Defining agro-ecological regions for field crops in variable target production environments: a case study for mungbean

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Crop improvement requires

- Crosses of parents with desirable traits and selection of progenies for target production environments
- Evaluation of progenies in different environments
- Release of superior lines
Fair bit of modelling goes on in breeders’ mind to learn

- What traits should be considered for selecting parents in a crossing program?

- What environments will be suitable to test their lines?

- Which environments will their lines be better adapted to?

- Crop improvement becomes complicated for variable environments due to high g x e x m interactions
Lack of understanding about contributing factors can lead to

- Undefined environmental challenges
- Under exploitation of the environmental potential – the yield gap
- Seasonal fluctuations in yield will remain large
- Slows progress in breeding
- Farmers profitability and interest in the crop will decline
Biological characterisation of physical environment using crop models

- Helps identify factors that determine the yield potential and influence genotypic performance
- Characterise target population of environments (TEP) experienced by the crop in a region
- Assist in evaluating the role of different traits in conferring adaptation to different TEPs
- Define agro-ecologies based on above considerations
- Identify the most productive genotype x environment x management interaction in the GEM landscape
Defining agro-environments: a case study with mungbean

- Used mungbean as a case study to characterise its environments in the Northern Grains Region
- The industry has evolved well over the last 10 years
- Yields have remain low and variable
- The breeding focus has been on quality and disease resistance
- Adaptation to climatic variability equally important?
Characterising environments

• What type of production environments mungbean experiences in the region?
• Do these affect yield and by how much?
• Based on this info can breeders choose better test sites?
• Do we have environments which are similar (iso-environments)
• Traits that will confer better adaptation to these iso-environments
Characterisation of mungbean environments: model validation

The APSIM Model

Validation with observed data on Crystal

Yield
\[ y = 1x + 0.22 \]

\[ R^2 = 0.87 \]

(1:1 line)
Sites used in the study
Mungbean experiences five dominant moisture patterns in 28 locations of NGR

Drought adversely impacts mungbean in >2/3rd of the years
Extent of variability in yield
Cumulative probability distribution across seasons among a few sites
Stress patterns in the sites of two different clusters
Defining agro-ecoregions based on seasonal risk to production
Frequency of stresses at individual sites in the NGR
Principal component analysis of yield and drought frequencies

\[ y = -0.8669x - 3 \times 10^{-10} \]
\[ R^2 = 0.6817 \]

\[ y = 0.132x + 1 \times 10^{-11} \]
\[ R^2 = 0.1229 \]

\[ y = 0.1019x - 2 \times 10^{-17} \]
\[ R^2 = 0.0035 \]

\[ y = -0.2801x - 4 \times 10^{-11} \]
\[ R^2 = 0.203 \]
Defining agro-eco regions and frequencies of moisture patterns

- **Central Queensland Highlands**
  - Clermont: 13%
  - Capella: 10%
  - Emerald: 36%

- **Western Darling Downs**
  - Clermont: 21%
  - Capella: 20%
  - Emerald: 38%

- **Burnett**
  - Clermont: 20%
  - Capella: 22%
  - Emerald: 24%

- **Douglas**
  - Clermont: 22%
  - Capella: 24%
  - Emerald: 22%

- **Eastern Darling Downs**
  - Clermont: 22%
  - Capella: 23%
  - Emerald: 22%

- **Dawson-Callide**
  - Clermont: 19%
  - Capella: 22%
  - Emerald: 24%

- **Liverpool Plains**
  - Clermont: 20%
  - Capella: 21%
  - Emerald: 22%
Do traits affect drought frequencies?

Crystal

Satin
Summary

- A novel method to define mungbean agro-ecoregions using APSIM has been developed which helps identify drought challenges in different regions.
- This new method can greatly increase the geographical relevance of crop modelling work.
- The types and frequencies of drought patterns mungbean experiences in Queensland have been characterised.
- Overall drought reduces yield of mungbean in about 2/3rd of the years (when diseases and insects are under control).
- A paper that discusses implications of this work for breeding and agronomy is being submitted to Agriculture and Forest Meteorology.