Review of Program 4

12th February 2002

Compiled by: Clare Johnson
Review of Program 4:

Germplasm Production,
Agronomy & Storage

12 February 2002

Convened by
Drs Peter Sharp and Matthew Turner

Compiled by Clare Johnson
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Summary of Discussion (to be read as an adjunct to the slides)  

Clare Johnson

The benchmarking component of the Flexibility project (QWCRC project 2.1.5, now VAWCRC project 4.1.4) has been completed, but results are not as useful as expected, due to flawed experimental design. As project 4.1.5 had only started in January, it was not reviewed.

Project 4.1.1: New Genetic Markers for Quality Traits
- Novel Variation  

Matthew Turner

Traits being examined include low blackpoint, high apparent amylose, milling yield and water absorption, and noodle brightness and colour. The slides demonstrate a trend toward decreased water absorption in Australian varieties, correlated with selection for higher milling yield. Pentosans (non-starch polysaccharides) are under investigation.

Water absorption is to be measured in lines in the current experiment, to overcome conflicting data from the past, in which apparent water absorption depended on the extraction method used. There is also a need to examine flour colour vs milling yield. Barley could provide a useful source of blackpoint resistance.

- Molecular Markers  

Mui-Keng Tan

Markers for Late Maturity Amylasc (LMA), which correlate with phenotypic data, have been identified. Maringa provides the non-LMA tag, and Spica provides the high LMA tag. In a Spica X Maringa cross, 60% of lines lacked LMA, while 40% had LMA, and as the gene seems to be the same in both types, this defines the QTL. Seven polymorphic alleles have been examined.

Work has also begun on marker development for sprouting tolerance. Cascade X Aus1408 is being used in preference to Janz X Aus1408. (Janz X Aus1408 could nonetheless be worth examining, as markers are on chromosomes other than 3D, which had in the past had insufficient crossing over). The aim is to obtain 16 markers well-distributed over the region. There is a 50 CentiMorgan gap near the telomere. Some incorrect labelling has been identified in the Oxley X Aus1308 3DL chromosome.

In explanation of some slides, PaagMgct (slide 14) is an AFLP marker which has been converted into an STS marker. The vpl gene (slide 15) is discussed in the TAGS spring X winter wheat paper mentioned by Michael Francki (below).

F. Ellison queried the use of germination index (GI) for typing, and advised it would be better to use something present in the seed coat or embryo. GI creates noise for phenotyping. He suggested crossing two sources of LMA and obtaining information on the two alleles. Peter Sharp agreed to look for some suitable populations.

- Molecular Markers  

Michael Francki

Work has also started on marker validation for grain quality, and discovery for disease resistance in WA-adapted germplasm. Over 100 polymorphic SSR markers for resistance to Septoria nodorum blotch have been identified for mapping. Marker-trait validation studies for flour colour will be performed initially on a Cadoux X Reeves doubled haploid population (both null 4A noodle wheats). Other populations for marker-trait validation are listed on slide 4.
Project 4.1.2: Rapid Breeding Technologies – Novel Adapted Wheats

- Doubled Haploids

Nizam Ahmed
This project started in July 2001. Nizam reported that he now has the capability of producing doubled haploids throughout the year. In response to a query by Neil Howes as to why this had been a problem, since the technology is working well in other states, it was agreed that a visit be arranged so that an exchange of techniques could occur.

- Durum Wheats

Mike Sissons
The project is focussed on development of full and partial-waxy durums and high amylose durums. The Watanabe high amylose durum collection has now been screened completely for amylose. Of 16 accessions identified with amylose >30%, 9 lines are at Tamworth, with no restrictions on their use, while 7 need to go through quarantine and will be available in early 2002.

A PhD student, Cindy Soh, will start in late May, using reconstitution techniques to give breeding programs an indication of new targets and products.

Andrew Kennett expressed interest in pasta that can survive retorting, for Campbell's canned goods, since current Australian pasta is unsuitable. This could be related to stickiness and high amylose. He and Mike Sissons agreed to discuss this further, for Arnott's and wider application. Europe currently imports US pasta at $500,000/year.

Project 4.1.3: Elite Germplasm with New & Novel Quality Attributes

- Prime Soft Wheat

Frank Ellison, for Shakir Shah
QAL2000 had undesirable stripe rust susceptibility. Advanced lines 2001-13 (soft, similar to QAL2000) and 2001-15 (club-type, similar to WA variety, Tincurrin) exhibit better resistance, along with other desirable disease resistance, processing properties and agronomic quality, as listed in the slides. (Note: not all data in these tables came from the same set, so protein differences are not significant.) These lines could feed into the soft wheat trials of project 4.1.5. The club-headed wheat could be tested in WA. Despite disruption at PBI Narrabri, it is logistically feasible to continue this work.

- Waxy Wheat

Mohammad Shariflou
Abbreviations: MAS = Marker-assisted selection; PVT = Preliminary yield trial.; AYT = Advanced yield trial.

Discussion focussed on the recent contamination of waxy wheat, and how to prevent any future occurrence. The error had occurred prior to sowing. Peter Sharp was charged with putting procedures in place for appropriate quality control in future.

Molecular markers had not been used to estimate the recurrent parents, and Mike Francki suggested markers across the genome could be used, with multiplexing. Lots of back-cross seed would be required, and this is not feasible. We are seeking properties markedly better than those of the recurrent parent, not just the recurrent parent plus the waxy trait. Other important QTLS should be considered. If we obtain a good line after this season, commercialisation would be possible in 2004 following seed increase. Rust testing is included in the current protocol.
- B granules

Extremes in B-granule content were identified in earlier work, from which *Ae. Crassa* / 3*Kewell F5 grains were multiplied in 2001 and will be available for analysis in 2003. In Vulcan X Kewell doubled haploids, we are seeking B-granule content similar to Vulcan’s 32%, but yield better than Vulcan’s 1.59 t/ha, and have a number of lines suitable for quality evaluation. Di Miskelly is liaising with Ken Quail and Helen Allen – project 2.1.2, covering such evaluations, has started.

A source of low B granules, “Outlier 67”, has been crossed with Vulcan, and doubled haploids produced. Crosses of Outlier 67 with Janz, Sunstate and QAL2000 will progress toward doubled haploid production next year.

Starch manufacturers work on a commodity basis, using the cheapest source. Discussion with Manildra may be productive – Ian Batey and Colin Wrigley are already in discussion there. Neil Howes and DI Miskely were asked to discuss low B-granules and low polyphenol oxidase with Manildra, with Peter Vaughan’s involvement, and to inform Matt Turner of the outcome. Strong gluten is another niche that could be explored with this starch/gluten manufacturer.
Program Overview

Peter Sharp
Value-Added Wheat CRC
Program 4

Germplasm Production
Agronomy Storage

4.1.4 Flexibility of wheat use
Helen Allen
QWCRC 2.1.5 GRDC Funding
Completed
4.1.5 Increasing the quantity of grain delivered to premium grades
Andrew Verrell
Develop management for growers to improve chances of achieving quality targets
NSW Agriculture, Agriculture WA, SARDI, biscuit, noodle, durum milling, noodle durum
Commenced 1/1/2002

4.1.1 New genetic variation & markers for quality traits
Matthew Turner & Peter Sharp
4.1.2 Rapid breeding technologies
Nizam Ahmed
4.1.3 Elite germplasm with new & novel quality attributes
Frank Ellison & Reg Lance

4.1.1 New genetic variation & markers for quality traits
Aims:
- extend the range of variation in important traits beyond that now available
- develop markers for this variation to allow rapid introgression

Research Providers:
University of Sydney Agriculture WA
NSW Agriculture Queensland DPTI
4.1.1 New genetic variation & markers for quality traits

**Targets:**
- LMA
- Sprouting
- Blackpoint
- Lipoygenase
- Flavonoid content
- Milling Yield
- Non-starch polysaccharides
- Noodle quality

4.1.2 Rapid breeding technologies - novel adapted wheats

**Aims:**
- Efficient rapid breeding technologies (doubled haploids & markers)
- Rapidly introgress new variation into adapted germplasm

**Research Providers:**
- University of Sydney
- Agriculture WA
- NSW Agriculture
- SARDI

4.1.2 Rapid breeding technologies - novel adapted wheats

**Targets:**
- low LMA
- high flavonoid content
- sprouting resistance
- high protein content
- low PPO
- zero blackpoint

4.1.3 Elite germplasm with new & novel quality attributes

**Aim:**
- To develop elite germplasm with new & novel quality attributes that can be commercialised through CRC partners

**Research Providers:**
- NSW Agriculture
- Agriculture WA
- University of Sydney
4.1.3 Elite germplasm with new & novel quality attributes

Targets:

- soft biscuit quality
- low & high B-granule contents
- "waxy" starch
- high amylose starch

Target traits

- screening
- DNA, molecular markers
- introgress into adapted lines
- DAS, molecular markers
- plant breeding, quality testing

Released germplasm
- commercialisation

$\text{mmmm for VAWCRC}$
Project 4.1.1:
New Genetic Markers for Quality Traits

- Novel Variation

Matthew Turner
VALUE ADDED WHEAT CRC

Project 4.1.1

NEW GENETIC VARIATION AND MARKERS FOR QUALITY TRAITS

Matthew Tumer

PROJECT OUTLINE

- Identification of new sources of variation
- Identification of molecular markers for desirable characters
- Characterisation of relationships between quality and variation for a character

NEW SOURCES OF VARIATION

- Low blackpoint incidence
- High apparent amylose content
- Milling yield and water absorption
- Noodle brightness and colour

IDENTIFICATION OF MARKERS

Initial targets include:

- Sprouting tolerance
- Late maturity alpha amylase
- Flour swelling volume
- Septoria resistance
CHARACTERISATION OF RELATIONSHIPS

- Starch granule size distribution and product quality
- Yellow pigments and noodle brightness

BLACKPOINT INCIDENCE

- Blackpoint is a grain discolouration that results in downgrading to feed wheats
- It is associated with humid conditions during grain filling
- Most Australian wheat varieties are susceptible to blackpoint

PROGRESS

- The most well characterised source of resistance is "Cascades". This resistance is not complete.
- Better sources of resistance have been identified in barley

- 75 hexaploid wheats were grown in pots at South Perth and in the field at Northampton
- 150 synthetic wheats were grown at Narrabri with overhead irrigation
- It appears that blackpoint was induced at all sites and the material is being evaluated
MILLING YIELD & WATER ABSORPTION

- Milling yield and flour water absorption are inversely correlated.
- Seed size and shape influence milling yield.

PROGRESS

- Large grained backcross material has been generated in Sunco, Sunfield and Hartog backgrounds.
- These are to be multiplied and evaluated for milling yield.

- The role of pentosans (non starch polysaccharides with high affinity to water) in influencing water absorption is being investigated.
- To complement this strategy, some reputed high milling yield wheats from overseas are being evaluated.
COLOUR

- Colour and brightness are important criteria by which noodle quality is assessed.
- Daring wheats have high PPO activity. PPO is an undesirable character.
- Most hexaploid wheats have high PPO activities. The lowest PPO bread wheats are moderately high.

NODDLE BRIGHTNESS &

- Large seeded synthetic wheats (60mg) X Lang F1's generated
- Material has been dispatched to Neil Howes (CARGO) to generate double haplotypes

PROGRESS

- Approximately 75 synthetic wheats and 15 amphiploid wheats have been evaluated for PPO activity using a small scale test.
- Some of this material exhibits significantly lower PPO activity than that observed in Australian wheat varieties.
- The lines were grown and evaluated for PPO activity confirming initial observations and rust resistance. Crossing to Lang was performed.

COLOUR

- Colour and brightness are important criteria by which noodle quality is assessed.
- Daring wheats have high PPO activity. PPO is an undesirable character.
- Most hexaploid wheats have high PPO activities. The lowest PPO bread wheats are moderately high.
THE RELATIONSHIP BETWEEN b GRANULE CONTENT & MILLING YIELD

- A subset of a Vulcan X Kewell double haploid population was grown at Narrabri. Their flour yields were determined and related to the previous years field b granule data.
- A relationship between b granule content and milling yield was observed in this material.

Comparison of flour milling yield of wheat lines varying for B granule content
Project 4.1.1:
New Genetic Markers for Quality Traits

- Molecular Markers

Mui-Keng Tan
Marker Development for LMA
Moi-Kong Tan

Populations examined:
1. Spica X Aus1408 (30 lines)
2. Spica X Maringa (125 lines)
3. Jaz X Cleo-inia (55 lines)

Previous work:
- A QTL on 7BL in Halberd X Craokes
- A gene on 6BL

Correlation of LMA phenotype with markers

Spica X Maringa SD subpopulation (66 lines)

Phenotypes of genotypes with high LMA
- Xgwm377, LRS=7.3
- P=0.007
- Xgwm377, LRS=1.7
QT links report using quantitative trait, GI
Chi square statistics, P=0.01

QT links report using quantitative trait, GI (genomewide max)
Chi square statistics, P<0.01, additive regression model

<table>
<thead>
<tr>
<th>Chr</th>
<th>Locus</th>
<th>LRS</th>
<th>%</th>
<th>P</th>
<th>Add</th>
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<td>3AL</td>
<td>Vp1</td>
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<tr>
<td>4BL</td>
<td>PaqMget</td>
<td>7.5</td>
<td>8</td>
<td>0.00615</td>
<td>-0.05</td>
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<tr>
<td>7BL</td>
<td>C61214B</td>
<td>10.0</td>
<td>10</td>
<td>0.00155</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Vp1 on 3AL

LRS=11.5

LRS=14.5

Acknowledgements:

• Dr. Peter Sharp
• Dr. Matthew Hayden
• Dr. D. Mares
• Ms Resu Srivastava
• Luo Shuming
• Chen Jiai
• Grant Chambers
Project 4.1.1: New Genetic Markers for Quality Traits

- Molecular Markers

Michael Francki
Marker validation for grain quality attributes and discovery for disease resistance in WA adapted permpulse.

- Dr Michael Francki
- Prof Rudi Appels
- Ms Karon Ryan

Aims

- Validate marker-trait association for quality attributes in WA populations
- Identify novel markers linked to Septoria resistance
- Implement molecular markers for quality and disease resistance in WA breeding program

Priority quality attributes for marker-trait validation

- Flour colour
- Flour swelling volume (null-4A varieties)
- Grain size
- Milling yield
- Water absorption

DH populations: Marker-trait validation

- Flour colour
  - Cadoux x Reeves 132 individuals
  - Westonia x Janz 203 individuals

- Grain size
  - Westonia x Janz 203 individuals

- Flour swelling volume
  - Cadoux x Reeves 132 individuals
**RIL populations: Marker-trait validation**

- **Milling yield**
  - WAWHT2046 x Carnamah: 133 indiv.
  - Water absorption
  - Ajana x WAWHT2074: 248 indiv.

- Validation commenced Feb 2002

**Developing efficient system to analyze SSR markers**

- Validation populations
  - 716 individuals in all populations

- Assuming 200 markers for validation using framework maps
  - 143,200 samples

- PAGE systems
  - Protean XII Cell system (20 cm x 20 cm)

**PAGE system Protean XII Cell system**

- **Advantages:**
  - High throughput (200-300 samples/day)
  - Short run times (3-5 hours)
  - Multiplexing capabilities
  - Inexpensive

- **Disadvantages:**
  - Detection of > 5 bp differences

**RIL population - Marker discovery for disease resistance**

- RIL mapping population for Septoria resistance

- Screened 280 SSR markers across five parents (Protean XII system)

- Identified 117-126 polymorphic markers for mapping

- Screening mapping populations commencing Feb 2002
Project 4.1.2:
Rapid Breeding Technologies/
Novel Adapted Wheats

- Doubled Haploids

Nizam Ahmed
VALUE ADDED WHEAT CRC

Project 4.1.2

RAPID BREEDING TECHNOLOGIES
NOVEL ADAPTED WHEATS

Doubled Haploid Production
Nizam Ahmed

DOUBLED HAPLOID PRODUCTION

- During the last year, significant progress has been made in doubled haploid production
- About 800 spring wheat haploids have been produced and half of them were treated with colchicine

DOUBLED HAPLOID PRODUCTION

- First lot of doubled haploid spring wheats will be harvested next month
- We inherited only a few seeds for each cross and as a result the number of doubled haploid for each cross will be limited

PROTOCOL REFINEMENT

New dose for 2,4-D

- We have confirmed our findings that 80 ppm, 2,4-D + 40 ppm Kinetin was more effective in producing embryos than 100 ppm 2,4-D + 60 ppm Kinetin normally used. We are now using the new dose for routine work.
PROTOCOL REFINEMENT

New 2,4-D application technique

- We have confirmed that the technique we developed for 2,4-D application was at least 5 times faster than the earlier technique. We are using the new technique for routine work.

PROTOCOL REFINEMENT

Spike culture

- As reported earlier, high temperatures during the summer months, badly affect embryo development and its quality
- Although we have been able to produce sufficient numbers of embryos during this summer, we did not get the expected number of haploids from them because of poor germination (30%)

PROTOCOL REFINEMENT

- In order to overcome this problem, we are now culturing the spikes in a solution containing 2,4-D and sugar
- Initial results indicate that the frequency of embryos developed by this system was similar to that obtained with the usual technique
- However, the germination rate of these embryos appeared to be much higher (70%). Further tests are being performed to confirm these results.

PROTOCOL REFINEMENT

- This technique will allow us to produce doubled haploids throughout the year
- This will also help us to produce doubled haploid from those genotypes, which are susceptible to the required dose of 2,4-D
**POPULATIONS FOR VAWCRC PROJECTS**

**GRDC US284 Milling Yield**

**Component**: New sources of variation for high milling yield. (Project 4.1.1)

- Hybrids involving parents with low and high flour yields are being grown at SARDI for DH production

**POPULATIONS FOR VAWCRC PROJECTS**

**GRDC US284 Milling Yield**

**Component**: Large grained wheats for enhanced milling yield, grain protein content and plant vigour. (Project 4.1.1)

- Hybrids involving large grain & large embryo wheats (2 crosses) are being grown at P3IC for DH production
- Hybrids involving large grained and large embryo wheats (5 crosses) are being grown at SARDI for DH production
- Hybrids between large grained parents and Lang (2 crosses) are being grown at SARDI for DH production

**POPULATIONS FOR VAWCRC PROJECTS**

**Waxy Wheats**

*Project 4.1.3*

- BC3 Janz waxy plants are growing for DH production

**POPULATIONS FOR VAWCRC PROJECTS**

**Noodle Brightness**

*Project 4.1.1 - Polyphenol Oxidase*

- Hybrids between null PPO synthetic wheats and Lang (2 crosses) are being grown at SARDI for DH production
Project 4.1.2: Rapid Breeding Technologies/ Novel Adapted Wheats

- Durum Wheats

Mike Sissons
**VALUE ADDED WHEAT CRC**

**Project 4.1.2**

**RAPID BREEDING TECHNOLOGIES**

**NOVEL ADAPTED WHEATS**

**Durum Wheats**

Mike Sissons

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**Durum Work**

- Who is involved?
  - NSW Ag Tamworth
  - M Sissons, R Hare, casual assistance as needed
  - PhD student-Ms Cindy Soh
  - U of S Cobbity
  - M Turner

- Topics
  - develop waxy and high amylose durum wheat
  - breed for low LOX activity
  - reconstitution to elucidate targets for breeders

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**Waxy proteins in Durum Wheat**

<table>
<thead>
<tr>
<th>Chromosomes</th>
<th>Wx-Al loci</th>
<th>Wx-B1 loci</th>
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</thead>
<tbody>
<tr>
<td>7A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4A</td>
<td>Mutations</td>
<td>reduction GBSS</td>
</tr>
<tr>
<td>7A Sissons</td>
<td></td>
<td>decrease amylose</td>
</tr>
<tr>
<td>4A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Develop partial and full waxy durum wheats**

**Why?**

- potential new uses for durum wheat as starch
  - properties of Wx durums are markedly different to normal durum starch
- starch affects pasta quality
  - Sissons, Sissons, Radler, and Jenner J Cereal Sci. (in press)
  - Grant et al Cereal Chem 2001 78:390-395
  - Giambell, Sissons, Moore, and Harry RACI CCC 2003 pp 429-433
  - Giambell, Sissons, and Bassy JACI CCC 199 pp 366-264
Waxy durum wheats - Approach

- Using partially waxy null-4A and null-7A durums cross into adapted material using backcrossing and create full waxy double null
- Characterise protein, starch, dough rheology, grain properties and pasta making quality of final lines grown in field (long term)

Waxy durum wheats - Results

- 69 F2 plants from a cross between elite durum and null-7A were screened for GBSS status using PAGE method developed at Cobbity
- NN 27
- Nn 22
- nn 20

Tested homogeneity of 4 nulls (testing 10 seed of each line - all null)

Performed RVA analysis on isolated starch

<table>
<thead>
<tr>
<th>Sample</th>
<th>Peak V</th>
<th>Breakdown</th>
<th>Final V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>217</td>
<td>156</td>
<td>179</td>
</tr>
<tr>
<td>Null-7A</td>
<td>299</td>
<td>232</td>
<td></td>
</tr>
<tr>
<td>Null-4A</td>
<td>366</td>
<td>199</td>
<td></td>
</tr>
<tr>
<td>BC2 null-7A</td>
<td>324</td>
<td>318</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>301</td>
<td>226</td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>390</td>
<td>326</td>
<td></td>
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<tr>
<td>85</td>
<td>249</td>
<td>277</td>
<td></td>
</tr>
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</table>
High Amylose Durums

- Why develop?
  - High amylose content increases resistant starch fraction of the starch. This type of starch has benefits like fibre for human health. Possibly pasta with higher than normal amylose could be beneficial to human health—novel product
  - Evidence from reconstitution studies shows higher amylose durum starch produces pasta with lower stickiness
  - Glanville, Shewry, and Batey, RACI CCC, 199 pp. 268-264

High Amylose Durums - Approach

- Screening germplasm banks of T. durum has identified accessions with apparent amylose >40% of normal durum wheat ~25-28% (Watanabe et al. Euphytica 101: 289-306, 1998)
- Collection screened by Watanabe identified, imported and screening for amylose in progress (450/655 screened-11/01)

High Amylose Durums - Results

- 16 accessions with amylose >30% identified
  - 9 found in WCC planted 2002 — crossed to elite durum
  - 7 need to go through WCC quarantine glasshouse — early 2002

PhD Project

- Using reconstitution techniques developed in QWCRC Durum project 4.1.3 further develop the work to provide breeding programs (and processors) an indication of new targets/products for the market place. The advantage of this system is being able to manipulate the composition of a dough in a defined way so that the effect of one variable can be measured.
PhD Student

- Student offered/accepted
  - Ms Cindy Soh
    - B. Food Science and Technology (hon 2A) Curtin University of Technology (WA)
    - Honours project: defining the quality of dried pasta
    - Currently working as a food technologist for Singapore Airlines In-flight Catering
    - Australian resident
    - Excellent references from Graham Crookie and Vicky Solah
    - Plans to start late May
Project 4.1.3: Elite Germplasm with New & Novel Quality Attributes

- Prime Soft Wheat

Frank Ellison
EVALUATION OF SOFT WHEAT BREEDING LINES

- In 2001, 117 soft wheat breeding lines were tested in 2
ground trials (AYT1 & AYT2) planted at multiple sites,
namely, Northstar (NSW), Narrabri (NEB), West Wyal
(WWA), Forbes (FBS), Cobariby (CBY), Numurkah
Irrigated (NMX), and Numurkah Dryland (NMKD).

AYT1 & AYT2
No. of series = 81 & 38
Design = 6x6
Lattice square with two replications
Plot size = 6m x 1.7m

EVALUATION OF SOFT WHEAT BREEDING LINES

- Nearest Neighbours Analysis (NNA) was used to
adjust the mean values using following
options (1). Adjacent residue (2). Pbi layout-
Cartesian. (3). No. of plots per range were 9 &
5 for AYT1 and AYT2 respectively.

- Several lines with comparable grain yield and
superior disease resistance to QAL 2000 were
identified from these analyses.

Table 1.1
Grain yield production across regional sites

<table>
<thead>
<tr>
<th>Site</th>
<th>CV adjusted (%)</th>
<th>CV unadjusted (%)</th>
<th>Relative precision (%)</th>
<th>Site Mean ± SE (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northstar (NSW)</td>
<td>8.3</td>
<td>10.8</td>
<td>157.2</td>
<td>4.7 ± 0.3</td>
</tr>
<tr>
<td>Narrabri (NEB)</td>
<td>6.2</td>
<td>9.9</td>
<td>215.1</td>
<td>5.2 ± 0.3</td>
</tr>
<tr>
<td>West Wyal (WWA)</td>
<td>7.8</td>
<td>9.9</td>
<td>152.0</td>
<td>7.3 ± 0.3</td>
</tr>
<tr>
<td>Forbes (FBS)</td>
<td>10.6</td>
<td>19.0</td>
<td>285.2</td>
<td>2.8 ± 0.3</td>
</tr>
<tr>
<td>Cobariby (CBY)</td>
<td>28.8</td>
<td>45.2</td>
<td>243.9</td>
<td>2.8 ± 0.7</td>
</tr>
<tr>
<td>Numurkah (VPC)</td>
<td>1.7</td>
<td>3.1</td>
<td>161.3</td>
<td>2.3 ± 0.2</td>
</tr>
<tr>
<td>1. Crop yield</td>
<td>7.0</td>
<td>11.7</td>
<td>255.5</td>
<td>6.3 ± 0.5</td>
</tr>
</tbody>
</table>
Table 1.2
Heritability (h²) estimate before & after adjustments in different environments

<table>
<thead>
<tr>
<th>Site</th>
<th>H2 adjusted (%)</th>
<th>H2 unadjusted (%)</th>
<th>Site Mean (UHμ)</th>
<th>LSD 0.05 (1-sided)</th>
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<tbody>
<tr>
<td>Northstar (NSW)</td>
<td>70</td>
<td>21</td>
<td>4.7</td>
<td>0.6</td>
</tr>
<tr>
<td>Narrabri (NSW)</td>
<td>80</td>
<td>29</td>
<td>5.2</td>
<td>0.5</td>
</tr>
<tr>
<td>West Waia (NSW)</td>
<td>76</td>
<td>37</td>
<td>7.3</td>
<td>0.9</td>
</tr>
<tr>
<td>Forbes (NSW)</td>
<td>72</td>
<td>5</td>
<td>2.8</td>
<td>0.5</td>
</tr>
<tr>
<td>Collambally (NSW)</td>
<td>67</td>
<td>9</td>
<td>2.6</td>
<td>1.2</td>
</tr>
<tr>
<td>Numurkah (VIC)</td>
<td>64</td>
<td>5</td>
<td>2.3</td>
<td>0.2</td>
</tr>
<tr>
<td>Dry land</td>
<td>84</td>
<td>51</td>
<td>6.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Irrigated</td>
<td>83</td>
<td>37</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1.3
Top 40 soft wheat breeding lines showing wide adaptability across regional sites

- Check: Snow (98%)
- Finaric: (83%)
- Future (100%)
- QAL2000 (950%)

FUTURE PLANS
- Quality evaluation of selected lines
- Flour samples will be provided to Arnott's Biscuits for further evaluation
- Final selection to be based on yield and quality data

FUTURE PLANS
- Elite lines will be increased for commercial scale milling tests in 2002
- Superior lines to be progressed to commercialization
RELEASE OF TWO ADVANCED BREEDING LINES

- Two advanced breeding lines (2001-13 & 2001-15) are currently undergoing summer increase at Nemakal, Vic. Anticipate 1.5 t will be available in April for winter increase 2002.

- PBR application (Part 1) is being processed.

Agronomic Attributes

<table>
<thead>
<tr>
<th>Attributes</th>
<th>2001-13</th>
<th>2001-15</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant height (cm)</td>
<td>85</td>
<td>90</td>
<td>- No obvious difference</td>
</tr>
<tr>
<td>Day to tillering</td>
<td>31</td>
<td>24</td>
<td>- 2001-15 line is quick in tillering &amp; starts tillering about 1 week prior to GAL2000 &amp; the other advanced breeding line (2001-13)</td>
</tr>
<tr>
<td>Day to heading</td>
<td>120-130</td>
<td>110-125</td>
<td>- One week difference</td>
</tr>
<tr>
<td>Day to 50% anthesis</td>
<td>125-135</td>
<td>125-135</td>
<td>- No obvious difference</td>
</tr>
<tr>
<td>Day to 50% maturity</td>
<td>160-170</td>
<td>160-170</td>
<td>- No obvious difference</td>
</tr>
</tbody>
</table>

- Head type: Normal Club
  - 2001-15 line is club type & closely related to 'Tincumn'.
  - 2001-13 line is similar to the soft wheat biennial variety G/L3000 & has normal (pseudom) type spikes.

Grain Yield Performance

Grain yield performance of these lines is comparable to that of GAL2009 and exceeds the performance of the best parental check. Mean grain yield (25 site-years) of these breeding lines along with GAL2009 and target parent varieties is summarized below:

<table>
<thead>
<tr>
<th>ID</th>
<th>Mean grain yield (25 site-years)</th>
<th>% of best check</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-13</td>
<td>3.02</td>
<td>110</td>
</tr>
<tr>
<td>2001-15</td>
<td>2.94</td>
<td>105</td>
</tr>
<tr>
<td>GAL2009</td>
<td>3.28</td>
<td>116</td>
</tr>
<tr>
<td>Tincumn</td>
<td>2.81</td>
<td>100</td>
</tr>
<tr>
<td>Talara</td>
<td>2.67</td>
<td>95</td>
</tr>
</tbody>
</table>

Disease Resistance

<table>
<thead>
<tr>
<th>Breeding Line</th>
<th>Rust Resistance</th>
<th>CCN</th>
<th>Flag Spot</th>
<th>Common Rool Knot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stem</td>
<td>Spike</td>
<td>Leaf</td>
<td>Res</td>
</tr>
<tr>
<td>2001-13</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>MS/IR</td>
</tr>
<tr>
<td>2001-15</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>MS/IR</td>
</tr>
<tr>
<td>GAL2000</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>MS/IR</td>
</tr>
</tbody>
</table>

Rust resistance data provided by PBL Celebrity. *20R against new 104 ESTA+Yr17 pathotype. Possibly derived from Talara parent.
### Quality Attributes

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-13</td>
<td>70%</td>
<td>9.5%</td>
<td>*</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>2001-15</td>
<td>10%</td>
<td>8.8%</td>
<td>*</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>QAL2000</td>
<td>74%</td>
<td>9.0%</td>
<td>*</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Thoevis</td>
<td>70%</td>
<td>8.7%</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Amcol Std</td>
<td>-</td>
<td>8.5%</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
</tbody>
</table>

**Excellent**   **Very Good**   **Good**   **Q.J. Quad Junior**
Project 4.1.3:
Elite Germplasm with
New & Novel Quality Attributes

- Waxy Wheat

Mohammad Shariflou
Marker-Assisted Selection waxy wheat breeding

Mohammad Reza Sharifoo
Peter Sharp
University of Sydney
Plant Breeding Institute
Value Added Wheat CRC

Donor and recurrent parents

DH waxy line X NP150 (double null)
(triple null)
Silverstar (single null)
Goldmark (single null)
Janz (normal)

Outlines of waxy wheat breeding

- Backcross to recurrent parents up to BC4
- NAS of BC plants for the null waxy loci
- NAS of BC plants for the recurrent parent genotype
- Proceed to advanced lines from two directions
  - DH production from BC3 and BC4 lines
  - Self-pollination of BC3 and BC4 lines
- Selection for rust genes and plant type in the field
- PYT and AYT in multi-locations
- Release of waxy wheat cultivars

Marker-assisted selection of the waxy loci
Advanced waxy lines in the field
(winter 2001, PBIC)

Advanced waxy lines selected in 2001

Advanced waxy lines collected for quality tests

Advanced Waxy Janz lines
- No. of lines tested in 2001 = 34
- No. of sites = 2 (Narrabri and Forbes)
Production of waxy wheat in new backgrounds:

Parents

<table>
<thead>
<tr>
<th>Waxy Goldmark</th>
<th>Waxy Silverstar</th>
<th>Waxy MP160</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Diamondbird
Dollarbird
Saratate
Rosella
K1057

Diamondbird
Dollarbird
Saratate
Rosella
Sarasoft

No of BC1 seeds (2001)

<table>
<thead>
<tr>
<th>Background</th>
<th>BC1 seed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diamondbird</td>
<td>293</td>
</tr>
<tr>
<td>Dollarbird</td>
<td>292</td>
</tr>
<tr>
<td>Rosella</td>
<td>319</td>
</tr>
<tr>
<td>Sarasoft</td>
<td>162</td>
</tr>
<tr>
<td>Saratate</td>
<td>252</td>
</tr>
<tr>
<td>K1057</td>
<td>490</td>
</tr>
<tr>
<td>N6632</td>
<td>37</td>
</tr>
<tr>
<td>Total</td>
<td>1845</td>
</tr>
</tbody>
</table>

Reduced backcrossing strategy for MAS breeding

- Full set of DNA markers are available for the waxy locus
- Large number of markers are available for selection of background genotype
- Backcross to recurrent parent up to BC2
- MAS of BC plants for the null waxy locus
- MAS of BC plants for the recurrent parent
- Proceed to DH production in BC1 and BC2

Further work

- Advanced waxy lines
  - Confirm waxy genotypes with staining
  - PYT in three sites for lines with 400 g seed
  - PYT in a single site for lines with less than 150 g seed
  - Seed increase for lines with less than 20 g seed
  - Flour quality test on full and partial waxy lines
Further work

- Waxy-janz
  - Check for waxy genotype with staining
  - AYT in 8 sites

- Waxy lines in New background
  - NAS of BC1 plants
  - Backcross to recurrent parents
  - Proceed to DH production of BC1 and BC2 lines
Project 4.1.3:
Elite Germplasm with New & Novel Quality Attributes

- B granules

Matthew Turner
STARCH GRANULES

It is thought that 3 granules increase water adsorption.

This property may increase biscuit baking time (undesirable) and influence final quality (positive).

ELITE GERMPLASM WITH NEW & NOVEL QUALITY ATTRIBUTES

Manipulating the B-granule content of wheat starch

Matthew Turner

PROJECT 4.1.3

VALUE ADDED WHEAT CRC

IMPORTANCE OF GRANULE SIZE

Different industrial uses for different sizes

Small granules in wheat are not recovered in starch/gluten manufacture.
COMMON AND DURUM WHEATS

AEGILOPS CRASSA & AE. PEREGRINA

DOMESTICATING THE EXTREMES

- *Ae. crassa /3*Kewell F5 grains multiplied in 2001
- To be grown in the field in 2002 and analysed in 2003

- *Ae. peregrina* chromosome additions to wheat analysed. No low values identified.
- Potential for generation of *T. turgidum* var. *dicoccoides × Ae. tauschii* - novel AABBDD with small A, many B?
VULCAN X KEWELL DOUBLE HAPLOIDS

- Some of the lines yielded well
- Rust resistance is a problem
- Lines with extremes of β-granule content to be grown next year and hybridised with Australian varieties for DH production
DOMESTICATING 'OUTLIER 67'

- Vulcan x Outlier 67 doubled-haploid population of 124 lines: 75 grown at Narrabri this year in the field
- Old exotic winter wheat cultivar with 11% B-granule content
- Low-B spring types identified from controlled environment data

OUTLIER 67

- Crossed with:
  - Janz (wide adaptation, hard, low starch paste viscosity)
  - Sunstate (wide adaptation, hard, high starch paste viscosity, different gene pool)
  - QAL 2000 (stiff soft quality biscuit wheat)

CONCLUSIONS

- 700 F3 lines grown in hillplots in field at Cobbitty
- Lines with extremes of B granule content to be grown next year and hybridised with Australian varieties for DH1 production
- Survey has shown sources of higher & lower B-granule content
- Practical breeding is in progress