Wheat Breeding Programs

InterGrain – private company – WA Govt & GRDC
(Grain research and Development Corporation - grower levies and Federal Govt) – revenue source is EPR

Four wheat breeding programs based in WA covering Australia (emphasis on WA)

• Four Wheat Breeders
• 180,000 plots/year across 14 sites
• 3,000 crosses/year
Structure of Programs –

each with different white grained spring wheat germplasm

• “North Wheat program” (Iain Barclay)
  – North and Central WA
  – Drought tolerance & aluminium tolerance

• “Specialty program” (Robyn McLean)
  – Backcrossing rust resistance and sprouting tol into adapted lines
  – Udon noodles

• “Southern program” (Chris Moore)
  – Disease resistance emphasis
  – Alkaline soils tolerance in WA and SA

• “Eastern program” (Robin Wilson) – Vic & NSW
Wheat Breeding Objectives

- **Yield and adaptation**
  - Abiotic stress tolerance (Al Boron, Drought, Waterlogging and sprouting)

- **Quality (95% WA wheat exported)**
  - Six Milling Grades – White grain and Spring Wheat
  - Receival characteristics such as test weight, screenings, black point, low LMA etc

- **Disease resistance**
  - Three Rusts
  - Septoria nodorum blotch
  - Yellow spot
  - Septoria tritici blotch
  - Barley Yellow Dwarf Virus
  - Cereal Cyst Nematode
Wheat Breeding Methodology

- F2 Progeny Method (major)
- Backcrossing
- Doubled haploids & Single Seed Descent
  - routinely used often with Molecular Marker enrichment
- Marker Assisted Selection
Wheat Breeding Success

• Genetic Gain for yield – 1% per annum
• Quality
  – All our varieties eligible for premium grades
  – All Noodle and Aust Soft vars from our prog
• Disease resistance
  – Latest varieties have improved resistance
eg Wyalkatchem has better resistance to leaf and stripe rust compared to Westonia
• Abiotic stress tolerance
  – Wyalkatchem & Westonia drought tolerance
<table>
<thead>
<tr>
<th>Rank</th>
<th>Variety</th>
<th>Grade</th>
<th>%</th>
<th>Cumul %</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Wyalkatchem*</td>
<td>Aust Premium White</td>
<td>29.4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Calingiri*</td>
<td>ASWN (Noodles)</td>
<td>15.9</td>
<td>45.3</td>
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<tr>
<td>3</td>
<td>Carnamah *</td>
<td>Aust Hard</td>
<td>7.9</td>
<td>53.2</td>
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<tr>
<td>4</td>
<td>Yitpi</td>
<td>Aust Hard</td>
<td>7.6</td>
<td>60.8</td>
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<tr>
<td>5</td>
<td>Arrino*</td>
<td>APN (Premium Noodles)</td>
<td>7.1</td>
<td>67.9</td>
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<tr>
<td>6</td>
<td>Bonnie Rock*</td>
<td>Aust Hard</td>
<td>7.0</td>
<td>75.0</td>
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<tr>
<td>7</td>
<td>Westonia*</td>
<td>APWT</td>
<td>4.4</td>
<td>79.4</td>
</tr>
</tbody>
</table>

* From our breeding programs - 78% of area
Utilising New Technologies

• Considerable progress on the utilisation of the molecular marker technology
  
  – at several stages in the program including BC*F1 enrichment prior to backcrossing or production of doubled haploids or use in SSD
  
  – progress has been made for traits that are difficult to phenotype such as pre-harvest sprouting tolerance, or diseases such as BYDV
Utilising New technologies

• Molecular Marker Development
  – We have developed and phenotyped populations that have enabled molecular markers to be generated in conjunction with SABC (State Agricultural Biotechnology Centre) & CSIRO
  – eg marker for the rust resistance gene complex in Wyalkatchem (Yr29/Lr46) Loughman, Lagudah, Shankar etc

• Wyalkatchem selns

YrR YrR YrR Yrs YrR YrR Yrs

Attila ^
Utilising New Technologies

- Rust screening of all lines prior to any yield test
  - at Carnarvon (stem and leaf rust)
  - and
  - Manjimup (stripe rust)
Utilising New technologies

- Application of new quality calibrations for Near Infrared Reflectance (NIR)
  - for protein, flour yield and colour and water absorption
to all crossbreds before yield testing

Non-destructive small grain sample 50-100g
~250 samples / day
startup $$ high
Utilising New technologies

Quality

• a new quality test for micro-water absorption has been developed that allows this to be measured earlier in the program and on only 10 grams of seed

• Automation of preconditioning for milling tests means a greater throughput of samples
• Routine use of optimal trial designs and analysis methods
  – breeding lines can be placed at more sites than previously without loss of precision with new un-replicated designs, which can also have partial replication (Stefanova & Clarke, 2006)
Utilising New technologies

- automatic seed preparation machine will enable partial replication designs to be used, and routine different randomisations at each site
Utilising New technologies

• trial analysis
  – greater discrimination has been made by accounting for spatial trends over the trial
  – trials are routinely analysed adopting
    • a spatial linear mixed model approach (Gilmour et al., 1997) and
    • multiplicative models (Smith et al., 2001) using ASREML.
Plant Breeding database management system - “PBGenesis”

- designed by breeders
- is used for all operations involved in running large breeding programs
- has greater functionality than existing software packages
- is presently being developed into a web-based system
Utilising New technologies

Computerisation

Direct printing onto sample packets or harvest bags

Bar coding harvest samples
Collaboration

• ARC Linkage project with Hossein Saberi and Zed Rengel (UWA) on tolerance to Al, Mn and Fe toxicities
  – Provide information to *growers* and *breeders* as to which varieties are tolerant to each
  – identify *probe varieties* to establish the extent of areas affected by ion toxicities
  – Better understand the role of toxicity tolerance in *coping* with transient waterlogging
Collaboration

- Utilisation of sources of abiotic stress tolerances, eg waterlogging tolerance
  - strong linkage of our wheat breeding programs with the physiology group including UWA and international partners in India and China
  - project with India has identified good sources of waterlogging tolerance in varieties and the doubled haploid lines from the population used in this project
  - these are being used in the breeding programs in each country
Future Challenges and Opportunities

• Transition from DAFWA to Intergrain
  – Resources available (dependant on season)
  – Personnel in the company vs contract
  – Move to have impact on eastern states (and consequences on breeding for WA)
    • Need for functional markers for Cereal Cyst Nematode resistance (important in SA & Vic)
Future Challenges and Opportunities

• Marketing the wheat crop
  – With export wheat market deregulated there are now to be several marketers
  – We will need to establish relationships with each to ensure we are breeding for their market requirements
  – Marketers vary considerably in experience
  – Ensure Australia’s good reputation for quality is not diminished
  – Learn how to read the market trends
Future Challenges and Opportunities

- Further utilisation of the molecular marker technology
  - Need for the markers to have a greater impact in the selection phase (presently mostly used in BC*F1 enrichment phase)
  - Many markers need further refining
  - Development of markers for traits difficult to phenotype
  - Followup Hossein Saberi’s work with screening Doubled Haploids for ion toxicity tolerance to develop molecular markers
Future Challenges and Opportunities

- Targeted identification of parental material (prebreeding)
  - Scan Winter Cereals collection (AWCC) material selected to come from areas where the problem occurs regularly to identify new sources of variation to be utilised by breeders.
  - Build on UWAs's strength in selecting ion toxicity tolerance in new parental material.
Crop improvement Education

- We welcome the involvement of some UWA students in learning about our breeding programs by interview and assignment.
- An ideal time to see the breeding program is in the spring when students can appreciate the differences in wheat varieties, and see most of the stages of breeding before them.
- We would suggest seeing if you can take advantage of this opportunity to see the program in the field.
Breeding Methodology – F2 Progeny

Year
1. Parent 1 x Parent 2
2. Spaced plants - Selection of elite plants
3. Selection of elite F₃ bulks
   - Markers
   - Doubled Haploids
   - Single Seed Descent
   - Backcrossing
   - Bulk Methods
4 & 5. STAGE 1 - two years yield, quality and disease data
       - Reselection of elite lines
       - Seed increase
Breeding Methodology – F2 Progeny

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
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<tbody>
<tr>
<td>7 &amp; 8</td>
<td>STAGE 2 - two years yield, quality and disease data</td>
</tr>
<tr>
<td>9</td>
<td>STAGE 3</td>
</tr>
<tr>
<td>10 - 12</td>
<td>STAGE 4 - at least two years</td>
</tr>
</tbody>
</table>

- Reselection of elite lines → Seed increase
- CVT Widescale testing
- STAGE 3
- Release as a variety → Seed available to farmers
- STAGE 4 - at least two years → Seed Growers

Seed available to farmers