Enhancing cotton productivity in a changing climate

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Presentation Aims

Introduce some of the impacts of climate change on cotton production (some of our recent research)

Share some of my own thoughts how to meet some of these challenges......

Truly a snapshot!!

Crop focussed
Climatic changes in Australia

Australia's climate has warmed since 1910.

Source: Bureau of Meteorology

Australian surface air temperature
Some ‘Climate Change’ consequences in Australia

- Reduced water availability coupled with higher evaporative demand and potential water use
- Higher incidence of very hot days through season (lower net photosynthesis)
- Changes in frost/freeze incidence
- Potential changes in pest, weed and disease spectrum
- Increased incidences of extreme weather events
Some strategies to adapt to change

- Increase/maintain yields
- Improve production efficiencies
- Adaptive Management
- Harness understanding of existing variability
A focus on integrated climate change effects on cotton productivity
- Glasshouse and field experiments
Improving yield
What it takes to get the highest yields

Nutrient uptake of 384N, 83P, 384 K
Water Use – Crop Evapotranspiration – 10.7 Ml

Indeterminate growth habit with relatively slow fruit setting, but with greater final fruit number

Greater growth rates – higher and more efficient photosynthesis

Need crop resilience to stress

Healthy soil to allow these things
### Varietal development – exploit diversity

<table>
<thead>
<tr>
<th>Location</th>
<th>Summer Max.</th>
<th>Summer Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multan, Pakistan</td>
<td>42.3</td>
<td>28.7</td>
</tr>
<tr>
<td>Maricopa, Arizona, USA</td>
<td>41.6</td>
<td>24.1</td>
</tr>
<tr>
<td>Emerald</td>
<td>34.8</td>
<td>19.3</td>
</tr>
<tr>
<td>Narrabri</td>
<td>33.8</td>
<td>21.4</td>
</tr>
</tbody>
</table>

Monthly average
Improving Photosynthesis
Heat-Induced Photosynthetic Inhibition
The role of Rubisco?

Team models photosynthesis and finds room for improvement

CHAMPAIGN, Ill. — Teaching crop plants to concentrate carbon dioxide in their leaves could increase photosynthetic efficiency by 60 percent and yields by as much as 40 percent, researchers report in a new study.
Inter-Species Diversity in Heat Resilience
Demi Gamble ANU/CSIRO

G. australis
G. raimondii
G. hirsutum
G. sturtianum

New World AD-genome
G. aridum
G. klotschianum
G. harknessii
G. armourianum
G. trilobum
G. thurberi
G. gossypioles
G. raimondii

A-genome
G. herbaceum
G. arboreum

B-genome
G. anomalum

F-genome
G. longicalyx

E-genome
G. somalis

C-genome
G. sturtianum
G. robinsonii

G-genome
G. bickii
G. australis
G. Nelsonii
Photosynthesis & Stomatal Conductance
Old vs. New Genotypes

See Ziska et al. 2012 (review of other crops)
Heat tolerant varieties

Cell Membrane Integrity – higher values less tolerant

Pakistani Study (Azhar et al, 2009)

CSIRO study (Cottee)
Improving Production Efficiencies
Elevated carbon dioxide and warmer temperatures may alter how cotton plants grow.
Assessing water use and WUE in the glasshouse

The graph shows the relationship between biomass (g per plant) and water use (kg per plant) under different conditions:

- **Ambient CO₂**
  - Biomass range: 10 to 40 g per plant
  - Water use range: 0 to 12 kg per plant

- **Elevated CO₂**
  - Biomass range: 10 to 40 g per plant
  - Water use range: 0 to 12 kg per plant

- **Ambient temperature**
  - Biomass range: 10 to 40 g per plant
  - Water use range: 0 to 12 kg per plant

- **Warmer temperature**
  - Biomass range: 10 to 40 g per plant
  - Water use range: 0 to 12 kg per plant
Improving Water Use Efficiency

- **Alternative irrigation systems** (drip, overhead)
- **Better scheduling of irrigations** (dynamic deficits, plant based sensing)
- **Improving plant rooting zone** (min till, rotation, fallow)
- **Employing limited water management strategies**
  - Balancing area, with yield potential, cost and climatic risk (seasonal forecasts)
  - Utilizing stored soil water
  - Avoiding excess nitrogen
  - Skip row configurations
  - Avoiding stress during flowering
  - Consider rain-fed production.
  - Shorten the time to maturity
  - Modify sowing time
  - Monitor plant stress/soil water
Bio-degradable films to prevent soil moisture losses

TranspiratiONal (CSIRO)

Michael Braunack
Optimize crop nutrition through improved soil health
Cotton N uptake and use-efficiency

Study conducted over three different seasons

Rochester and Constable – Field Crops Research 2015
Nitrogen fixing crops

Transferring bacterial nitrogenase directly into plants

Advances in synthetic biology of bacteria and plants now allow CSIRO to re-investigate this 50 year old idea

Courtesy Craig Woods CSIRO
Adaptive Systems – Monitoring is the Key
Active Stress Management

- Aminoethoxyvinylglycine (AVG) ethylene inhibitor
- Applied 1 day before waterlogging event

![Graph showing yield vs. AVG rate](najeeb_2015.png)

Najeeb et al. (2015)
Growth regulator use in climate change conditions

For cotton grown at both high temperature and elevated CO₂, MC may not be effective in controlling vegetative biomass.

Temperature x CO₂ x Chemical: P<0.001
Data Driven / Digital Ag and Decision Making

How do we (humans) contribute to this?

How do we: ensure we capture peoples knowledge?
ensure the right questions are asked of the data/systems?
and ensure integrity of outcomes?

Each system needs to learn from each other
Harnessing Variability

Diversity meets Variability
Assessing the trends in heat accumulation for the cotton season

- 1957-2017 (60 years)
- 1957-1996 (39 years)
- 1997-2017 (20 years)
Climate Change and Variability: Learning

**Narrabri**

- Planting Year: 1960, 1980, 2000, 2020
- Day degrees: 2000, 2500, 3000, 3500

**Griffith**

- Planting Year: 1960, 1980, 2000, 2020
- Day degrees: 2000, 2500, 3000, 3500
Diversity helps us meet variability

Plant Today
Because it rained

Potential hot Period

Paddock 1

Paddock 2

Early rainfed planting that was delayed
TEP = Trinexapac ethyl. - Gibberellin biosynthesis inhibitor

Better Average Yield
Summing up

• Resilient climate ready cropping systems
  • not rely on any one option
  • flexibility to account for variability

• Opportunities and Challenges
  • Climate change and resource use tradeoffs
  • Regionally specific assessments will be vital
  • $\text{CO}_2 \times$ temperature $\times$ water $\times$ nutrition $\times$ genotype
  • (Transgenic and Digital) technologies will need to deliver benefits in the field
  • Challenging existing paradigms
  • Systems-based approaches will be needed
It is not the strongest of the species that survives, nor the most intelligent, but the one most responsive to change. -- Charles Darwin

Thank you