Linking Market to Research in Today’s Wheat World

Bill Rathmell
Managing Director
Value Added Wheat CRC

Introductory Theme
“Research Targeting”

Wheat CRC cash funding:
- Taxpayer 65%
- Earnings* 14%
- Growers 12%
- Industry** 9%

* Contract research + royalties
** Commercial participants ex. GRDC

“Turning innovative ideas and skills into commercial success to benefit Australia’s economic prosperity and social wellbeing”

Value Added Wheat CRC
Wheat CRC/GRDC Economic Analysis

- Single percent improvement worth $37M
- Large quality changes needed
- Processors needs most important
- Breeding main route to improvement (80%)
- High benefit:cost ratios to applied molecular marker work (80:1)

Wheat CRC Outcomes:

- Diagnostics

Wheat CRC Outcomes:

- Process improvements
- Mills
- Bakeries
- Direct uptake by industry

Wheat CRC Outcomes:

- Science to improve wheat germplasm
  - Triticarte™
  - Proteomics

Wheat CRC Outcomes:

- Pipeline of wheat germplasm
  - Biscuit wheats
  - Novel wheats
  - Improved or new foods

Wheat CRC Outcomes:

- Education and Training
  - Scientists technicians and growers
  - PhDs and students
  - Farmer training material
  - University/TAFE courses
  - Great Grain
**The Wheat CRC “Funding Gap”**

![Graph showing Wheat CRC funding gap]

*Actual Budget

**Environment we work in:**
- Privatisation
- Focus on profitability
- Changing ownership
- Changing alliances
- Research divestment
- Supplier research responsibility

**Environment we work in:**
- Customers looking for value
- Shared/leveraged research
- Some sectors still technology oriented

**Difficult to get clear market signals in this environment**
- Lack of funds amongst research users
- Lack of priority amongst research users
- Nevertheless must avoid research push attitude
- Dependent on industry funding
During the conference:

- The Innovation/Commercialisation cycle
- Studied in working groups
- Presentation skills

Research Targeting

- Evaluation of market needs in commercial terms (value and profitability)
- Orientation of research projects towards market needs

- Evaluation of market needs in technical and scientific terms (achievability / risk)
Signs of Success

- The Commercial partners collaborate with development
- Partners’ business plans
- Sales royalties or improvements achieved
Program 1: Diagnostics

Program Manager: Neil Howes
Plant Breeding Institute, Cobbitty

Aims of Program

- To develop diagnostic methods that will be applied by the Australian Wheat Industry, and where feasible commercialise world-wide.

Quality of Projects

- Unique or leading edge research
- Delivering novel products/services for grains industry
- Exploiting advantages of technology - low cost or fast tests

Structure of Program

- Project 1.1.1 Protein Separation Methods
  Ian Batey, CSIRO Food Science Aust., Nth Ryde
- Project 1.1.2 Antibody Diagnostics:
  James Chin, NSW Agriculture EMAI
- Project 1.2.3 Diagnostics Delivery
  Felice Driver, C-Qentec Diagnostics, Sydney
- New Project Small scale testing for breeders

Detailed Presentations

- Sujani Uthayakumauan: Protein analysis using capillary electrophoresis
- EMAI Team: Antibody Discovery
- Jan Gooden: Diagnostic Kits for Breeders
- Geoffrey Cornish: Small scale testing
- Annelise Rittau: The effect of heat shock on the SDS Sedimentation test
Project 1.1.1
Protein composition analysis

AIMS:
* Develop methods for more efficient identification of variety and quality type
* Investigate methods deployable beyond the requirements of a central laboratory
* Identify specific protein markers indicative of genotype and/or end-use quality
* Technology Transfer

**Staff involved**
- Ian Batey (VAWCRC & FSA)
- Colin Wrigley (VAWCRC & FSA)
- Surjani Uthayakumaran (FSA)
- Geoff Cornish (SARDI)
- Rebecca Tonkin (SARDI)
- Frank Bekes (consultant)
- Anneliese Rittau (PhD student)

**Approaches**
* Identify industry needs
* Develop suitable methods
* Technology transfers

**Methodology**

**Variety – gliadin composition**
- Microgels
- RP-HPLC
- Capillary electrophoresis
- Lab-on-a-Chip

**Dough quality – glutenin composition**
- SDS gel
- HPLC – SE and RP
- Capillary electrophoresis

**Variety Identification**
* Micro Gels of Gliadins
* Capillary Electrophoresis of Gliadins
Glutenin Markers of Dough Quality

CE of HMW sub-units of glutenin

Glutenin Markers

CE of HMW subunits

Glutenin Markers

CE of glutenin subunits (charge based separation)

Glutenin Markers

CE of glutenin subunits (size based separation)

Other Research Approaches

Agilent Lab-on-a-chip (portable CE equipment)

Other Research Approaches

Agilent Lab-on-a-chip (gliadin profiles)
Computer Assisted Techniques

- PatMatch - Variety identification and protein marker identification (e.g., HMW-GS)
- GeneJar – Listing genetic composition of wheat lines
- WhatWheat – Methods for variety identification

PatMatch

GeneJar

WhatWheat

Future Work

- Extend initial trial of “Lab on a chip”
- Other markers
  - GBSS
  - Other starch synthases
  - Serpins
- Computer-assisted interpretation (Improve)
- Simple test for dough strength (%UPP)
- Technology Transfer
  - VAW CRC Reports
  - Workshops
  - Conference presentations
Antibody Based Tests for Wheat Breeders

Jan Gooden, Located at SARDI, Adelaide

Requirements of Wheat Breeders
- Early generation testing:
  - Large numbers of samples (100-10,000)
  - Low value per sample ($10-50)
  - Often heterogeneous and heterozygous
  - Small sample size (1-1,000 grains)
  - Fast turnaround time (weeks)
- Late Generation Testing:
  - Small numbers of samples
  - High value ($500-100,000)

Advantages of Antibody Tests
- Low cost per sample ($0.5-1.5)
- High numbers of parallel assays (96-1,000) per day
- Rapid (1-2 days) or even minutes
- Low capital cost of testing
- Relatively “fool-proof”

Principles of ELISA test procedures
- Plate trapped antigen technique
  - eg. 1RS/1BS screening test

Breeders Kits
- 1B/1RS Wheat-Rye translocations - Target proteins soluble in 50% propanol
  - Plate trapped antigen technique
- Late Maturing Amylase (LMA)
  - Target protein soluble in aqueous NaCl
  - Indirect triple antibody technique
- Granule Bound Starch Synthetase (GBSS)
  - Target proteins soluble in 4M urea
**Late Maturity Amylase (LMA)**
- Common in CIMMYT wheats
- Expressed in cool ripening environment
- Poor quality; downgrade to feed
- Target protein soluble in aqueous NaCl
- Indirect triple antibody technique

**GBSS Tests**
- GBSS null 4A wheat's have high starch swelling
- Good noodle quality
- Common in Australian wheat’s
- GBSS triple null wheat's have low amylose (waxy)
- GBSS Target proteins soluble in 8M urea
- Plate trapped antigen technique (now developed)

**Future Directions**
- New Tests (GBSS null 7A, Serpins,)
- World-wide distribution
- Combination tests (multiplexing)
Small scale wheat quality screening

Program 1
Project Leader Geoffrey Cornish
Start date July 2004
Completion date June 2007

Participants

Organisation    Staff    Contribution
SARDI Geoffrey Cornish (0.1) MDL, TUR, SDS-PAGE, photosynthesis, DNA, RNA
Rebecca Tonkin (0.5) CE
Food Science Surjani Uthayakumaran (0.1) Cell culture, genomics, lab equipment, operating S
AGT Technician (0.5) Casual labour, genomics, lab equipment, operating S
SunPrime Technician (0.5) Quadrumat milling, genomics, operating S
Sydney Uni Neil Howes (0.1) Antibody tests, DH populations
Matthew Turner (0.1) Antibody tests, DH populations
VAWCRC Ferenec Bekes (0.1) 2-arm mixer

SS testing requirements

• S1 breeding stage
• Small sample size <10g
• Rapid 10,000 samples/3 months (~150/day)
• Low cost/sample ~$30/samples
• Tests with high H (High G, low E)
• Sequential culling of samples through tests

3 scales of laboratory tests

<table>
<thead>
<tr>
<th>Scale</th>
<th>Large</th>
<th>Medium</th>
<th>Small</th>
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<tbody>
<tr>
<td>Sample size</td>
<td>1-3 Kg</td>
<td>300-500g</td>
<td>5-15g</td>
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<tr>
<td>Breeding stage</td>
<td>S4, S3</td>
<td>S2</td>
<td>S1</td>
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<tr>
<td>Mill</td>
<td>Buhler</td>
<td>Quadrumat</td>
<td>Micro</td>
</tr>
<tr>
<td>Samples/day</td>
<td>5-10</td>
<td>20-25</td>
<td>100-150</td>
</tr>
<tr>
<td>Cost/sample</td>
<td>$300</td>
<td>$100</td>
<td>$30?</td>
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<tr>
<td>Time window</td>
<td>12mth.</td>
<td>6mth.</td>
<td>3mth.</td>
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<tr>
<td>Sample/year</td>
<td>1,000</td>
<td>3,000</td>
<td>10,000?</td>
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Laboratory Mills

- Buhler Mill
- Quadrumat Junior Mill
- Micromill

Grain quality laboratory tests

<table>
<thead>
<tr>
<th>Trait</th>
<th>Large</th>
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<tr>
<td>TKW</td>
<td>Contador</td>
<td>Contador</td>
<td>Contador</td>
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<tr>
<td>PPO</td>
<td>L-tyrosine</td>
<td>L-tyrosine</td>
<td>L-DOPA</td>
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<tr>
<td>Hardness</td>
<td>NIR PSI</td>
<td>NIR PSI</td>
<td>NIT PSI</td>
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<tr>
<td>Moisture</td>
<td>NIR</td>
<td>NIR</td>
<td>NIT</td>
</tr>
<tr>
<td>Protein</td>
<td>NIR</td>
<td>NIR</td>
<td>NIT</td>
</tr>
<tr>
<td>Flour yield</td>
<td>Buhler</td>
<td>Quadrumat</td>
<td>Micro</td>
</tr>
<tr>
<td>Glutenins</td>
<td>SDS-PAGE</td>
<td>SDS-PAGE</td>
<td>SDS-PAGE</td>
</tr>
</tbody>
</table>
**Flour quality - Proteins**

- Protein: NIT probe (Diode array)
- Moisture: NIT probe (Diode array)
- Gluten quality: SDS sedimentation (1g)
- Glutenin subunits: Type SDS-PAGE
- Type & amount: RP-HPLC and CE
- Insoluble polymeric protein: SIG (Swelling index of glutenin)

**Flour quality - dough rheology**

<table>
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<td>Farinograph</td>
<td>50g</td>
<td>50 or 10g</td>
<td>4g Z-arm</td>
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<tr>
<td>DoughLab</td>
<td>300 or 50g</td>
<td>50g</td>
<td>2g</td>
</tr>
<tr>
<td>Mixograph</td>
<td>35g</td>
<td>35 or 10g</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Extension</th>
<th>Extensograph 300/2X150</th>
<th>50/1x75</th>
<th>2.5/2x1.7</th>
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<tbody>
<tr>
<td></td>
<td>Textire Analyzer Sheet probe</td>
<td>Kieffer rig</td>
<td>3/4X0.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bubble 25g</td>
<td></td>
</tr>
</tbody>
</table>

**Flour quality - starch**

- Rheological: Amylograph 50g flour
- RVA: 3.5g flour
- GBSS (Wx-B1): Electrophoresis
- PCR
- ELISA

- Amylose/amylopectin ratio
- A:B granule ratio

**Proposed Approach**

- Validation: S3 samples
- Milling: Buhler 2000g, Quadramat 150 and 50g, Micromill 15 and 5g
- Comparison: Large vs small scale tests, Different flours on ss tests
Wheat Sedimentation Tests: Methodology, Efficacy and Biochemistry

Anneliese Rittau (PhD student, commenced 1/2003)

Industry and academic co-supervisors -
Ms Di Miskelly, Allied Mills Ltd.
Dr Ian Batey, Value Added Wheat CRC,
Dr Colin Wrigley, Value Added Wheat CRC,
Prof. Les Copeland, University of Sydney,

Project Aims

🌟 To investigate SDS sedimentation test results with regard to wheat quality, glutenin composition, climate and sample storage conditions
🌟 To examine the mechanism of action of sedimentation tests for both flour and wholemeal samples
🌟 To elucidate the biochemical basis of sedimentation
**Industrial Importance and Rationale**

- **The SDS sedimentation test**
  - Has been used for several years at Allied Mills and has proven effective in selection for bread-making quality
  - However...
    - is it effective to select biscuit-making quality?
    - does it indicate quality according to allelic variation in HMW-GS composition?
    - is the test affected by growing conditions e.g. heat shock, rainfall etc?
    - is the test affected by storage conditions, age of grain etc?

**Experimental Approach 1**

- **Aim:** test a set of multi-null genotypes in a biscuit wheat that provide combinations of deletions of HMW-GS
- **Samples:** Tincurrin x Gabo Olympic multi-nulls
- **Allele Combinations:** +++ (x3), ++- (x3), -++ (x2), -+- (x3)
- **Tests on Wholemeal:** NIR, SE-HPLC, SDS-sedimentation,
- **Tests of Flour:** NIR, SE-HPLC, Zeleny sedimentation, Extensograph, Farinograph, SRC
Experimental Approach 1

Results so far:

- Results indicated a stronger correlation between Zeleny sedimentation and dough properties than did SDS sedimentation.
- Zeleny sedimentation negatively correlated with dough resistance.
- Systematic deletion of HMW-GS results in a decrease in both parameters.


Conclusions

- The SDS sedimentation test is effective to select for good dough properties for bread-making.
- ... but it may be less effective than the Zeleny test in indicating dough properties in a biscuit wheat.
- Sedimentation is a good indicator of quality due to HMW-GS allele composition.
Aim: to develop an SDS flour sedimentation test which correlates strongly with the test for wholemeal and to use this test to analyse the effects of heat-shock on flour sedimentation

Samples:
- Test development- 02/03 harvest NW-NW, assorted grades
- Heat shock flours- 00/01 harvest, single variety flours, heat shock and control

Tests: SDS flour sedimentation

Results So Far

Early results indicate that the strongest correlation with wholemeal SDS sedimentation requires a reduced (2% rather than 3%) concentration of SDS (R=0.91)

This test may now be used to investigate the effects of heat shock on sedimentation levels
Experimental Approach 3

Aim: to investigate effects of environmental factors such as rainfall and extreme temperature on sedimentation and other quality tests.

Experimental Approach 4

Aim: to investigate the manner in which SDS sedimentation results change over time when samples are stored at ambient temperature.
Future Directions

- Investigate the relationship between sedimentation and solvent retention capacity for multi-null set.
- Complete sedimentation testing for heat shock flours
- Collate data for climatic study
- Collect SDS sedimentation storage data over 12 month period
Program 2
Products and Processing

Aims are to generate knowledge:

* for enhancement of the processing performance of wheats and
* for the creation of new and improved products

Collaborators:

* Allied Mills, Goodman Fielder, Arnotts
* CSIRO Food Science, BRI, QDPI, SARDI, Sydney University
<table>
<thead>
<tr>
<th>2.1.1</th>
<th>Blending – consequences for wheat breeding</th>
<th>Presenter</th>
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<tr>
<td>2.1.4</td>
<td>Optimisation of key stages of the baking process</td>
<td>Thomas Adamczak</td>
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<tr>
<td>2.1.5 *</td>
<td>Australian wheat for sponge and dough breadmaking process</td>
<td>Di Miskelly</td>
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<tr>
<td>2.1.6 *</td>
<td>Strategies to replace flour chlorination as a treatment for cake flours</td>
<td>Di Miskelly</td>
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<td>2.1.9 *</td>
<td>Gluten structure and modification for ingredient use</td>
<td>Li Day</td>
</tr>
<tr>
<td>2.2.10</td>
<td>Analysis of starch lipid complexes</td>
<td>Mary Tang</td>
</tr>
<tr>
<td>2.3.11</td>
<td>Extended shelf life bread and baked goods</td>
<td>Naomi Hehir</td>
</tr>
<tr>
<td>2.3.12</td>
<td>Wheat quality for starch and gluten production</td>
<td>Ian Batey</td>
</tr>
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</table>

* GRDC funded
**Progress Update**

- Part 1: Kukri-Janz Doubled Haploid Population
- Part 2: Non-Linear Interactions in Soft Wheat Flour Blending

**K-J DH Year 1**

- 70 lines tested
- Rmax range 140 - 640 BU

**Range of Rmax values in selected Kukri-Janz DH Population**

- Farinograph results showed significant differences in development times between allele combinations. Within some allele categories there was also high variation.

**K-J DH Year 2**

- Significant variation also occurred within allele categories.

**Extensograph results (Rmax).**

- Variation in Dough Strength in a single Allele Category
**K-J DH Year 3**

"New" Glu-B1 7x in Kukri - 7OE

- 16 K-J DH biotypes
- Over-expressed 7 in Kukri associated with Glu-B1 8*y
- RP-HPLC used to distinguish between 7OE and 7*, and 8 and 8*
- Further testing was required

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**Farinograph results**

It was extremely difficult to determine Dough Development Time for many lines.

(Farinograph for sample 33, alleles d b h)

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**Farinograph results**

The most effective measurement to differentiate the various lines was stability.

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**Role of Glu-B1 al in breeding programs:**

- Present in Kukri and Chara
- Appropriate glutenin allele combinations critical to obtain maximum benefit from this important allele.
Part 2: Soft Wheat Flour Blends

• This short project examined the dough properties and interactions between Soft and Strong commercial flour mixes, and between 4 wheat varieties (2 soft, 2 strong).

• The protein, starch and rheological characteristics of the flours and their blends were investigated, and a number of non-linear relationships found.

• The work in this project was carried out by Ms Dewi Hartono, a summer scholarship student in the VAW CRC.

Soft Wheat Flour Blends

Method:

• 2 commercial flours, Strong and Soft, and 4 variety flours (Diamondbird, H45, Rosella and Snipe) were sourced from Allied Mills.

• The commercial flours were blended at ratios of 25:75, 50:50 and 75:25, as were the variety flours.

Results:

• Most parameters gave linear results. However, a few, notably Mixograph Mix Time, Farinograph Mix Time, Breakdown for both instruments, and Mixograph Peak Height, showed non-linear effects.

Conclusions:

• Producers may wish to avoid mixing flours of different allele types for maximum predictability.

• Knowing the dominant allele types in commercial blends is of importance.

Summary:

• K-J DH Population:
  ➢ non-linear interactions
  ➢ over-expressed allele has a role in new cultivars

• Arnott’s blending:
  ➢ Part A – Soft/Strong wheat types completed
  ➢ Part B – Noodle/Biscuit Soft in progress

Acknowledgements:

I would like to acknowledge the assistance of Marie Vawser (SARDI) in providing the graphics of the RP-HPLC results for Janz and Kukri.
2.1.4 Optimisation of key stages of the baking process

Module 1:
Maximiser - Automatic Water Addition for Dough Mixers

Outline
- Introduction
- How is it achieved
- What are the benefits
- Results and benefits up to date
- Technology transfer opportunities
- Conclusions

Introduction
Definition of the Maximiser is a combination of software and sensors, which have been developed to assist bakeries to obtain optimum product quality and reduction of ingredient costs. This is achieved by continuously maximising water addition during mixing.

How is it achieved?
Sensors are positioned in critical points and connected to the water addition controller.

Maximiser - Overview

Rounder
Water Addition vs Stickiness Value

By increasing dough water addition,

- Stickiness value increases
- Potential of process difficulties increases

What are the benefits

- Product Yield - $1M p.a.
- Product Quality - softness
- Product Consistency - ?
- Process Efficiency - ?
- Product Throughput - ?
- Commercial opportunities overseas - ?

Benefits from Maximiser - Automatic Water Addition Module

(achieved during 3 weeks evaluation period)

- Control benefits - 1.47% in water increase
- Improved ingredients accuracy - flour, water, fat and yeast
- Improved equipment operation - consistent vacuum levels

Challenges for Technology Transfer - Local and Overseas opportunities

- Variability of bakeries
- After sales support structure

Conclusions
2.1.5 Australian wheat for the sponge and dough breadmaking process

Leader: Ken Quail

Aims:
- Identify key wheat parameters and appropriate varieties for sponge and dough wheats

Collaborators:
- BRI, QDPI

Relevance to industry problem
- Asian countries use sponge and dough baking process to produce white sliced bread.
- Large market: 6 million tonnes annually
- Currently all wheat from US.
- Good potential for Australian wheat.

Genotypes perform differently in the sponge and dough baking system compared to the rapid system.

Regression analysis of quality traits and loaf volume (2000 harvest)

Table IV. Correlations between variables: complex interpretation of the regression results.

<table>
<thead>
<tr>
<th>Trait</th>
<th>E1</th>
<th>E2</th>
<th>R1</th>
<th>R2</th>
<th>F1</th>
<th>F2</th>
<th>GP</th>
<th>FN</th>
<th>FC</th>
<th>TW</th>
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<tr>
<td>LV (cm³)</td>
<td>1</td>
<td>0.15</td>
<td>0.33</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
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<td>-0.24</td>
<td>-0.13</td>
<td>-0.07</td>
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<tr>
<td>E1 (cm)</td>
<td>0.32</td>
<td>1</td>
<td>0.12</td>
<td>0.54</td>
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<td>R1 (min)</td>
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<td>R2 (deg)</td>
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<td>0.44</td>
<td>0.51</td>
<td>0.32</td>
<td>0.28</td>
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<tr>
<td>F1 (%)</td>
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<td>GP (%)</td>
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<td>-0.72</td>
<td>-0.33</td>
<td>0.8</td>
<td>-0.71</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Significant correlations in bold type exceed 0.27 (P=0.05) and 0.35 (P=0.01). Inter correlations = high sponge and dough loaf volume cannot be attributed to any single factor.
A principal component analysis biplot

**Statistical analysis of 2001 harvest samples**
- Quality traits fitted as random effects to create BLUPs (best linear unbiased predictors)
- Results are liberated from effects of error

<table>
<thead>
<tr>
<th>Text</th>
<th>Genetic correlation with LV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour swelling volume</td>
<td>0.493</td>
</tr>
<tr>
<td>Extensograph resistance</td>
<td>0.361</td>
</tr>
<tr>
<td>Mixograph stability</td>
<td>0.517</td>
</tr>
<tr>
<td>Mixograph max’ stretch</td>
<td>0.403</td>
</tr>
</tbody>
</table>

**Evaluation of Asian Milled flour (AMF) samples**
- 3 flours from FFM in Malaysia evaluated
- 200g LRC test baking methods able to discriminate

**Alleles present of the glutenin sub-units, Glu.A1, Glu.B1, Glu.D1, Glu.A3, Glu.B3 and Glu.D3 determined**

(a) Glu.B1 alleles  
(b) Glu.D3 alleles  
(c) Glu.D1 alleles

Predicted mean (Basic Linear Unbiased) loaf volumes

**Alsien**

- Alsien, North Dakota Hard Red Spring
- Grown in QLD
- Renowned for prime sponge and dough bread quality
- QT8753 better than Alsien sample
- But US grown Alsien?

**What’s left**
- 2000 and 2001 harvest testing finalised.
- 2002 harvest testing almost complete.

**Statistical analysis**
- will include quality traits fitted as random effects to create BLUPs
- Model predicts mean values (no error effects)
  - accurate determination of genetic effects
- Project concludes June 2004

Acknowledgement: Tessa Lever, QRPI
2.1.6 Strategies to replace flour chlorination as a treatment for cake flours

Leader: Ken Quail
Aims: develop alternative, cost effective environmentally friendly strategies to replace flour chlorination
Collaborators: BRI, AM

Relevance to industry problem
- Chlorinated cake flours produce high quality cakes
- Treatment may be banned or withdrawn
Value to industry: 150,000 tonnes cake flour produced pa. Also export potential

Application of chlorine
- Lighter and sweeter cakes
  - increased liquid
  - increased sugar
  - high ratio cakes
- increase in liquid and sugar level decrease batter stability
- sugar also raises the starch paste temperature

Strategies
- Benchmark commercially available cake flours
  - examine published and new strategies eg ozone
  - heat treatment (flour/starch)
  - wheat types
  - milling treatments
  - ingredient optimisation
- proceed with “best” options

Heat Treatment trials
- Many published Time/Temp Combinations
  - Often equipment/procedure not well documented
  - Often actual flour temp history not given
- Initial results
  - Rather narrow acceptability range for this set of treatment conditions.
  - Optimum ~ 120 °C
  - Severe decline > ~ 140 °C
  - Particle size effect

![Flour Temperature vs Sponge Cake Score](image)
Starches/ Gelling Agents

- Starch substitution - match chlorinated flour RVA profile
  - tapioca/modified tapioca
  - potato/modified potato
  - Waxy wheat flour
- Alginates & gelatin
  - increase batter viscosity

Starch/ Gelling Agents Results

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>SG</th>
<th>Volume</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tapioca Starch</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Modified Tapioca</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Potato Starch</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Modified Potato</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Waxy Wheat Flour</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gelatin</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Alginate (Protanal Ester)</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

+  = Positive Effect  
-  = Negative Effect  
SG = Specific Gravity

Fluidised bed heat treatment

| 8 - 150°C 15 min |
| 9 - 180°C 6 min |

Outcomes to date

- optimal heat treatment defined
- ingredient optimisation work completed

Future work

- Further work in Starch Heat Treatment
- other high swelling varieties
- Microwaves
- Further work on fluidised bed heat treatment machine
- project finishes June 04
Gluten structure and modification for ingredient use

LI Day
Food Science Australia, Werribee, VIC

Background
• Australian gluten production
  – Main player in gluten (& starch) production
  – Second largest exporter of gluten to USA
  – The market is increasing each year

• Uses of commercial gluten
  – Bakery goods
  – Cereals, meats, snack bars
  – Pet foods, aquaculture feed, calf-milk replacer
  – Meat and seafood analogues
  – Functional food products such as sports drinks
  – Non-food uses: adhesives, cosmetics, pharmaceuticals, films, etc.

Diversify to maintain/increase market share

Project Aims
• To enhance knowledge about the composition and structure of gluten
  – Interactions, non-protein/protein components
  – Enzyme activity, polyphenol oxidase (PPO)

• To modify and add value to commercial gluten for value-added ingredient uses

Results so far

• Snap shot at half way…

Lipids - gluten colour

• Removal of lipids reduces gluten yellowness
**Polyphenol oxidase – gluten colour**

- High PPO in flour results in gluten ‘greyness’

**Lipids – gluten rheological property**

- Removal of lipids produces gluten that is more elastic and has better recovery

**Removal of lipids – Industrial approach**

- Chloroform
  - Good for flour, but not acceptable by industry
  - Extract little lipids from gluten
- Ethanol (at 70°C)
  - Good for gluten
  - Diminish gluten visco-elastic properties
- Alternative approach – the use of salt

**Summary**

- Lipids
  - Contribute to gluten colour (yellowness)
  - Play important role in gluten formation and its physical properties
- Removal of lipids
  - Promising solution: addition of salt in washing process
- Polyphenol oxidase
  - Contributes to flour colour, likely to gluten colour (greyness)

**Effect of salt in gluten washing process**

- Salt washing reduces lipids in gluten by up to 50%
  - Improve gluten elasticity and recovery
Future work plans

• Seek/widen the use of other mineral salts
  – Alternative/new product(s) ?

• Investigate the use of enzyme inhibitors
  – Improve gluten colour (Ms Anastasia Widjaja, MSc, MU)

• Explore chemical and enzymic reagents to increase recovery and nutritional quality of gluten
  – The use of transglutaminase

Future work plans
  - beyond the current project

• Fundamental study – protein/protein, protein/lipid interaction in gluten
  (Ms Thu Vu, PhD, RMIT)

• Study the use of gluten-based ingredients as encapsulants
  New materials/food ingredients — compete on cost!

Acknowledgements

• Grain Research & Development Corporation
• Manildra Group
• Value Added Wheat CRC

Thanks

• Dr Ian Batey (FSA North Ryde, VAW CRC)
• Dr Colin Wrigley (FSA North Ryde, VAW CRC)
• Dr MaryAnn Augustin (FSA Werribee)
• Dr John Pearce (Manildra Group)
Analysis of Starch-Lipid Complexes

(Project 2.2.10)

Mary Chiming Tang (PhD Student)
Faculty of Agriculture, Food and Natural Resources
University of Sydney

Supervisor: Prof Les Copeland,
Associate Supervisor: Dr Bob Caldwell

What are starch – lipid complexes

Example of a starch-lipid inclusion complex. An amylose helix is complexed with a monoglyceride (Thomas and Atwell, 1999)

Relevance to Industry

- Contribute to anti-staling in foods with a high starch content.
- Starch-lipid complexes can be used as additives, such as fat replacers, stabilizers, and as thickeners in foods; cosmetics.
- Starch-lipid complexes are hydrolysed more slowly and are considered to contribute to resistant starch, which brings potential health benefits.
- Resistant starch is a fermentable substrate for beneficial microflora in the lower gut.

Objectives of this study

- Measure formation of starch-lipid complexes
- Study properties and behaviour of starch-lipid complexes relevant to industry and potential health functions

Approach - analytical methods

- Rapid Visco Analyser (RVA)
- Complexing index (CI)
- X-ray diffraction
- Enzymic digestion
- Imaging analysis
- Microbiological study

Effect of starch-lipid complexes on pasting properties of wheat starch

RVA can be used as a rapid method to form and determine starch-lipid complexes by measuring:

- Increase of final viscosity and setback
- Decrease of minimum viscosity (Holding strength)
Effect of lipid concentration on starch-lipid complexing

Optimal concentration and fatty acid chain length

*Difference of final viscosity = Starch-lipid final viscosity - starch-only final viscosity.

*Optimal lipids concentration: the lipid concentration to obtain the highest CPs.

Key properties of lipids in forming starch-lipid complexes

- The formation of starch-lipid complexes is significantly associated with physical properties of the lipid, such as melting, water solubility and critical micelle concentration.
- When lipid concentration reaches certain level lipid self-association could occur, which affect the lipid binding with starch.
- The lipids with greater water solubility have a poor binding in low concentration and a good binding in high concentration.

Future work

- Analysis of properties of complexes
  - Imaging
  - X-ray diffraction
- Analysis of functionalities
  - Enzymic digestibility
  - Microbiological analysis
Project 2.3.12
Wheat quality for starch and gluten production

Collaborators
- Allied Mills Summer Hill NSW
- Penfords Starches Australia, Tamworth & Lane Cove NSW
- VAW CRC 2 year project

Personnel Involved
- Ian Batey VAW CRC (Project Leader)
- Natalie May (New appointment February 9 – Allied Mills)
- Di Miskelly (Allied Mills)
- Jenny Smit (Penfords, Tamworth)
- Ken McNaught (Penfords Lane Cove)

Research Problem
- Not all flours process correctly (Penfords view)
- All flours meet quality specifications (Allied Mills view)
- What is going wrong?

The Starch/Gluten Process
- Incomplete separation results in decreased yields of desired products, downgrading of product quality, and potentially increasing costs in waste disposal

Research Solution
- Identify the problem flours
- Identify the problem with each
- Characterise the flours in non-traditional ways
- Identify the cause of the problem
- Identify or develop tests to allow selection of wheat for starch/gluten processing
Program 3
Genomics and Proteomics

- 3.1.1: DNA Markers and Mapping Wheat Quality Traits
- 3.1.2: Wheat Proteomics
- 3.1.3: Targeted Mutagenesis of Wheat Grain Characteristics
- 3.1.4: DArT Technology for Wheat
DNA Markers and Mapping Wheat Quality Traits

Mohammad Shariflou
Joanne Elsden
Peter Sharp
Background

- Started by Matthew Hayden
- Recent transfer from Matthew to Mohammad Shariflou
- Matthew’s MOU
  - SAM and STMP techniques are publicly available
  - Markers developed from these techniques remains confidential properties of VAWCRC
  - Completion of new generation of STMP markers
Project Aims

- **Development of high-throughput DNA markers**
  - STMP-based SSRs
  - DArT microarray-based markers
- **Genetic mapping of STMP markers**
  - International mapping populations
  - Australian mapping populations
- **Implementation in Australian breeding programs**
  - Marker-assisted selection (MAS)
    - Disease resistance genes
    - Quality traits
    - Agronomical traits
  - Variety identifications
Current situation

- **STMP database**
  - Total of 364 SSRs
  - 223 STMP SSRs
  - 85 STMP-converted wmc SSRs
  - 56 STMP-converted gwm and gdm SSRs

- **Chromosomal locations**
  - 1-6 mapping populations
  - Mainly Opata x Synthetic
  - 284 markers located on chromosomes
### Summary statistics of multiplexable STMP markers

<table>
<thead>
<tr>
<th>Bins</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Total</th>
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<tr>
<td>2-plex</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>3-plex</td>
<td>9</td>
<td>30</td>
<td>48</td>
<td></td>
<td></td>
<td></td>
<td>87</td>
</tr>
<tr>
<td>4-plex</td>
<td>3</td>
<td>1</td>
<td>8</td>
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<td>15</td>
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<td>9</td>
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<tr>
<td>Total</td>
<td>15</td>
<td>43</td>
<td>60</td>
<td>22</td>
<td>27</td>
<td>21</td>
<td>188</td>
</tr>
</tbody>
</table>

Mixture of weak and strong amplifications in multiplex bins
Not consistent amplifications
6-plex PCR
Future directions

- More work to fine tune multiplex PCR bins
  - Extending the no of bins to cover the whole genome
  - Specific bins for specific breeding targets
  - Cost efficiency
    - Increasing the no of markers/bin
    - Post-PCR mixing of bins
    - Multiple load of gels
    - High-throughput DNA extraction method

- Fine mapping
  - Relating to other DNA markers in wheat genetic maps
  - Linkage with genes/characters of interest
  - Classify for linkage distance and identify perfect markers

- DArT
  - Collaboration with CANBIA
Future directions

• Breeding services
• Marker-assisted selection (MAS)
  – Comprehensive list of breeding target (Niel Howse)
    • Disease resistance genes
    • Quality traits
    • Agronomical traits
    • Priority list of breeding characters
  – Screen breeding lines with candidate SSRs
  – MAS of breeding lines
  – Validation of linked markers
• Identification/confirmation of gene resources
• Variety identification
  – DNA fingerprinting
    • Line identification
    • Tracking lines
    • Parentage testing
This project is a collaboration between the VAWCRC and the Australian Proteome Analysis Facility (APAF) which is based at Macquarie University.

APAF is a consortium involving the University of Sydney, University of NSW and TGR BioSciences (a start-up biotech company in Adelaide).

APAF is a Major National Research Facility (MNRF) providing the infrastructure and expertise in proteomics.

In 2001 the consortium was awarded a second round MNRF grant of $16.25M over a 5-year period as well as additional grants from both NSW ($2M) and SA ($1M) State Governments.

PROJECT AIM

- To use proteomic technologies to find wheat grain proteins that differ between cultivars, and that are related to quality type.

RELEVANCE TO INDUSTRY

- There is a growing need for diagnostic tests in the grain industry, to identify cultivars throughout the marketing chain, and to identify samples with particular characteristics.
Wheat Grain Proteomics
Overview of some projects

- **Proteomics of soft wheat cultivars (Bowie and Rosella)**
  - Characterisation and identification of cultivar-specific proteins
  - Information on identified proteins supplied to diagnostics program

- **Serine protease inhibitor (serpin) polymorphism in Australian wheat cultivars**

- **Proteomic characterisation of wheat germ and bran tissues**
  - Conducted by PhD student Xian Mak
  - Large-scale analysis of proteins expressed in these specific tissues
  - One part of this study involves the comparison of control grain versus blackpoint damaged grain
  - Hopefully leading to the identification of more target proteins

Serpin polymorphism in Australian wheat cultivars
Collaboration with Dr Thomas Roberts (Macquarie University)

**Background information**
- Serpins are found throughout the plant kingdom
- They have been studied in a variety of plants (such as wheat, Barley, rye, oat and pumpkin)
- Six serpin forms have been identified in grains of hexaploid wheats
- Five of these serpins have been cloned and purified from *E.coli* (Danish research group)
- They are major albumins of wheat endosperm (~3-4 mg serpin/gram of grain)
- This is a good starting point in the search for non-storage related, cultivar-specific proteins
- The mobility of wheat grain serpins using native-PAGE is reproducible and an excellent means of testing for polymorphisms
Extraction of serpins from Sunco wheat cultivar
(method taken from Østergaard et al., 2000)

- Washing with 0.1 M Tris/HCl pH 8.0 (30 min for each wash)
- 20 mM DTT is added to washing buffer to extract serpins

Screening of wheat serpins using Native-PAGE

SYPRO Ruby fluorescent protein stain
Serpin polymorphism in Australian wheat cultivars

- A total of 74 hexaploid wheats and 4 durum pasta wheats were screened for serpin polymorphisms
  - 15 hexaploid wheats did not contain serpin 1a (~20% null)
  - 18 hexaploid wheats expressed a form of serpin 3 which had a higher mobility in native-PAGE (~25%)
  - ALL 4 durum wheats contained serpin 1a but did not contain any form of serpin 3

Serpin 3 detected in hexaploid wheats

(1) Lorikeet (biscuit wheat)
(2) Kamilaroi (pasta wheat)

Serpin polymorphism in Australian wheat cultivars

Chromosomal localisation of serpin genes

- Chinese Spring aneuploid and diteleocentric (DT) wheat lines were screened to localise serpin genes to chromosomes and chromosome arms

Summary

- **Serpin 1a** was not detected in nulli5B-tetra5A wheat lines, indicating that the serpin 1a gene is located on chromosome 5B
- Further analysis of DT wheat lines indicated that the serpin 1a gene is located on the long arm of chromosome 5B (DT5BL)
- **Serpin 3** was not detected in nulli7D-tetra7A or nulli7D-tetra7B wheat lines, indicating that the serpin 3 gene is located on chromosome 7D
- Further analysis of DT wheat lines indicated that the serpin 3 gene is located on the short arm of chromosome 7D (DT7DS)
Serpin polymorphism in Australian wheat cultivars

Chromosomal localisation of serpin genes (1a and 3)

Chinese Spring
Native-PAGE

Mapping serpin genes - screening double haploid populations

- Egret/Sunstar double haploid population
  • 157 samples screened

- Carnamah/WAWHT2046 double haploid population
  • 105 samples screened

- Ajana/WAWHT2074 double haploid population
  • 241 samples to be screened (currently half-way through sample set)
**Serpin polymorphism in Australian wheat cultivars**

**Mapping serpin 3 by screening the Egret/Sunstar double haploid population**
Samples were screened for the presence of the normal or higher mobility form of serpin 3.

<table>
<thead>
<tr>
<th></th>
<th>Hallard</th>
<th>CO37</th>
<th>Crabbrook</th>
<th>Sunstar</th>
<th>Egret</th>
<th>Katsina</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3)</td>
<td></td>
<td></td>
<td></td>
<td>Sunstar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4)</td>
<td></td>
<td></td>
<td></td>
<td>Egret</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sunstar** - normal mobility form
**Egret** - higher mobility form

This data set was sent to Rudi Appels for mapping.

It was mapped to 7D.

Confirms the aneuploid results.

---

**Mapping serpin 1a and serpin 3 by screening the Carnamah/WAWHT2046 double haploid population**
Samples were screened for the presence/absence of serpin 1a and serpin 3.

<table>
<thead>
<tr>
<th>Carnamah</th>
<th>serpin 1a(+) / serpin 3 (higher mobility form)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAWHT2046</td>
<td>serpin 1a(-) / serpin 3 (normal mobility form)</td>
</tr>
</tbody>
</table>

---

**Diagram 1:**
- Lanes: Carnamah 1a, Carnamah 3, WAWHT2046 1a, WAWHT2046 3
- Sizes: 5B, 7A

**Diagram 2:**
- Lanes: Carnamah 1a, Carnamah 3, WAWHT2046 1a, WAWHT2046 3
- Sizes: 5B, 7A

---

(7D ???)
**Serpin polymorphism in Australian wheat cultivars**

- **WHAT NEXT?**
  - Complete serpin screening for the Ajana/WAWHT2074 double haploid population – obtain mapping data
  - Wheat quality data will be available for these populations soon
  - Need to determine if serpin composition can be correlated to wheat quality………
  - On completion of the serpin work, I will be hunting for more polymorphic proteins………
  - There variety of projects waiting to start!

---

**Acknowledgments**

**APAF**
Stuart Cordwell  
Angela Connolly  
Bernie McInerny  
David Selby

**Macquarie University**
Thomas Roberts

**EMAI**
James Chin  
Ming Wu  
Thomas Giersch

**VAW CRC**
Peter Sharp  
Neil Howes  
Colin Wrigley  
Yunxian Mak

**Murdoch University**
Rudi Appels

**DAWA**
Michael Francki
3.1.3 Targeted mutagenesis of wheat grain characteristics

- The principle
- Proof of principle
- Tissue culture procedure
- AHAS targeting
- Future direction

The principle

![Diagram of the principle](image)

History of Targeted Gene Repair

- Yeast: oligonucleotide targeting 15 years ago
- Bacterium: homologous pairing 10 years ago
- Mammalian and Human cells: gene targeting and gene therapy 8 years ago
- Plant: Tobacco, Maize 4 years ago
- Rice: last year

Proof-of-principle in wheat

*In vivo transient GFP restoration by gene repair*

![Image of proof-of-principle](image)

Wild-type GFP

![Image of wild-type GFP](image)
**In vivo DNA repair in wheat**

**Efficiency of gene repair on point and deletion mutations**

<table>
<thead>
<tr>
<th></th>
<th>Green spots on 100 embryos</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA + SSO</td>
<td></td>
</tr>
<tr>
<td>Deletion-gfp</td>
<td>65</td>
</tr>
<tr>
<td>Stop-gfp</td>
<td>128</td>
</tr>
</tbody>
</table>

**Affect of medium on gene repair**

<table>
<thead>
<tr>
<th>medium</th>
<th>DNA</th>
<th>MSC</th>
<th>MSR</th>
<th>MSC-O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop-gfp + SSO</td>
<td>128</td>
<td>20</td>
<td>886</td>
<td></td>
</tr>
<tr>
<td>Wild-type GFP</td>
<td>307*</td>
<td>99*</td>
<td>1027*</td>
<td></td>
</tr>
</tbody>
</table>

* Average number of green spots on medium size embryo.

**Affect of embryo size on gene repair**

<table>
<thead>
<tr>
<th>Size*</th>
<th>Percentage of embryos had gene repair events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>Large</td>
</tr>
<tr>
<td>MSC</td>
<td>57%</td>
</tr>
<tr>
<td>MSC-O</td>
<td>92%</td>
</tr>
</tbody>
</table>

**Tissue culture procedure**

**AHAS targeting a selection strategy**

- Acetohydroxyacid synthase (AHAS) gene
  Branched-chain amino acid synthesis pathway
- Imidazolinone or sulfonylurea resistance by mutation of AHAS
  Pro165, Trp542, Ser621
- Double mutation will be the strategy for grain quality gene mutation
**Wheat AHAS gene**

```
GCCTATGATC CCAAGCGGTG GTGCTTTCAA
GCCTATGATC CCAAGCGGTG GTGCTTTCAA
GCCTATGATC CCAAGCGGTG GTGCTTTCAA
GCCTATGATC CCAAGCGGTG GTGCTTTCAA
GCCTATGATC CCAAGCGGTG GTGCTTTCAA
GCCTATGATC CCAAGCGGTG GTGCTTTCAA
GCCTATGATC CCAAGCGGTG GTGCTTTCAA
GCCTATGATC CCAAGCGGTG GTGCTTTCAA
```

The proposed mutation is AGC (Ser) to AAC (Asn).

**Imazethapyr selection**

![Imazethapyr selection image]

**Future direction**

- Use efficient genoplast.
- Improve tissue culture efficiency.
  - Callus induction from mature seeds.
  - Pollen tube pathway.
- Test other genotypes for mutation.
- Double mutation.
  - AHAS + grain quality related gene.
**PhD Project Outline:**

- Development of the Diversity Array Technology (DArT) to aid wheat genome studies and plant breeding

**Focus on Molecular Markers:**

- Miniature Inverted Repeat Transposable Element polymorphisms – genome polymorphisms and evolution
- DNA methylation variation – as a tool for analysis of epigenetic phenomena

**Start date:** March 2003

**Supervisors:**
- Dr Andrzej Kilian (Triticarte Pty. Ltd.)
- Professor Peter Sharp (PBI, University of Sydney)
Molecular Markers

- Based on the detection of sequence variation between individuals
- Usually closely linked to a trait of interest i.e. disease resistance
- Used to predict presence or absence of the trait of interest
- Accelerate and facilitate genetic improvement of crops through easier application of genetics

Uses include:
- Genetic fingerprinting
- Evaluate genetic diversity in germplasm
- Identify plant varieties
- Identify genomic regions associated with traits
- Follow traits in progenies of crosses
- Marker assisted selection

Transposable Elements

- In the 1940s Barbara Maclintock discovered transposable elements
- TE’s are classified in families according to their sequences similarity
- Class I: RNA intermediate,
  - i.e. retroelements, retroviruses, LINE’s, SINE’s
- Class II: DNA intermediate,
  - i.e. Ac, Ds, Tam, Spm
  > Subclass: MITES transposition mechanism is unclear.
Miniature Inverted Transposable Elements

- Super family of DNA type transposons
- Grouped into sub families based on TIR sequence i.e.
  - Stowaway (5’-TA-3’)
  - Tourist (5’-TAA-3’)
  - Emigrant (5’-CAGT-3’)
- Abundant in eukaryotic genomes (thousands of copies ~ 100-500bp)
- No obvious clustering in the genome
- Good genome coverage
- Recognised source of genetic variation (insertion/deletion events)
- Surrounded by low copy sequences
- Single primer amplifies both adjacent MITE regions
- Amenable for use with DArT

Experimental Approach - DArT

- Develop DArT panels using DNA from several wheat cultivars
- Digest with restriction enzyme and ligate adapter
- 1st round amplification using Adapter-specific and TIR primers (1:10)
- 2nd round amplification using adapter-specific and TIR primers (1:1)
- Amplify MITE adjacent regions
- Amplify product from 1st round
Initial Results

1. Janz and Westonia genomic DNA digested with MseI and ligation of F1/F1b adapter

2. First (suppression) and Second round amplification to amplify MITE-adjacent regions

3. Cloning, selection and insert amplification. Preparation of MITE-adjacent fragments for microarray printing

4. Preparation of Cy-3 and Cy-5 labelled targets for hybridisation

Hybridisation to Microarrays

5. Hybridisation of labelled targets to microarray

6. Image analysis, data extraction and candidate polymorphisms identification (DArTsoft)

Normalisation, background subtraction, replicate comparisons - grid-to-grid and slide-to-slide
Preliminary Results

**Method One – test DArT on Wheat**
- Creation of a 1500 clone Wheat Msel Stowaway library
- DNA - Janz and Westonia
- Several hundred microarray slides printed
- Targets prepared using F1 adapter, F1b adapter

**Results:**
- Adapter F1 - 41 candidate polymorphisms (2.7%)
- Adapter F1b - 139 candidate polymorphisms (9.0%)

**Conclusions:**
- Difference in % due to different adapter sequence/amplification efficiency
- This study was designed to test DArT’s performance using techniques developed for Rice on Wheat
- Further optimisation required to increase polymorphism detection

Current Results

**Method Two – decrease complexity reduction**
- Use Bsp1286I restriction enzyme instead of Msel
- Reduce the cutting frequency to detect more polymorphic fragments
- Expand initial studies to include Wheat DNA from:
  - Janz - Glebe - Trident
  - Westonia - Amery - Frame
- Use three new forward adapter sequences
  - AdaptC_TGCA-3’ - AdaptC_TGCC-3’
  - AdaptC_TGCT-3’ - all with AdapC_reverse primer
- Use 7 different TIR primers from Stowaway, Tourist and Emigrant MITE sub families designed for Rice and Wheat

6 DNA samples x 3 adapters sequences x 7 TIR primers = 126 reactions
Current Results

6 genomic DNA samples digested with restriction enzyme Bsp1286I and 3 adapters ligated (18 DNA samples)

<table>
<thead>
<tr>
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<th>Length</th>
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<tr>
<td>Janz</td>
<td>100bp</td>
</tr>
<tr>
<td>West</td>
<td>1kb</td>
</tr>
<tr>
<td>Grebe</td>
<td></td>
</tr>
<tr>
<td>Frame</td>
<td></td>
</tr>
<tr>
<td>Trident</td>
<td></td>
</tr>
<tr>
<td>Amery</td>
<td></td>
</tr>
</tbody>
</table>

Current Results

18 DNA samples amplified using Adapter primer and one of 7 TIR primers

- Pangangji (wheat)
- Orpheus (wheat)
- Castaway (rice)
- Ditto (rice)
- Stowaway (rice)
- Pangangji (rice)
- Gaijin (rice)

From these results it can be seen that further optimisation is required due to the presence of bands in the genomic representation.
**Optimisation**

Genomic Representation Optimisations

Bsp1286I

(a) Janz and (b) West DNA
Stowaway and Orpheus MITE's

(1) TIR and Adapter primer
(2) TIR primer only
(3) Adapter primer only

Smear/Bands in 3 = adapter to adapter
Smear/Bands in 2 = TIR to TIR
Smear 1 = TIR to Adapter plus bands from 2 and 3

Objective is to eliminate bands in 1

---

**Future Directions**

Lab:

- Further optimise complexity reduction methods established for other species for use with Wheat
- Design new TIR primer / Adapter / digestion combinations
- Explore DNA methylation patterns using methylation sensitive enzymes and similar techniques to those used for MITE

Equipment:

Develop the microarrayer and scanning potentials to include printing into poly-L-lysine microtitre plates and larger glass plates instead of microscope slides in 96 well format
Introducing Program 4

J R Oliver

What 4?

Output:
- Varieties with improved or novel traits

Who 4?

Clients & Stakeholders:
- Arnotts Australia
- Allied Mills
- Goodman Fielder
- GRDC
- EGA
- SunPrime
- Uni Sydney
- NSWA, DAWA
- GrainCorp,
- Goodman Fielder
- GRDC
- EGA
- SunPrime
- Uni Sydney
- NSWA, DAWA
- GrainCorp,

4merly...

- 4.1.1 - Extremes in germplasm & markers
- 4.1.2 - Doubled haploid production
- 4.1.3 - Soft wheat varieties
- 4.1.5 - Agronomy to target quality

4thWith....

- 4.1.1 Identifying extremes ...
- 4.1.3 = DH production
- 4.1.5 = Agronomy - Terminated
- 4.2.6 = Waxy wheats - contract research
- 4.2.7 = Commercialisation of DM5637*B8
- 4.3.10 = Triticale & Rye

Per4mance

- QalBis
- Waxy wheat line
- Novel extremes in germplasm identified:
  - Null PPO
  - B-granule starch variants
  - High apparent amylose
  - Extremes in soluble pentosans
  - Large grain size
- Molecular markers PHS; LMA; 4A, 7A, 7D GBSS
Where √4?

Molecular technologies: 4.1.1, 4.3.8; 4.1.2
Variety development: 4.1.3, 4.3.8; 4.2.6, 4.2.7

Breeding Programs

Outcomes: Varieties for Industry

4mat 4 (4)²day

Molecular Matters:
- Matthew Turner 4.1.1, 4.3.8
- A Sadeque, S Begum, K Sandhu: PhD projects
- C Soh, 4.1.1 PhD presentation - durum aspects
- MK Tan, 4.1.1 PHS & LMA
- M Francki, 4.3.9 WA markers & mapping

Production Perspectives:
- H Allen, 4.1.3 soft wheat
- M Shariflou, 4.2.6, measuring waxiness
- J Roake, Triticale & Rye
Objectives

Project 4.1.1
- Identification of novel quality characters
- Development of molecular markers

Project 4.3.8
- Generation of wheats with novel characters

Introduction
- Quality targets
  - Starch granule size distribution
  - Elevated amylose content
  - Low blackpoint incidence
  - Increased grain size
  - Null polyphenol oxidase
  - Extremes of water absorption
  - Improved milling yield

Starch Granule Size Distribution
- Starch is stored in granules in endosperm of cereal grains
- There are two types of granules in wheat endosperm which are designated A and B based on size and shape
- Little is known about variation in starch granule size distribution in wheat

Industrial Importance
- Different industrial uses for different sizes
- Processing
  - Small granules in wheat are not recovered in starch/gluten manufacture
- Product quality
  - B granules increase water adsorption?
  - This property may increase biscuit baking time (undesirable) and influence loaf quality (positive)

Objectives
- This work aims to identify germplasm with extremes of starch granule size distribution and to introgress them into elite wheats
A typical starch granule size distribution

Survey Results

- An exotic winter wheat with approximately 10% B granules identified
- Australian wheats with 20% (low) and 35% (high) B identified

Experimental Material

- Doubled haploid population generated from a hybrid of low B granule (Kewell) and high B granule (Vulcan) Australian wheats

Inheritance of B Granule Content

Breeding Material

- QAL2000 X Outlier 67
  - Selection for agronomy/rust resistance
  - F3 phenotyping revealed a continuous distribution for B granule content
  - Single head selections made in F4 (PBIC)
  - F5 evaluated last year at EMAI
  - B granule phenotyping to be performed on F6 seed this year

Future Work

- Further characterisation of the influence of starch granule size distribution on processing and product quality
- Continued effort to develop elite wheat cultivars with extreme starch granule size distributions
**Null Polyphenol Oxidase Activity in Wheat**

Abdus Sadeque

**Supervisors:** Dr Matthew Turner
Dr Akram Khan

---

**Background**

- Yellow alkaline noodles (YAN) are a major wheat product in Asia.
- Colour and brightness are important criteria by which noodle quality is assessed.
- Undesirable darkening is caused by polyphenol oxidase (PPO) and other enzymes.

**Background (cont)**

- Most hexaploid wheats have high PPO activities. The lowest PPO bread wheats are moderately high.
- Null PPO genotypes were identified in 4.1.1 and DH populations involving the null sources have been developed.

**Objective**

- To develop low darkening wheats that have null PPO activity.

**Thesis Outline**

- **Chapter 1**
  Optimise small scale PPO testing for breeding (GXE, sampling, substrate)

- **Chapter 2**
  Identify/ validate molecular markers for low/ null PPO

- **Chapter 3**
  Identify relevance of other darkening enzymes (lipoxygenase, peroxidases) and survey germplasm

- **Chapter 4**
  Characterise the influence of increasing milling yield (Null PPO lines) on YAN quality
Introduction

- Selection strategy in wheat breeding
  - Early generations: agronomy, disease, (yield)
  - Late generations: yield and quality

Problems of conventional breeding

- Good quality material can't be identified in early generations (and is often discarded)
- Difficulty recapturing extremes of quality

Aims

- To optimise breeding efficiency by incorporating:
  - Small scale testing
  - Marker assisted selection
  - Different breeding strategy

Thesis outline

- Chapter 1: Identify and validate molecular markers in wheat populations (WA, MY)
- Chapter 2: Evaluate field methods for screening single plants (MY, WA, Strength & extensibility)
- Chapters 3&4: Assessing the efficiency of early generation phenotyping, MAS and DH at different stages

Methodology

- Identify molecular markers in a Goldmark x sprouting tolerant line DH population
- Topcross Goldmark X DM5637*B8 (F1) with Frame
- Screen TCF1, TCF2 using MAS, phenotyping
- Produce DH from TCF1, TCF2, TCF1 intercrosses
- Evaluate the influence of selection on population distributions (by comparison to no selection)
Program 4 : Germplasm & Production

Durum Quality: Influence of Protein on Pasta Quality

Presented By: Cindy Soh
Supervisors: Dr. Mike Sissons
            Dr. Matthew Turner

Background

- Aim of project:
  o to determine the influence of protein fraction (HMW and LMW glutenins, soluble proteins and gliadins) on pasta quality using a reconstitution model
  o To investigate the influence of starch granule size distribution on pasta quality
  o To determine influence on pentosans on pasta quality
Reconstitution System

Fractionation of Components

Semolina (400g) + 240g water, 15°C → Dough

Wash dough water (800ml) over silk screen

Centrifugation

Remove gluten ball

Solubles → Residue = “tailings”

Starch

Approach

- Influence of HMW-GS on pasta quality
  - Assessed using a set of lines with common LMW-GS but varying HMW-GS [Glu A1(null, 1, 2*) and Glu B1 (7+16, 13+16, 17+18)]

- Similar method used to test effect of LMW-GS
  - Assessed using a set of lines with a common HMW-GS but varying LMW-GS [cfa, caa, caa/dab and bba]
Results

- **HMW-GS experiment:**

Results con’t

- **HMW-GS Reconstitution experiment**
  - Farinograph, mixograph and micro-extensograph testing carried out on all reconstituted samples
    - No significant differences between samples for all farinograph and mixograph parameters
    - Presence of Glu A1 (1 or 2*) caused significant increase in dough extensibility
  - Pasta quality testing (firmness and stickiness test) found no significant differences between samples.
Results con’t

LMW-GS experiment

- LMW pattern “bba” found to be the weakest with the shortest dough development time.
- LMW pattern “cfa” showed the least breakdown.
- Reduced extensibility in samples containing “caa/dab” and “bba” patterns are observed.
- No significant differences were noticed between the samples for pasta quality testing (firmness and stickiness).
Other Experiments Planned for 2004

- Protein experiment
  - To test effect of varying HMW-GS and LMW-GS ratio.
- Determine possible effects of water extractable pentosans (WEP) on pasta quality, particularly water absorption, by adding isolated WEP to base flour
- Influence of starch granule distribution on pasta quality
  - Starch with various A/B granule ratio to be isolated and used in reconstitution model
- Influence of high amylose on pasta quality by substituting durum starch for high amylose maize, barley and hexaploid wheat starch
Molecular Markers for seed dormancy and LMA in wheat

Mui-Keng Tan
EMAI, NSW Agriculture

Marker Development for seed dormancy and LMA

• Pre-harvest sprouting: involves release of high pI α-amylase from embryo

Sprouted Grains From Liverpool Plains in 2000

• LMA:
  • presence of high pI α-amylase in the entire grain
  • no obvious defects on grain appearance
Wheat Genotypes with PHS tolerance
include: red wheats, Aus 1408

Wheat genotypes prone to LMA
include: spica, Seri, Kennedy, Spear, Suneca

Markers for seed dormancy
Mapping pop: Cascade X Aus 1408 DH 80 lines
174 microsatellite markers
5 sets of phenotype data (D. Mares): 1999-2003

QTLs for seed dormancy

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<td>taVP1</td>
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<tr>
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<td>Xgwm604</td>
<td>3.9-5.7</td>
<td>5-7</td>
<td>4 trials</td>
</tr>
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</table>
Contributions to PHS from blackpoint expression

Blackpoint expression confound the measurement of germination data for QTL analysis in three environments.

Validation

Some selected wheat lines from the following crosses have been used for validation
- Janz 3*/Aus1408
- Rosella2*/Aus1408
- Seri82/Aus1408
- 2*HTG/Vasco///Aus1408
- 2*URES/Jun/KAUZ//Au1408
- Sunco/2*QT7475

Implementation: In progress
Marker Development for LMA

- Screen
  - Induction
  - Measurement of LMA activity
  - Spica is used as a reference

- LMA index = 
  \[(\text{raw OD450} - \text{Blank mean})/\text{spica mean} \times 10\]

Spica was assigned an LMA index of 10.

Populations

- Spica X Maringa DH 135 lines
- Seri X Hartog 200 RILs
- WW1842 X Whistler DH 225 lines
**WW1842 X Whistler**

- Both parents have LMA
- **WW1842:** (2 trials-2001 and 2003)
  - 47 lots of 5 grains = 235 grains screened
    - 1 lot has a LMA index of 10
    - 6 lots have very low index (0.1-0.32)
- **Whistler:** (2 trials) ???
  - 36 lots of 5 grains = 180 grains screened
    - 1 lot has a LMA index of 3.14
    - 5 lots have low index (0.1-4.9)

**Distribution of LMA**

- Distribution of LMA in Spica X Maringa DH
- Distribution of LMA in WW1842 X Whistler
Spica X Maringa

- Highly significant QTL on 7BL in Spica
- Coincided with LMA marker for Cranbrook
- Not associated with LMA in Seri

WW1842 X Whistler

Mapping:
80 lines using stm, Barc, Xwmc, Xgwm and AFLP markers
A Putative QTL on 2B linked to LMA

Acknowledgements

- Daryl Mares/Kolumbina Mrva
- Ruijun Li
- Renu Srivastava
- Meiqin Lu
- Peter Sharp
- Neil Howes
- Jan Gooden
- Matthew Hayden
- Peter Martin
- Andrew Milgate
4.3.9 Marker validation and identification for key quality attributes in WA adapted germplasm

Dr Michael Francki (Project Leader)
Ms Karon Ryan (PhD student)
Ms Natalie Parry (Research Officer-genotyping)
Ms Tash Teakle (Research Officer-genotyping)
Mr Bill Lambe (Cereal Chemist-phenotyping)

General aim

- To identify similar and alternative QTLs controlling quality traits in WA adapted germplasm

Quality traits and populations

- *Westonia*^2^/Janz (n=194)
  - Flour colour, grain Size
- Carnamah/WAWHT2046 (n=122)
  - Flour colour, Milling yield
- Ajana/WAWHT2074 (n=202)
  - Flour colour, Water absorption
- Ajana/WAWHT2046 (n=175)
  - Flour colour, Water absorption
- Cadoux/Reeves (n=130)
  - Flour colour, non-null4A GBSS FSV

Strategy

- Develop framework SSR maps of DH populations
- Quality analysis of populations grown in different environments
- Integrate genotyping and phenotyping for marker-trait associations

Genetic framework map: an example

Phenotyping

- Filed trials: augmented random block design
  - Biometric adjustment for spatial variation in field and laboratory
- 2002 trials of three populations
  - Wongan Hills and Katanning (failed)
  - Quality analysis completed one site only
  - Data suitable for marker-trait analysis
- 2003 trials of three populations
  - Wongan Hills, Merredin and Katanning (failed)
  - Quality analysis for 2 sites in progress
Future work

- Grain quality analysis of three populations from 2003 field trials
- Marker-trait associations confirmed from 2003 trials (2 locations)
- Validation of traits in Ajana/WAWHT2046 population
- Identification/validation of markers for flour colour and non-null 4A FSV in Cadoux/Reeves
Program 4 : Germplasm & Production

Soft Wheat Program

Project Leaders:
Helen Allen and Andrew Kennett

2003 Trial Report

Series 3
- 5 sites Narrabri, Wagga, Trangie, Coleambally and Benerembah

Series 1
- 2 sites Narrabri and Wagga
  - All sites were irrigated but still most sites have higher than desirable protein for Semi-Sweet biscuits.
  - Stripe rust caused devastation in the trials and many lines have been rejected for susceptibility to stripe rust

Yield Across Sites Analysis 1997-2003

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<tr>
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<td></td>
<td>101%</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Bowie</td>
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<td></td>
<td></td>
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</table>

Crossbreds

VAW26 = 94%, VAW15 = 97%, WW5888 = 101%
WW3362 = 102%, WW3363 = 102%, C1064 = 103%
C1091 = 104%, WW4363 = 104%, C1092 = 105%
WW9900 = 105%, VAW11 = 107%, VAW35 = 107%

Pure Seed Supply

VAW26 = 94%  VAW15 = 97%
WW5888 = 101%* WW3362 = 102%
WW3363 = 102%  C1064 = 103%
C1091 = 104%  WW4363 = 104%
C1092 = 105%  WW9900 = 105%*
VAW11 = 107%  VAW35 = 107%

VAW26 and 15 will be discarded on poor yields
Lines in green have approximately 25 kg pure seed
Lines in orange have no pure seed

*WW5888 and WW9900 = Rosella Crosses (HPS)

Research

Development of a cracker biscuit bake test
- Test is based on a cracker biscuit method used at Arnotts
- It has been adapted for use in the WWAI laboratory
- We used wheat from a high protein irrigated site from 2002 (11.5-12% WP)
- Both hard and soft wheat were used from the trial

Jennifer Pumpa helped with the work, Jennifer works on a GRDC irrigated wheat project aimed at identifying management practices that will enhance production on the irrigation areas SNSW, without affecting quality.

Mixing was conducted in a Newport Scientific Doughlab Work input and mixing curves were recorded.
The Process

- Mixing the sponge (yeast, flour and sugar)
- Mixing the dough
- Resting (3 hours)
- Sheeting
- Laminating
- Cutting and Docking
- Baking
- Cool 30 mins and take the measurements

Results Indicate

- Strong Hards
  o Baked thick hard biscuits, high work input on mixing and were light uneven brown
- Weak Hards
  o Baked acceptable biscuits
- Strong Softs
  o Baked nice golden brown biscuits
- Weak Softs
  o Baked thin biscuits, with uneven light and dark brown colour
Rapid Identification of Waxy Wheat Seeds by Staining in the Field and in the Laboratory

Mohammad Shariflou
Peter Sharp
Background

- Waxy character is controlled by 3 waxy loci in bread wheat
- Expected low frequency of waxy seeds in segregating populations
  - 1 in 8 in DH lines (segregation between lines)
  - 1 in 64 in F2 lines (segregation within lines)
- Requirement for rapid identification of waxy lines to cost effectively enhance breeding programs
  - Development of a rapid assay of waxyness in the field
  - Development of a rapid assay of waxyness in laboratory
Identification of waxy seeds in the field: equipment

- narrow nose secateurs for cutting seeds
- 500-ml spraying bottle of iodine solution for staining
- labels and pens
Identification of waxy seeds in the field: protocol

1. Cut 2-3 seeds at once on the plant head
   Best stage for cutting is 2-3 weeks prior to harvest
   When seeds are ripened but not completely dried

2. Spray the cut seeds with $I_2/KI_2$ solution

3. Visually score in few seconds (spray can be repeated if needed)

4. Label single heads carrying waxy seed
Detection of segregant seeds within a single head in the field

Cut seeds before staining

Cut seeds after staining

Dark blue indicates non-waxy seed
Light pink indicates waxy seed
Detection of segregant seeds between single heads in the field

Two single heads each with 3 seeds were stained. Left: light colored seeds represent the whole single head as waxy. Right: dark colored seeds represent the whole single head as non-waxy.
Labelling single heads carrying waxy seeds
Identification of waxy seeds in the field:
value of the technique

• **Advantages**
  – Huge saving of resources for elimination of unwanted lines from
    • harvesting
    • threshing
    • Post-threshing assay for waxyness
  – Selection of waxy lines in early stage, allowing the advanced planning for the future

• **Efficiency**
  – Simple and easy to apply
  – Fast and reliable results
  – Cost effective
  – Fast method for gene enrichment when selecting for three waxy loci
Identification of waxy seeds in laboratory

• Identifying single waxy seeds is needed
  – Breeding purposes
  – Breeding of the embryo side, and DNA extraction from the non-embryo side

• Problems
  – Staining the embryo side reduces the germination rates
  – Staining the non-embryo side is needed for selection of the embryo side
  – Extra work for storing embryo and non-embryo side separately in either single tubes or 96-well plates
  – Extra work for labelling embryo and non-embryo side when using single tubes or tedious work for tracking them, when using 96-well plates

• Development of an alternate simple method
Identification of waxy seeds in laboratory: equipment
Identification of waxy seeds in laboratory: schematic procedure
Identification of waxy seeds in laboratory: protocol

1. Fix single seeds between 2 length of sticky tape (with ~1.5 cm spacing and all with the same orientation)
2. Cut the fixed seeds in the strip with scissors
3. Stain the non-embryo side of the cut strip by dipping into staining solution
4. Align the two cut strips to identify the embryo side of the waxy seeds
5. Store the strips in the original seed bags for later use
Identification of waxy seeds in laboratory value of the technique

• **Advantages**
  – **Key point**
    • Handling seeds in batches and not individually
  – **Saving resources**
    • No requirement for individual labelling
    • No requirement for individual storage
    • No requirement for tracking IDs of cut sides for finding waxy seed
  – Easy and safe cutting seeds

• **Efficiency**
  – Simple and easy to apply
  – Fast and reliable results
  – Cost effective
  – Fast method for gene enrichment when selecting for three waxy loci
Conclusion

• Both methods are
  – Useful tools for waxy wheat breeding
  – Proven valid with implementing on large numbers of commercial breeding lines
  – Very simple and independent of field or laboratory conditions
  – Rapid and reliable
  – Cost effective
Triticale and Rye Program
University of Sydney

Figure 1 - Triticale Production in Australia 1992 - 2000

Figure 2 - Triticale Production 2000 State by State

Figure 3 - Dry Matter 1 and 2, and Grain Yield of D.P. Triticale Compared to Maiden - Across Sites and Years Analysis 1998-2003

Breeding of Dual Purpose Triticales

- Higher Grain Yield,
- Improve forage biomass in Autumn and Winter
- Improve growth habit for grazing
- Selection for improved grain quality for animal feed

Winter Triticale

- 50-60% higher yielding than Jackie
- Lower Dry matter production in early stages
- Flowers 10-14 days earlier
- Accounts for 1 – 1.5 t/ha yield difference
Future Directions

• Improved Feed Quality – Changing Amylose content, high and low
• Triticale for Bread production
• Triticale as a Hay Crop

Triticale – Baking Quality

• Translocation Stock in Presto Triticale - Glutenins and Gliadin from 1D in 1R.
• Glu-D1 (5+10)
• Glu-D3
• Gli-D1

Triticale – Baking Quality

• White Seeded Triticale
• Hard Triticale
• 7+8 Duplication from Glenlea

Cereal Rye

• Rysun (Crossbred) – Rust resistant – 1979
• Westwood (Crossbred) – Westons – 2004
  10 % Higher yielding than Rysun

Cereal Rye

• High Soluble Pentosan Rye – 2005/6 Population 5% higher yielding than Rysun
  Mean Population – 9.3 μg/mg
  Lowest – 7.05 μg/mg
  High – 11.5 μg/mg
  Mean – 10.5 μg/mg top 13 lines for Synthetic

Cereal Rye

• White Seeded Rye – Release 2006
• Hybrid Rye – Release 2006, 20% higher yielding than Rysun
Education & Technology Transfer
- from research to implementation

Program Manager:
Clare Johnson

VAWCRC Conference
Feb. 2004

Australian government’s criteria:

3.4.1 research training will be the main component - includes value-adding (professional development)
3.4.2 should meet the needs of the user sector.
3.4.7 emphasis on user linkages & participation
3.4.9 appropriate professional training for workforce to update technical skills and facilitate technology transfer.
3.4.10 to produce CRC’s enduring achievements.

Balance to fit requirements of the wheat industry

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A balanced program addressing strategic industry requirements

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<td>5.1.1: Students, technical workshops</td>
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<td>5.1.2: Technology transfer</td>
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<td>5.1.3: Farmer publications</td>
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<td>5.1.4: Farmer courses</td>
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<td>5.3.5: PhD: new biscuit process</td>
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<td>5.3.6: Breeding initiative: 7 PhDs</td>
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Income from Education & Technology Transfer

Courses:
- average 78% cost recovery, 22% subsidy

Sales of publications
- Grain storage CD $1,360 so far 2003/04

External grants
- $3,875 High Growth Bio-Business Program Grant, NSW Dept. State & Regional Development, for Dr MK Tan to attend:
  - Microarrays & Analysis
  - Protein Structure BioIT and
  - BioIT Programming courses by BioLateral
- Food Innovation Grant to pay 50% cost of 5.3.5 ($43,907 over 3 yrs)

Seeking:
- AusIndustry IAccP Technology Diffusion ($60K), and
- GRDC “New Generation Breeders” grant ($1M over 4 yrs).

---

5.1.1: Research training - undergraduates
2002-2003

- Summer students: Arnott’s Product Research
  1. Strategic blending of flours – Arnott’s: C. Chow
  2. Interactions between flour blends, hard & soft wheats - SARDI: D. Hartono
- Summer students: Molecular Technologies
  3. MAb’s against LMW peptides from starch granules – EMAI: P. Scheffeld

  * Applicant field had good potential for higher degrees later.

- Undergraduate scholarship 2003-2005, $6,500 / year
  - Awarded to Angela Bennett, UAI 99%, enrolled in BScAgr
    - HSC Maths, Chemistry, Agriculture, IT and Advanced English

5.1.1: Research training - undergraduates
2003-2004

Summer students:
1. BioIT, CSIRO Food Science Australia: W. Gao
   - system for automatic interpretation of protein results.
2. Triticarte operations, Triticarte P/L: L. Foran
   - development & application of wheat arrays
3. Antibody diagnostics, NSWAg: EMAI: A. Zheng
   - food attributes, e.g. colour, glycaemic index
4. Industry project, Goodman Fielder: K. Song
   - Correlation of newly developed Bread Imaging System with traditional methods

  * Applicant field had good potential for higher degrees later
5.1.2: Internal project information exchange: the SharePoint Portal

Documents appear in ‘Categories’ once approved

5.1.2: Maintaining dialogue with Participants

- VAWCRC conferences Feb 2002 and 2004
- Review of research and education
  - Training in management and presentation skills
  - produced industry-responsive project charter and report forms (Prog 5)
- IP session
- New student induction
- Industry Forum
- Focus groups: innovation process, cross-project linkages and commercial focus
- Industry Forum conducted during AOP process April each year
- Workshops on specific value chain issues, when required

5.1.2: Technology Transfer Achievements: Triticarte identity and survey

- Survey preceding 3 breeder workshops, Aug 2003
  - provided input on:
    - breeders’ current use of molecular markers,
    - their potential use of Triticarte services, and
    - adaptations required to better meet their needs.
- Flyer and poster designed for launch
- Database of Australian and International breeders assembled
- Interactive website and newsletter to be designed

5.1.2: Co-publication with RACI-CCD

- based on varietal data summarised in QWCRC report 48 and VAWCRC report 8

5.1.2: Revision of Stalk to Store book; on-farm Grain Storage CD package

- CJ invited to source up-to-date information
- Included Wheat CRC outcomes:
  - WheatRite, aeration, QA, and
- external research outcomes:
  - heat disinfestation, wet harvesting
- Cross-referenced, to present rounded picture
- Distribution agreement: package
- Sales: 880 CDs since Aug. 2002 (currently $9)
5.1.3: FertiPlan published Feb 2003 (Rural Solutions SA)
- user-friendly software for farmers in SE Australia, to aid fertiliser application decisions
- Calculates N and P for target yield and quality, each crop
- Shows outcome if yield or protein vary
- Calculates least-cost fertiliser rates
- Calculates optimal grain protein for the highest return

5.1.4: “WA Wheat” database on CD-ROM for farmers
Technology transfer from GRDC research project DAW632, which involved APSRU, AgWA, GRDC and CSSRO Sustainable Ecosystems & Land and Water
- over 7 million data points, covers
  - 101 seasons (1900 to 2001)
  - 20 locations
  - 2 rotational histories
  - 2 levels of starting soil moisture,
  - 3 broad soil types
  - 4 rates of nitrogen
  - 3 timings of nitrogen application
  - 7 sowing dates
- predicts impact of season and management on wheat yield, protein content and leakage of water and nitrate beyond the root zone for locations and soil types across the WA wheatbelt.
- Agreed: VAWCRC logo on product and publicity, with others. Royalty under negotiation.

5.1.4: Value Chain Marketing Course
Australian wheat producers now require:
- greater chain and consumer awareness
- more downstream linkages
- increased accountability in production and marketing
Course to help farmers evaluate their market focus & target:
- the commodity arena
- the contract arena
- the branded product arena
Delivery 2004:
- 2 day workshops, stand-alone CD-ROM, TopActive modules
- online delivery via USyd Orange
- Interest from AFFA, GrainGrowers

5.1.4: wheat quality courses, WA
Quality: Suitability for a particular end use
- Courses for farmers and grain handlers
- Market/customer end-use requirements for:
  - Noodles (YAN, WSN, instant, long-life)
  - Breads (pan, flat, steamed)
  - Pasta
  - Cakes, biscuits
- Key grain specifications for these products
- Role of grain quality in milling efficiency for specific end use
- Strategy to achieve target market profitably
- Course held July/August for 33 farmers
  - Droughtlast year impacted on enrolments
  - Setting up TopActive module delivery

5.1.3: for farmers: TopActive modules
- training resource packages for use by farm advisers when delivering a workshop
Published:
- Growing quality durum wheat – module #CE701TA
- Modules in progress 2003/2004:
  - Preseason planning - assured production systems and risk management for short supply years (link agronomy projects)
  - Nutrition management to meet quality specifications (FertiPlan link)
  - Harvesting and storage - developing QA using best practice Environmental Management Systems (CD link)
  - Marketing: quality wheat for speciality end uses (Quality course link)
  - Exploring opportunities in Value Chain business (VCM course link)
  - Building a new Value Chain business (VCM course link)
  - Soft wheat agronomy and value chain marketing (SW Forum etc.)

5.1.1/5.1.2: Workshops at Conferences - maximise accessibility
Cereal Chemistry Conference, Sept 2003:
- Pre-screening for Breeders (21 attendees)
- NIR (Phil Williams, PDK Grain, Canada): statistics, software, sampling, validation and calibration. (26 attendees)
ComBio, Oct. 2002:
- 3-D structure - Design for Mutagenesis (21 attendees)
- Microarrays and Proteomics for Gene Discovery (30 attendees)
- Diversity Array Technology (19 attendees)
- Bioinformatics (17 attendees)
- 3 day Masterclass: “Population Breeding Methodology and Plant Improvement” (54 attendees)
Cereal Chemistry Conference, Sept. 2002:
- Prebiotic Carbohydrates and Gut Health (also presented in Perth, Wagga and in a private session to Goodman Fielder, Rutherglen)
- Enzymes in Industry, 2002 (30 attendees)
- Diagnostics (internal)

Manuals produced for all workshops
Workshops/short courses 2004/2005

- Genomics (VS)
- Grain morphology (VS)
- Graphical Genotyping for Triticate (CJ)
- Breeding Masterclass 2005 (CJ)

Student Training, and Breeding Initiative

C. Johnson

Postgraduate students

Target: 30 in CRC term 2001-2008

- 6 from QWRC completing
  (3 accepted, 1 submitted, 2 to submit by June 2004)
- 5 started in early 2002; complete 2005
- 3 started in 2003
- 5 starting in 2004 (projects 112, 219, 313, 438 & 535)

Breeding succession initiative: further 5 in early 2004 - 2 appointed so far, several under offer
Total: 24

- 6 required in 2004/05 AOP
  e.g. in diagnostics, breeding/technology, BioIT and processing

5.3.6: Address urgent succession issue in wheat breeding with Sydney University and UWA

- 7 PhD scholarships in wheat breeding, with placements in breeding companies later in the PhD (AGT, EGA, SunPrime)
- Students to visit international centre of excellence
- Masterclasses etc at conferences
- Undergraduate, Hons and summer scholarships to attract students into plant breeding at USyd and UWA
- Promotion to school students of high-tech breeding as a career

5.1.1: PhD student training

Targeted technical training: proteomics, mutagenesis, BioIT, conferences
- e.g. 50% efficiency gain in database searching for student and staff
- Industry co-supervision
- Quarterly reporting: budgeting, project management
- Supervisors' assessments
- Communications and IP

<table>
<thead>
<tr>
<th>Year</th>
<th>Task</th>
<th>Timeline expected by VWA/CRC</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>1st experimental approaches in research work started</td>
<td>month 3</td>
</tr>
<tr>
<td></td>
<td>Identification of further data required (extension needed?)</td>
<td>month 12</td>
</tr>
<tr>
<td>2</td>
<td>Required change of direction determined</td>
<td>month 13</td>
</tr>
<tr>
<td></td>
<td>Student participates in budget planning for next financial year</td>
<td>month 13</td>
</tr>
<tr>
<td>3</td>
<td>Thesis sketched</td>
<td>month 25</td>
</tr>
<tr>
<td></td>
<td>Identification of further data required (extension needed?)</td>
<td>month 25</td>
</tr>
<tr>
<td></td>
<td>Student submits budget planning for next financial year</td>
<td>month 25</td>
</tr>
<tr>
<td></td>
<td>Experiments complete</td>
<td>month 30</td>
</tr>
<tr>
<td></td>
<td>First draft of thesis complete</td>
<td>month 33</td>
</tr>
<tr>
<td></td>
<td>Final thesis complete</td>
<td>month 36</td>
</tr>
</tbody>
</table>

5.1.1: PhD student professional training

CRC Leadership and Career Development Course, Sept 2003
- Leadership
- Team building
- Influencing
- Creativity in research
- Strategic planning and career context
- Industry and CRC context
- Individual action planning

IP in Agriculture and Biosciences, Nov 2003
- Plant breeders’ rights, commercialisation of research, recent controversies, GM food labelling, govt inquiries & possible reforms

Presentation Skills Courses, May-Nov 2003
- Structure, delivery & performance
Program 5
Education and Technology Adoption

Vicky Solah
CURTIN UNIVERSITY

CURTIN UNIVERSITY’S CONTRIBUTION TO PROGRAM 5

- 5.3.5 Novel Biscuit Process
  Project leader Vicky Solah
  Principal researcher/PhD Wendy Newton

- 5.1.1 Skilled graduates and postgraduates for industry succession
  Annual relevant technical workshop developed

Short course /technical programs

- Prof Carl Hoseney Starch
- Dr Colin Wrigley Protein
- Dr Andrew Ross Enzymes
- Dr Martin Playne Prebiotics*
- Nick Harkness and others Colour workshop
- Dr John Munro GGE*
- Dr Stan Cauvain Cakes
- Dr Phil Williams NIR*
- Prof Geoff Fincher Genomics*

Selection of a presenter- teacher focus

- Expert in area
- Passion for topic
- Able to transmit information- interesting, maybe a little humour
- Clear speaking

THINK OF BEST LECTURE EVER
WRITE DOWN WHAT MAKES A GREAT TEACHER

Cereal Chemistry Division Further Education
The Royal Australian Chemical Institute

UNDERSTANDING GENOMICS
– an overview for those with other expertise

Presented by Prof Geoff Fincher
Australian Centre for Plant Functional Genomics

10 Feb 2004
Novotel St Kilda, Vic.

A Course Sponsored by Value Added Wheat CRC Ltd
What makes the presentation good

• Organised
• Balanced coverage of area
• Not too much on slides
• Correct font size
• Easy to read
• Animation if appropriate

Interpretation of Errors

• From the previous table (Table 8.3 in the manual), it is clear that the NIR error was responsible for about one third of the overall SEP, and that the instrument error at about 1.5% was only a small factor in the overall error of testing.
• Once the residual error is obtained it can be used to estimate the minimum that the SEP could be if the other sources of error (NIR and reference testing) could be improved.

THE REAL DIFFERENCE

Student focus

• Able to facilitate students own professional understanding
  Phil - this is a great area I want to help you understand
• Guide student to explore and develop
  Martin & John – how to use my knowledge to develop your research
• Challenge and enable students
  AB: Send a student! I'm excited and planning the future research
  Good back up material
• Connect
  Carl and Geoff - leave students wanting more
5.3.5 Novel Biscuit Process

Wendy Newton
Curtin University of Technology

Background
B.Sc: Food Science & Technology
Advanced MBA: Marketing
Microbiology
AIFST: WA Branch Chairperson
Family

Novel Biscuit Process

Project leader - Vicky Solah
Stakeholders - VAWCRC and Westons
Description - Relationship between starch and process
Jessica Dalton-Morgan
Supervisor: Prof Peter Sharp
Associate Supervisor: Dr. Chong-Mei Dong

Project: Targeted mutagenesis technology for wheat

Previous experience

• Honours project: Characterisation of an Arabidopsis mutant defective in Jasmonate-induced expression of defence genes
  – PDF1.2 compared against actin stds
  • Both qualitative and quantitative methods

Previous experience

• CSIRO macadamia group
  – Individual kernel identification project

• PhytoLink Australia Pty Ltd
  – Brisbane-based Phytoremediation company
  – Based on American research
    – Hyperaccumulation of toxic metals
The relationship between proteomics, protein structure and functions

Structural proteomics is the determination of atomic resolution 3-D protein structures on a genome-wide scale in order to ascribe biochemical functions to gene products and to better understand the relationship between protein sequence, structure and function.
Protein structure – Primary structure

- Primary structure is the linear sequence of amino acids joined together by peptide bonds.
Protein structure – secondary structure

Secondary structure in a protein refers to the regular folding of regions of the polypeptide chain, to form $\alpha$-helix and $\beta$-pleated sheet.

Protein structure – tertiary structure

Tertiary structure is the full 3-dimensional folded structure of the polypeptide chain and is dependent on the interactions between the amino acid side chains. Disulfide bond patterns and ionic and hydrophobic interactions will greatly impact tertiary structure.
Protein structure – quaternary structure

Quaternary structure refers to the spatial arrangement of polypeptide chains. This structure may be a monomer, dimer, trimer, etc. The polypeptide chains may be identical (i.e., homodimer) or different (i.e., heterodimer).

Protein structure determination

- The 3-dimensional structure of a protein can be determined almost to the atomic level by the techniques of X-ray crystallography and nuclear magnetic resonance (NMR) spectroscopy.
- In X-ray crystallography a crystal of the protein to be visualized is exposed to a beam of X-rays and the resulting diffraction pattern caused as the X-rays encounter the protein crystal is recorded on photographic film. The intensities of the diffraction maxima (the darkness of the spots on the film) are then used to mathematically construct the 3-D image of the protein crystal.
- NMR spectroscopy can be used to determine the 3-D structures of small (up to approximately 30 kDa) proteins in aqueous solution.
The searching method from proteomic sequencing to 3-D structural image

Search Protein in http://expasy.org

Cross-references: PDBID

Download and save the structure explorer file from http://www.rcsb.org/pdb/

Input the structure explorer file in the PDB to MutiGIF Page

http://www.dkfq-heidelberg.de/spec/pdb2mgif/
Graduate Certificate in Cereal Science

Chris Blanchard
School of Wine and Food Sciences

Project Aims

- Develop 4 subject Cereal Science Certificate to:
  - Improved cereal chemistry education in Australia
  - Have a vehicle to integrate VAWCRC findings into the industry

Project outline

- Stage One:
  - Develop first two cereal science subjects based on Kansas State University package and VAWCRC material
- Stage Two:
  - Develop final two cereal science subjects based on CSU and VAWCRC material

Progress

- Cereal Science 1 complete and will run in Autumn Session 2004 (10 students?)
- Cereal Science 2: Structure approved and close to completion
- Cereal Science 3 & 4: In progress

Cereal Science 1

- Resources:
  - Subject outline
  - CSU study guide
  - KSU Study guide
  - Lecture videos
  - Home projects
  - EASTS
  - Forum access

Other courses served by subjects

- BSc (Plant Biotech)
- Grad Cert (Food Science)
- Grad Cert (Agriculture)
- Grad Cert (Generic)
- Grad Dip (Agriculture)

Future plans?
- Graduate diploma (Cereal Science)
- Coursework masters (Cereal Science)
Project 5.1.2: Initiatives for Uptake of VAWCRC Innovation

Hayfa Salman
Research Officer – Technology Transfer

Achievements

- Oven Technology Manuals
- Cereal Science Methods TAFE course
- Microbiological Safety and Stability of Refrigerated Noodles workshop
- Soft Wheat Supply Chain Forum
- DH Wheat Variety database
- Plant Breeders Database

Oven Technology

5 manuals were produced for the Bakery Advisory System- Dough Processing Optimiser Module
- b.a.s.1.1.1 Installation and Maintenance Guide
- b.a.s.1.2.1 Work book for Commissioning of DPO
- b.a.s.1.3.1 Training Manual for production and operation staff
- b.a.s.1.4.1 Training Manual for Mixing Operation Staff
- b.a.s.1.5.1 Dough Processing Optimiser Bakery Production and Operation Staff Overview

Oven Technology

Goodman Fielder  Burns Philp
(Semi automatic system) (Fully automatic system)

70% of material in old manuals will be used to produce new manuals for the fully automatic system

Additional Hardware Installation

Generate information to assist with optimum control
Cereal Science Methods TAFE course
• AACC Standard Methods, ICC Standards and RACI Official Testing Methods were used
• Consultation within the industry
• Chosen methods were mapped against units of competencies in Laboratory Operations Training Package.

Microbiological Safety and Stability of Refrigerated Noodles Workshop
• 22 people attended the workshop from different size organisations
• One factory followed the guidelines and developed HACCP plan
• Letters were sent to FSANZ, AWB and Safe Food NSW to seek endorsement of the guidelines, marketing and future cooperation
• Several requests have been received from trainers in Victoria, who wish to deliver workshops on this topic

Soft Wheat Supply Chain Forum
**Aim:** Understand the supply chain and discuss commercial issues
**Outcome:** Process to negotiate contract

VAWCRC confidential report No. 33 was produced.

Doubled Haploid Wheat Database
**Aim:** To help VAWCRC track the ownership of doubled haploid wheat populations and Conventional wheats for the IP register.

Plant Breeders Database
**Aim:** Target Triticate mailouts

Future work
• Produce new manuals for the oven technology project
• Continue with DH database
• Develop TOPACTIVE workshop on Soft Wheat
• Continue to identify opportunities for Technology Transfer within CRC program outcomes
Teamwork for Cooperative Research

Clare Johnson

- System design for records
- Effective oral presentation and reporting
- Meeting deadlines
- Keeping working relationships productive

Why set up systems?

- Time passes, memory fades
- Others may be interested in your data, methods or materials
- Traceability
  (Quarantine, QA in Industry, IP / Patents)
- Saves work

Map inputs, processes, outputs: self-prompting, cross-referenced system

Task 1
Buy
Prepare
Task 2
Project
Record
Report

Apply to:

- Reagents / methods
  - LIMS
  - (web applications ideal to link, e.g. buffer recipes to full protocol)
- Bibliographies - software:
  - Endnote (PC), Reference Manager (Mac)
- Variety / strain collections
  - Use systematic nomenclature, including year, initials, record type, no.
- Written report collections

System links

- lab. books
- reagents / methods
- products
- fridge / freezer
- cultures / cultivars
- cell stocks
- pedigrees
- antibodies
- scans
- computer files
- photos / printouts
- reports / references
- quarantine reagents
- media
- outputs
- dates
- data sheets
- patents

Oral and written presentation: Why present well?

- Accurate understanding
- Effective collaboration
- Respect for others’ workloads
- Perception of your ability
**Pitch**

- Senior Group
  - strategy, progress tables, schematics
- Technical team
  - strategy and detail
- General technical audience
  - strategy, graphs, schematics
- Wider audience
  - background & relevance, ≤ 3 core points

**Meeting deadlines “I’m too busy”:**

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<th>Important and urgent</th>
<th>Not important, urgent</th>
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<tbody>
<tr>
<td>Important, not urgent</td>
<td>Not important, not urgent</td>
</tr>
</tbody>
</table>

Plan & set priorities so you’re mostly in the green zone. Minimise any non-important activities.

**Recognise all aspects of the job**

*Managing time, several strategies at once, helps you:*

- Define decision points
- Detect gaps in project design
- Build reports gradually for papers or thesis
- Decide when to stop an unsuccessful approach
- Detect gaps in training
- Develop your career

*Use quarterly reporting to your advantage!*

**Negotiation tips:**

- Keep working relationships productive
  - Is the problem the task or the process?
  - Focus on the problem, not the person – map it out together on paper
  - I would like more of this / less of that / and the same level of…..
  - Focus on goals, priorities and development

**Cooperative Research**

- Combined strength
- Balance innovation and carry-through
- Focus and discipline
- Benefit to Australian economy
- Your part in lasting legacy
Commercialisation Activities of the Value Added Wheat CRC

Peter Vaughan
Commercial Director
CRC Conference - Toukley
February 2004

Presentation Overview

- Commercialisation
- Business Plan and Recommendations - Current Commercialisation Activities
- Future of the CRC

Review of the External Earnings Target Policy Applying to CSIRO, ANSTO and AIMS

Beneficial Outcomes of Policy:

- Commercially aware culture and are responsive to client needs
- Strong relationships with the commissioners and users of their research services and outputs
- Staff have an awareness of the commercial values of their skills and expertise

Unintended Outcomes of Policy:

- Encouraged short-termism in research planning
- Skewed research service provision to larger firms in more established sectors that could pay for the research services
- Discouraged collaborations among research providers
- Led to sub-optimal research commercialisation outcomes

Commercialisation Elements of CRC AOP

Project Proposal:

- Relevance to industry problem – demand driven research
- Value to industry – potential market size for IP
- Freedom to operate – existing and background IP
- People, technical and environmental risks
- Who will adopt the IP developed
- IP being generated and how protected
- Competitive/Complementary research in market
Commercialisation Elements of CRC AOP

Quarterly Reports:
- Progress
- Major achievements
- Issues inhibiting progress
- Critical decision points for research direction
- IP protection or technology transfer required

Methods of Commercialisation
- License to CRC Participant
- License to External Organisation
- Joint Venture
- Contract Research/Project Sponsorship (share of IP developed with the sponsor)
- Outright Sale of IP
- “Spin Off” Company

VAWCRC Business Plan

Objective of Business Plan:
To present a strategy to ensure revenue to fill the research budget “funding gap” of the CRC is maximised by providing benefit to the Australian Wheat Industry.

- Enhance the likelihood of the CRC’s continued operation at the end of the Commonwealth Agreement.

VAWCRC Business Plan

Starting Point – The “Funding Gap”

VAWCRC Business Plan

Starting Point – The “funding gap”
- Format developed and approved
- Valuation of CRC Projects
- Revenue Generation Options and Commercialisation Strategies identified
- Approval of Funding Options
- Completion, Approval and Implementation

VAWCRC Business Plan

Project Valuation - Weaknesses Exposed:
- If the “funding gap” is not filled the CRC will fall short of its Commonwealth Agreement budget and be ill-prepared to operate independently at the end of the contract
- Some projects have low NPV’s – outcomes not commercial products but feed into other projects of the CRC
- Likely beneficiaries of some projects do not contribute to the projects.
VAWCRC Business Plan

Recommendations for Utilisation and Commercialisation of Research Outputs:

- Continue with current activities
- Pursue Contract Research Project Sponsorship Opportunities
- Joint Venture – Triticarte Pty Ltd
- Strategic Alliance with Breeding Program
- Review Business Plan prior to 2005/06 Financial Year to determine if strategy is meeting objectives of VAWCRC

Current Commercialisation Activities

Soft Wheat Program

QAL2000

- Exclusive Licence Agreement with Austgrains International in 2001
- Production, Marketing and Distribution of Seed
- Production, Accumulation and Distribution of Grain
- Minimum Performance Requirements
- End Point Royalty: $2.00 per tonne

Current Commercialisation Activities

Soft Wheat Program

QALBis

- Plant Breeder Rights Licence Agreement with Austgrains
- Production, Marketing and Distribution of Seed
- Production, Accumulation and Distribution of Grain
- Minimum Performance Requirements
- Licence Issue Fee, End Point Royalty, PBR payment

Current Commercialisation Activities

Soft Wheat Program – Value Generation

- Grain Production and Royalty: 4,500 t: $9,000 (2001); 6,000 t: $12,000 (2002); est 4,500 t: $9,000 (2003)
- Potential Demand: 50,000 tonnes
- Industry Value: $50 per tonne produced – grower options, freight savings, continuity of supply
- Breeder Training: important for industry

Current Commercialisation Activities

WheatRite® and ReadRite™

- Patent, Trade Mark and Know How Licence with C-Qentec Diagnostics in 2001
- Patent – Detection of pre-harvest sprouting in cereal grains
- Trade Marks – WheatRite® and ReadRite™
- Licence Issue Fee
- Royalty: $0.40 per WheatRite® test
- $150.00 per ReadRite™ unit

Projected Income to CRC:

- $70,000 (2004)
- $95,000 (2005)
- $140,000 (2006)
- $250,000 (2007)
- $390,000 (2008)
Current Commercialisation Activities

**WheatRite ®**

**ReadRite ®**

**Current Commercialisation Activities**

**Bakery Advisory System:**
- **Aim:** To develop process control modules that increase bakery plant efficiency
- Dough Module has been installed and demonstrated to work at two Goodman Fielder bakeries
- Aim to “roll out” in 4-6 GF bakeries in next year
- Commercialisation arrangements being negotiated – Licence Agreement with Goodman Fielder
- Intellectual Property – Software®; Know How/Confidential Information

**Current Commercialisation Activities**

**Micro-Instrument – Z-arm Mixer:**
- Manufacturing, Marketing and Distribution Agreement being negotiated with Newport Scientific
- Intellectual Property – Prototype Unit
- Minimum Performance Obligations
- Royalty - % of Wholesale cost of unit
- Territory – The World*

**Current Commercialisation Activities**

**Breeder Test Kits:**
- Antibody tests to assist breeders select germplasm
- Commercialisation process to be finalised

**Germplasm Licensing:**
- Germplasm Transfer Agreements
- Access Fee and Equity in varieties commercialised

**Great Grain Quality Assurance Program:**
- Program in process of being sold

**Current Commercialisation Activities**

**Joint Venture – Triticarte Pty Ltd:**
- Business – High throughput, low cost whole genotyping service for wheat and barley breeding programs in Australia
- Joint Venture Agreement between Value Added Wheat CRC and DArT Pty Ltd
- Term - Commenced 1 July 2003 for a period 5 years; then to be determined
- Co-investment from GRDC – Shareholder through the VAWCRC
- Business Plan developed

**Current Commercialisation Activities**

**Strategic Alliance with Breeding Program:**
- Value of Germplasm can only really be obtained by commercialisation of varieties
- CRC is in discussion/negotiation with all wheat breeding programs in Australia
- Industry is very dynamic currently
Future of Wheat CRC

Short Term – 1-2 years
Aim is to implement strategies and recommendations of the Business Plan.

Medium Term – 4 – 5 years
End of Commonwealth Agreement
Future operation will be decided – Continue? Finish?
Funding sources to be reviewed/investigated:
- Self sufficient
- Another round from the Commonwealth
- One or two years funding requested from Commonwealth
- Approach Venture Capitalist

Presentation Summary
- Commercialisation
- Business Plan and Recommendations - Current Commercialisation Activities
- Future of the CRC
“Linking Market to Research”

- “Linking Market to Research” or “Linking Research to Market”? No one right or wrong
- Perhaps “Linking Market and Research”
- Decline in commercial R and D Departments numbers and $ spend over the last 5 - 10 years - Lots of “Band Aid” fixes
- In 1998 Bunge, Defiance and Goodman Fielder employed approx. 50 people in Commercial R and D. Today the figure is less than 8. Not an isolated case
- Bad and Good - Gone is the Day of Large Commercial R and D Departments
- Creates an Opportunity for “Commercial Research Providers” - CRC’s, BRI, CSIRO, Crop and Food, CCFRA, AACC - also creates competition amongst this group
- UNDERSTANDING of what the market NEEDS.

“Business”

- Business - Financial Pressure to perform, Little Understanding of R and D, More Focussed on Numbers
- R and D - (Dramatically?) Reduced Staff Numbers and therefore time
- Therefore less Information flow of WHAT IT IS INDUSTRY WANTS FROM RESEARCH.
- So we need to go and get this information…………and sell ourselves.

- Allied Mills Aust manufactures a range of bakery premixes - Bread, Cake and Donuts etc
- Allied Mills would have approx. 600 (non wheat) Raw Material Suppliers. We asked this group ………………
- If this was your business which of your ingredients would you use?
- LESS than 10 understand this segment of our business - and they are KEY INGREDIENT suppliers.

We have an opportunity to replicate this type of success in our market

- Minimise the DISCONNECT between Business and Commercial R and D and the Research Providers.
- We need to UNDERSTAND our market and respond to it. We need to see opportunities for the market and make them aware of it.
- Possibly a larger COMMERCIALISATION Dept? Or COMMERCIAL KPI’S for us all?

My challenge to the group is ………………Of the research you are conducting what is ABSOLUTELY FUNDAMENTAL that Allied Mills (or the other commercial partners) is aware of and that it integrates into its business?
What is Intellectual Property?

- Patents
- Plant Breeder’s Rights
- Trade Marks
- Registered Designs
- Copyright
- Confidential Information (and Trade Secrets)
- Circuit Layouts

Nature of a Patent

- National/regional rights.
- A patent provides the exclusive right to exploit the invention for a limited period*, in return for which the patentee must disclose how to perform the invention.
- Two types of AU patents:
  - standard patents *(20 year term)
  - innovation patents *(8 year term)

To be patentable, an invention must be…

- a ‘manner of manufacture’ (i.e., it must have relevance to the useful arts or commercial application).
- novel.
- inventive (standard patent) or sufficiently innovative (innovation patent).
- useful
Specialised Drafting Requirements in Biotechnology

Process of obtaining a patent
- Provisional application
- Complete application
  - individual applications
  - international type application
    (PCT application)
  individual applications

Nature of PBR
- National/regional right covering propagating material of a registrable plant variety.
- Duration of protection: 20 years (or 25 years for trees or vines) from grant.
- A ‘plant variety’ is defined in the Act as a plant grouping (including a hybrid) contained within a single botanical taxon (classification) of the lowest known rank.

Nature of PBR
To be registrable, a plant variety must:
- have been bred using 1+ breeding steps;
- be ‘distinct’ from other known varieties;
- be ‘uniform’;
- and
- be ‘stable’ between generations.

Nature of a Trademark
- A trademark is a sign used in the course of trade to indicate the source of goods or services and thereby distinguish them from the goods or services of other traders (i.e. it is a badge of origin!).
- The term of registration is 10 years, renewable in perpetuum.

Nature of a trademark
The main registrability requirements:
- that the mark is not an excluded sign.
- there are no prior conflicting applications or registrations.
- the use of the mark will not likely deceive or cause confusion, including deception or confusion with another mark or a varietal name.
- the trade mark is capable of distinguishing the goods and services of the applicant.

Ownership of IP
- Ownership of IP generally resides with a legal person who is the inventor, author of the design or literary/artistic work, breeder of a new variety, person who made the invention, design, new variety, or first to use a trademark.
- In the case of an employee who develops IP in the course of normal duties, the title devolves to a legal person who is the employer (an entitled person).
- A person who is the legal successor of an owner supra.
Specialised Drafting Requirements in Biotechnology

How the CRC captures new IP

- Staff Induction.
- Use of CRC laboratory/notebook.
- Reporting flow of IP from scientists to IP working group via Program Managers and Senior Management. IP working group discusses and advises on centre IP.
- Requirements for approval for publication.
- Requirements for specific CDA/MTA.

Value Added Wheat CRC
Linking Market to Research

Rachel Butler, Associate
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