A wheat breeders’ perspective on NIR application

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Introduction

• Wheat breeding is a multi-faceted discipline

• The breeder has to juggle the competing requirements from different sectors in the value chain

• Needs to be within the operational constraints of available resources
Demands on Breeding

• Grower
  – High and stable yield
  – *Agronomical* superior genotypes
  – Resistance to the biotic and abiotic threats in the target region
  – Best *quality* classification possible

• Millers
  – High yield of white flour that meets customer *quality* requirements.

• Bakers
  – Flours that give high yield of *consistently high quality* product.

• Processors
  – High product yield of *consistent quality at each step* in the process chain.

• End users
  – The consumers, who ultimately drive the value chain demand consistently *high quality products* at a competitive price.

• Feed formulators
  – Competitively priced grain of consistent *quality* and *high energy value*. 
Grain quality

• This presentation will focus on the area of grain quality and how NIR fulfils the needs of the breeder.
Grain quality

What is grain quality?

It means different things, depending who you are in the wheat processing chain.
Quality Targets

• The different demands for each quality target
• Two noodle types as examples:
  • Australian Prime Hard:
    – Hard grained wheat of protein content >12.8%
    – Very high milling quality (high flour yield at low ash content and flour colour)
    – Strong and extensible dough properties
    – Good baking quality over a range of baking technologies
    – High quality yellow alkaline noodles, (colour development and stability are critical)
  • Australian Noodle Wheat:
    – Soft grained wheat of protein content of 10.5%
    – Creamy coloured flour preferred for Japanese market, whiter flour acceptable for Korean market.
    – Colour development and stability critical
    – Must have high starch paste viscosity for preferred noodle texture
Hitting the target

Early generations
1000’s of lines

Mid stage
100’s of lines

Late stage
10’s of lines

The target, one line, the variety
Quality Testing

- Wheat breeders handle thousands of breeding lines annually, so it is not feasible to use end-product evaluations until only a relatively few elite lines have been identified.

- Requirements of an early generation quality test
  - **Small** sample size
  - **Rapid and repeatable** so as to result in a high daily throughput
  - **Correlated with and predictive of end-use quality** that will result in genetic advance
  - Ability to reliably predict real differences in quality among breeding materials **within and over seasons**.
  - Demonstrating that its application results in response to selection **producing genetic gain**
Quality Testing

• Many traditional early generation tests use grain or flour, which requires a relative large sample size

• Examples of early generation quality tests are:
  – Test milling:
    • Gives an estimate of potential flour yield.
    • The resultant flour can be assessed for flour colour
    • and used for tests of potential end-use quality, such as.
  – Physical tests:
    • Mixograph, micro-farinograph and extensograph
  – Chemical tests:
    • SDS or Zeleny sedimentation volume
  – Physico-chemical tests:
    • Pelshenke fermentation time
NIR

- NIR meets all of the requirements of an early generation quality test with one additional advantage:
  - Small sample, quick, correlate with end-use quality
  - Ability to predict real differences in quality among breeding materials
  - Results in response to selection producing genetic gain
  - **Testing can be non-destructive, leaving the grain for planting the next breeding cycle**

- The application of NIR in breeding for wheat quality began in the early 1980’s with the development of calibrations for the fixed filter instruments of the time for:
  - Moisture content
  - Grain and flour protein content
  - Grain hardness
NIR

• As the power of the instruments and interest in its applications developed, calibrations emerged for the prediction of:
  – Flour yield
  – Flour colour
  – Dough properties
  – Ratio of glutenin to gliadin
  – Ratio of UPP to total glutenin content
### Some NIR predicted quality data

<table>
<thead>
<tr>
<th>Quality measure</th>
<th>Mean</th>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain protein content (%)</td>
<td>13.8</td>
<td>17.2</td>
<td>11.7</td>
</tr>
<tr>
<td>Particle size index (w/w)</td>
<td>20.2</td>
<td>32.5</td>
<td>11.5</td>
</tr>
<tr>
<td>Milling yield (%)</td>
<td>74.7</td>
<td>76.5</td>
<td>73.3</td>
</tr>
<tr>
<td>Flour b* (CIE)</td>
<td>10.6</td>
<td>12.7</td>
<td>8.8</td>
</tr>
<tr>
<td>Water absorption (%)</td>
<td>63.0</td>
<td>67</td>
<td>55.8</td>
</tr>
<tr>
<td>Dough development time (min)</td>
<td>5.9</td>
<td>7.9</td>
<td>3.0</td>
</tr>
<tr>
<td>Extensibility (cm)</td>
<td>22.2</td>
<td>24.2</td>
<td>20.0</td>
</tr>
<tr>
<td>Maximum resistance (BU)</td>
<td>366</td>
<td>470</td>
<td>299</td>
</tr>
</tbody>
</table>
### Summary of ANOVA’s of NIR predicted quality data

<table>
<thead>
<tr>
<th>Quality measure</th>
<th>F Ratio</th>
<th>Pooled sd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain protein content (%)</td>
<td>***</td>
<td>0.68</td>
</tr>
<tr>
<td>Particle size index (w/w)</td>
<td>***</td>
<td>2.18</td>
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<tr>
<td>Milling yield (%)</td>
<td>***</td>
<td>0.38</td>
</tr>
<tr>
<td>Flour b* (CIE)</td>
<td>***</td>
<td>0.27</td>
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<tr>
<td>Water absorption (%)</td>
<td>***</td>
<td>0.99</td>
</tr>
<tr>
<td>Dough development time (min)</td>
<td>***</td>
<td>0.49</td>
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<tr>
<td>Extensibility (cm)</td>
<td>***</td>
<td>0.56</td>
</tr>
<tr>
<td>Maximum resistance (BU)</td>
<td>***</td>
<td>29.3</td>
</tr>
</tbody>
</table>
Selected high yield lines year 1, also yield better than those discarded in year 2.
Conclusion

- LongReach Plant Breeders have produced two high yielding varieties suited to production in high yielding regions targeting feed grain use

  - **Sentinel 3R**
    - Resistant to prevalent field strains of the three rust diseases, with high yield potential when planted in early May over a target production area from southern Queensland to Western Victoria

  - **LongReach Beaufort**
    - A very high yielding wheat suited to early plantings in the higher rainfall production zones of NSW and Victoria

- LongReach is committed to work with the different sectors of the grains industry to develop new varieties suited to their needs