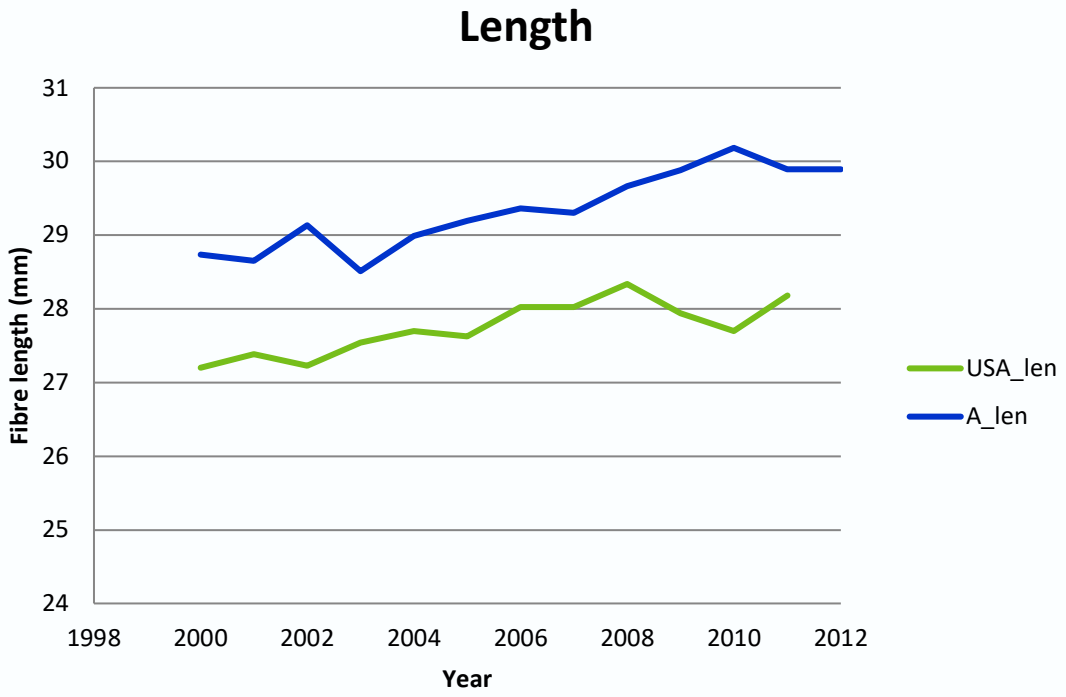


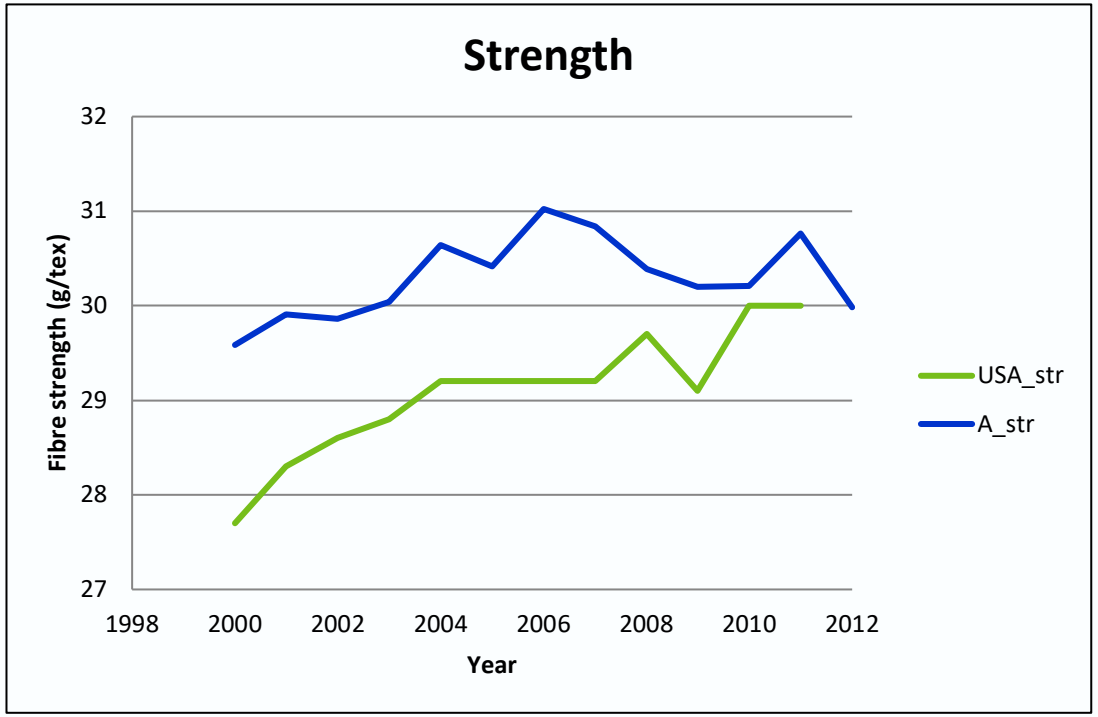
Note:
theoretical yield ~ 5,000

Rainfed:

- Dry seasons recently
- Grown in drier locations to west
- Yield increasing if corrected for rain

How does Australian cotton fibre compare with USA?





Data from ACSA and USDA (whole crop)

Water use efficiency

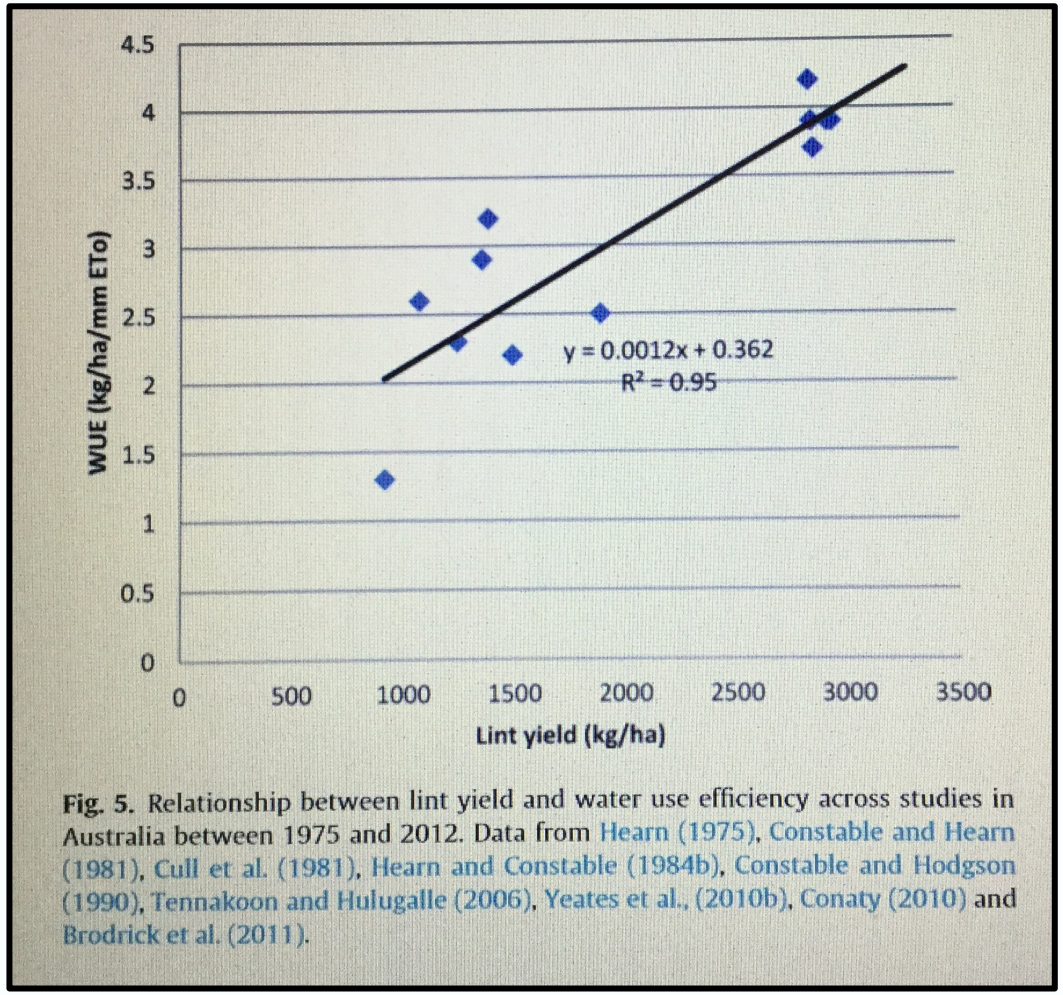


Fig. 5. Relationship between lint yield and water use efficiency across studies in Australia between 1975 and 2012. Data from Hearn (1975), Constable and Hearn (1981), Cull et al. (1981), Hearn and Constable (1984b), Constable and Hodgson (1990), Tennakoon and Hulugalle (2006), Yeates et al., (2010b), Conaty (2010) and Brodrick et al. (2011).

ie, more yield with same water use.

Nutrient use efficiency

- For cotton varieties released 1973 to 2006, nutrient use efficiency increased by >20% (kg lint yield/kg nutrient uptake).

- Current efficiencies, eg:
  - 15 kg/kg N
  - 70 kg/kg P
  - 12 kg/kg K

(*Rochester and Constable 2015*)

Future – vision for cotton research

- Opportunities for improved production and efficiency.
- New technology – eg molecular tools.
- Will production areas change? (Ord, NQ, Vic)
- Change in fibre quality preferences (*eg*, El).
- Problems/challenges:
  - Drought – direct and indirect politically.
  - Disease – Verticillium strain, new viral.
  - Pests and Weeds will remain/new.
  - Price – competition x2.
  - Research funding … lean and keen.
  - Researchers balance research v extension; basic v applied

FINISH

THANK YOU

Thanks to all researchers.

My personal thanks to all CSIRO cotton teams,

especially Norm Thomson, Peter Reid, Warwick Stiller and Shiming Liu