Crop Updates 2002 - Cereals

Peter Burgess  
_Agritech_

Gary Fawell  
_Farmanco Management_

Dean Diepeveen  
_Dept of Agriculture_

Tim Setter  
_Dept of Agriculture_

Jeff Russell  
_Dept of Agriculture_

Follow this and additional works at: [https://researchlibrary.agric.wa.gov.au/crop_up](https://researchlibrary.agric.wa.gov.au/crop_up)

Part of the Agribusiness Commons, Agronomy and Crop Sciences Commons, Climate Commons, Entomology Commons, Plant Breeding and Genetics Commons, and the Plant Pathology Commons

**Recommended Citation**


This conference proceeding is brought to you for free and open access by the Grain and other field crop research at Research Library. It has been accepted for inclusion in Crop Updates by an authorized administrator of Research Library. For more information, please contact jennifer.heathcote@agric.wa.gov.au, sandra.papenfus@agric.wa.gov.au, paul.orange@dpird.wa.gov.au.
Authors
2002
CEREALS UPDATE
- Western Australia

PRESENTED AT THE SHERATON HOTEL, PERTH
WESTERN AUSTRALIA, 20-21 FEBRUARY 2002

Compiled and edited by Roslyn Jettner

© Chief Executive Officer, Department of Agriculture, Western Australia, 2002

Permission of the publisher is required for articles being reproduced or presented.

IMPORTANT DISCLAIMER
In relying on or using this document or any advice or information expressly or impliedly contained within it, you accept all risks and responsibility for loss, injury, damages, costs and other consequences of any kind whatsoever resulting directly or indirectly to you or any other person from your doing so. It is for you to obtain your own advice and conduct your own investigations and assessments of any proposals that you may be considering in light of your own circumstances. Further, the State of Western Australia, the Chief Executive Officer of the Department of Agriculture, the Agriculture Protection Board, the authors, the publisher and their officers, employees and agents do not warrant the accuracy, currency, reliability or correctness of this document or any advice or information expressly or impliedly contained within it, and exclude all liability of any kind whatsoever to any person arising directly or indirectly from reliance on or the use of this document or any advice or information expressly or impliedly contained within it by you or any other person.
# CEREALS UPDATE, 2002

## Table of Contents

### VARIETIES AND BREEDING

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agronomic evaluation of wheat and barley in the central wheatbelt of Western Australia</td>
<td>1</td>
</tr>
<tr>
<td>Peter Burgess and Gary Fawell</td>
<td></td>
</tr>
<tr>
<td>Evaluating stress tolerance to terminal drought by Western Australian wheats</td>
<td>5</td>
</tr>
<tr>
<td>Dean Diepeveen and Tim Setter</td>
<td></td>
</tr>
<tr>
<td>Broadscale wheat variety comparisons featuring Wyalkatchem</td>
<td>7</td>
</tr>
<tr>
<td>Jeff Russell</td>
<td></td>
</tr>
<tr>
<td>Australian crop accreditation system variety selector</td>
<td>9</td>
</tr>
<tr>
<td>Tony Seymour</td>
<td></td>
</tr>
<tr>
<td>Future wheat varieties</td>
<td>11</td>
</tr>
<tr>
<td>Robin Wilson, Iain Barclay, Robyn McLean, Robert Loughman, Jenny Garlinge, Bill Lambe, Neil Venn and Peter Clarke</td>
<td></td>
</tr>
</tbody>
</table>

### AGRONOMY

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beware of wheat variety interactions with row spacing and seed rate</td>
<td>13</td>
</tr>
<tr>
<td>Mohammad Amjad and Wal Anderson</td>
<td></td>
</tr>
<tr>
<td>Yield and falling numbers of wheat varieties on the South Coast</td>
<td>15</td>
</tr>
<tr>
<td>Mohammad Amjad and Wal Anderson</td>
<td></td>
</tr>
<tr>
<td>Maximising wheat variety performance through agronomic management</td>
<td>17</td>
</tr>
<tr>
<td>Wal Anderson, Raffaele Del Cima, James Bee, Darshan Sharma, Sheena Lyon, Melaine Kupsch, Mohammad Amjad, Pam Burgess, Veronika Reck, Brenda Shackley, Ray Tugwell, Bindi Webb and Steve Penny Jr</td>
<td></td>
</tr>
<tr>
<td>High impact of soil type and seasonal rainfall on optimum wheat seed rate</td>
<td>19</td>
</tr>
<tr>
<td>Raffaele Del Cima and Wal Anderson</td>
<td></td>
</tr>
<tr>
<td>101 seasons in one day: Using the 'WA Wheat' database to predict wheat yield</td>
<td>21</td>
</tr>
<tr>
<td>James Fisher, Bill Bowden, Craig Scanlan, Senthold Asseng and Michael Robertson</td>
<td></td>
</tr>
<tr>
<td>Economics of improving compact soils</td>
<td>23</td>
</tr>
<tr>
<td>M.A. Hamza, G. McConnell and W.K. Anderson</td>
<td></td>
</tr>
<tr>
<td>Reducing the risks in producing durum wheat in Western Australia</td>
<td>25</td>
</tr>
<tr>
<td>Md Shahajahan Miyan and Wal Anderson</td>
<td></td>
</tr>
<tr>
<td>Taking the Why out of Wyalkatchem - the new widely adapted wheat variety</td>
<td>27</td>
</tr>
<tr>
<td>Steve Penny</td>
<td></td>
</tr>
<tr>
<td>Influence of nutrition and environmental factors on seed vigour in wheat</td>
<td>29</td>
</tr>
<tr>
<td>Darshan Sharma, Wal Anderson and Daya Patabendige</td>
<td></td>
</tr>
</tbody>
</table>
# NUTRITION

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>N and K are important for oat yield and quality</td>
<td>Patrick Gethin, Stephen Loss, Tim O’Dea, Ryan Guthrie and Lisa Leaver</td>
<td>31</td>
</tr>
<tr>
<td>Effects of nitrogen and phosphorus on the grain yield and quality of noodle wheat</td>
<td>Tyrone Henning, Lionel Martin and Wal Anderson</td>
<td>33</td>
</tr>
<tr>
<td>Assessment of a high input fertiliser regime on the yield and quality of Gairdner barley</td>
<td>Narelle Hill, Simon Wallwork and Laurence Carslake</td>
<td>35</td>
</tr>
<tr>
<td>The use of Flexi-N to achieve high yielding, high protein wheat</td>
<td>Darren Hughes, Lionel Martin, Wal Anderson and Stephen Loss</td>
<td>37</td>
</tr>
<tr>
<td>Are liquid phosphorus fertilisers more efficient than solid fertilisers in Western Australia?</td>
<td>Stephen Loss, Lisa Leaver, Ryan Guthrie, Patrick Gethin and Tim O’Dea</td>
<td>39</td>
</tr>
<tr>
<td>Oats respond to phosphorus and potassium</td>
<td>Glenn McDonald</td>
<td>41</td>
</tr>
</tbody>
</table>

# PESTS AND DISEASES

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereal disease diagnostics and rust monitoring</td>
<td>Nichole Burges and Dominie Wright</td>
<td>43</td>
</tr>
<tr>
<td>Distribution and incidence of aphids and barley yellow dwarf virus in over-summering grasses in the Western Australian wheatbelt</td>
<td>Jenny Hawkes and Roger Jones</td>
<td>45</td>
</tr>
<tr>
<td>Spring sprays for powdery mildew control in cereals</td>
<td>Kith Jayasena, Kazue Tanaka, Vanessa Johnson, Robert Loughman and Josh Jury</td>
<td>47</td>
</tr>
<tr>
<td>Impact of root lesion nematodes on wheat and triticale in Western Australia</td>
<td>Sean Kelly and Shashi Sharma</td>
<td>49</td>
</tr>
<tr>
<td>Cropping options for the management of root lesion nematodes in Western Australia</td>
<td>Sean Kelly, Shashi Sharma and Robert Loughman</td>
<td>51</td>
</tr>
<tr>
<td>Cereal rust update 2002 - new stem rust on Camm wheat</td>
<td>Robert Loughman and Robert Park</td>
<td>53</td>
</tr>
<tr>
<td>Cereal aphids and direct feeding damage to cereals</td>
<td>Phil Michael</td>
<td>55</td>
</tr>
<tr>
<td>A decision support system for control of aphids and BYDV in cereal crops</td>
<td>Debbie Thackray, Jenny Hawkes and Roger Jones</td>
<td>57</td>
</tr>
</tbody>
</table>

# STORAGE

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeration - opportunity for profit</td>
<td>Christopher Newman</td>
<td>59</td>
</tr>
</tbody>
</table>

# CLIMATE

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial impact of frost on the Western Australian grains industry</td>
<td>Garren Knell and Kim Povey</td>
<td>61</td>
</tr>
<tr>
<td>Summary of 2001 weather and seasonal prospects for 2002</td>
<td>David Stephens</td>
<td>63</td>
</tr>
</tbody>
</table>
Agronomic evaluation of wheat and barley in the central wheatbelt of Western Australia

Peter Burgess¹ and Gary Fawell², ¹Agritech and ²Farmanco Management

KEY MESSAGE
In recent years, growers have made significant changes in crop rotations, agronomy and management practices with the objective being to diversify, implement IWM strategies and reduce risk in the farming operation. With the new varieties of malt and barley on the horizon there is a need to evaluate the role of barley and compare its profitability to that of wheat. The trials conducted by Agritech in 2001 show that when barley is provided the opportunity to reach genetic potential through correct sowing time, crop rotation and rainfall, it can provide gross margins equal or better than wheat in the high rainfall zones of the central wheatbelt. Gross margins are similar to wheat in the medium rainfall zones provided barley is sown early. In low rainfall zones barley is a greater risk for growers and struggles to match wheat for gross margin.

AIM
To compare the relative profitability of growing malting barley to commonly grown noodle and hard wheat varieties on a range of soil types, crop rotations and rainfall zones.

METHOD
Two times of sowing at three sites. The Bolgart (pH 4.9, Red loam) and Cunderdin (pH 5.8, Salmon gum loam) trials were sown following canola and the Wubin (pH 5.1, Salmon Gum Loam) site was following a poor 2 year grassy pasture in a bid to clean up resistant ryegrass.

RESULTS

<table>
<thead>
<tr>
<th>Variety</th>
<th>Yield t/ha</th>
<th>Gross income $/ha</th>
<th>Yield as % of highest income wheat</th>
<th>Yield required as % of highest income wheat for equal income</th>
<th>$/ha gross income assuming standard quality and using five year average grain price (del. Frem.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Barley 100% Malting Barley 50% Malting Barley 100% Feed</td>
</tr>
<tr>
<td>Time sow - 1: 11/5/01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gairdner</td>
<td>5.52</td>
<td>$1,270.0</td>
<td>126%</td>
<td>124%</td>
<td>$1,016 $903 $789</td>
</tr>
<tr>
<td>Stirling</td>
<td>4.90</td>
<td>$1,119.0</td>
<td>112%</td>
<td>125%</td>
<td>$902 $801 $701</td>
</tr>
<tr>
<td>WABAR2080</td>
<td>5.20</td>
<td>$1,196.0</td>
<td>119%</td>
<td>124%</td>
<td>$857 $850 $744</td>
</tr>
<tr>
<td>WABAR2110</td>
<td>5.00</td>
<td>$1,150.0</td>
<td>114%</td>
<td>124%</td>
<td>$820 $818 $715</td>
</tr>
<tr>
<td>WABAR2109</td>
<td>4.91</td>
<td>$1,129.0</td>
<td>112%</td>
<td>124%</td>
<td>$803 $803 $702</td>
</tr>
<tr>
<td>Calingiri</td>
<td>4.63</td>
<td>$1,067.0</td>
<td>106%</td>
<td>124%</td>
<td>$1,000 $1,000 $1,000</td>
</tr>
<tr>
<td>Carnamah</td>
<td>4.49</td>
<td>$1,156.0</td>
<td>103%</td>
<td>111%</td>
<td>$840 $840 $840</td>
</tr>
<tr>
<td>Arrino</td>
<td>4.38</td>
<td>$1,250.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$946 $946 $946</td>
</tr>
<tr>
<td>Time sow - 2: 13/6/01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gairdner</td>
<td>4.28</td>
<td>$995.0</td>
<td>101%</td>
<td>123%</td>
<td>$768 $700 $612</td>
</tr>
<tr>
<td>Stirling</td>
<td>4.05</td>
<td>$936.0</td>
<td>95%</td>
<td>123%</td>
<td>$745 $662 $579</td>
</tr>
<tr>
<td>WABAR2080</td>
<td>4.72</td>
<td>$1,097.0</td>
<td>111%</td>
<td>123%</td>
<td>$868 $772 $675</td>
</tr>
<tr>
<td>WABAR2110</td>
<td>4.52</td>
<td>$1,050.0</td>
<td>106%</td>
<td>123%</td>
<td>$832 $739 $646</td>
</tr>
<tr>
<td>WABAR2109</td>
<td>4.51</td>
<td>$1,047.0</td>
<td>106%</td>
<td>123%</td>
<td>$830 $737 $645</td>
</tr>
<tr>
<td>Calingiri</td>
<td>4.03</td>
<td>$929.0</td>
<td>95%</td>
<td>124%</td>
<td>$870 $870 $870</td>
</tr>
<tr>
<td>Carnamah</td>
<td>4.03</td>
<td>$1,104.0</td>
<td>95%</td>
<td>104%</td>
<td>$754 $754 $754</td>
</tr>
<tr>
<td>Arrino</td>
<td>4.25</td>
<td>$1,213.0</td>
<td></td>
<td></td>
<td>$918 w $918</td>
</tr>
<tr>
<td>LSD</td>
<td>0.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Cunderdin - wheat/barley comparison

<table>
<thead>
<tr>
<th>Variety</th>
<th>Yield t/ha</th>
<th>Gross income $/ha</th>
<th>Yield as % of highest income wheat</th>
<th>Yield required as % of highest income wheat for equal income</th>
<th>$/ha gross income assuming standard quality and using five year average grain price (del. Frem.)</th>
<th>Barley 100% Malting</th>
<th>Barley 50% Malting</th>
<th>Barley 100% Feed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Barley 100% Malting</td>
<td>Barley 50% Malting</td>
<td>Barley 100% Feed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gairdner</td>
<td>2.77</td>
<td>$615</td>
<td>121%</td>
<td>125%</td>
<td>$510</td>
<td>$453</td>
<td>$396</td>
<td></td>
</tr>
<tr>
<td>Stirling</td>
<td>2.70</td>
<td>$620</td>
<td>118%</td>
<td>121%</td>
<td>$497</td>
<td>$441</td>
<td>$386</td>
<td></td>
</tr>
<tr>
<td>WABAR2080</td>
<td>2.68</td>
<td>$620</td>
<td>117%</td>
<td>120%</td>
<td>$493</td>
<td>$438</td>
<td>$383</td>
<td></td>
</tr>
<tr>
<td>WABAR2110</td>
<td>2.73</td>
<td>$608</td>
<td>119%</td>
<td>125%</td>
<td>$502</td>
<td>$446</td>
<td>$390</td>
<td></td>
</tr>
<tr>
<td>WABAR2109</td>
<td>2.66</td>
<td>$602</td>
<td>116%</td>
<td>123%</td>
<td>$489</td>
<td>$435</td>
<td>$380</td>
<td></td>
</tr>
<tr>
<td>Calingiri</td>
<td>2.29</td>
<td>$638</td>
<td>100%</td>
<td>123%</td>
<td>$502</td>
<td>$453</td>
<td>$396</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carnamah</td>
<td>2.05</td>
<td>$524</td>
<td>91%</td>
<td>111%</td>
<td>$389</td>
<td>$339</td>
<td>$389</td>
<td></td>
</tr>
<tr>
<td>Arrino</td>
<td>2.23</td>
<td>$622</td>
<td>97%</td>
<td>100%</td>
<td>$482</td>
<td>$482</td>
<td>$482</td>
<td></td>
</tr>
<tr>
<td>LSD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.28</td>
</tr>
</tbody>
</table>

### Time sow - 1: 9/5/01

Time sow - 2: 7/6/01

## Wubin - wheat/barley comparison

<table>
<thead>
<tr>
<th>Variety</th>
<th>Yield t/ha</th>
<th>Gross income $/ha</th>
<th>Yield as % of highest income wheat</th>
<th>Yield required as % of highest income wheat for equal income</th>
<th>$/ha gross income assuming standard quality and using five year average grain price (del. Frem.)</th>
<th>Barley 100% Malting</th>
<th>Barley 50% Malting</th>
<th>Barley 100% Feed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Barley 100% Malting</td>
<td>Barley 50% Malting</td>
<td>Barley 100% Feed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stirling</td>
<td>1.45</td>
<td>$268</td>
<td>72%</td>
<td>136%</td>
<td>$267</td>
<td>$237</td>
<td>$207</td>
<td></td>
</tr>
<tr>
<td>WABAR2110</td>
<td>1.26</td>
<td>$233</td>
<td>62%</td>
<td>135%</td>
<td>$232</td>
<td>$206</td>
<td>$180</td>
<td></td>
</tr>
<tr>
<td>WABAR2109</td>
<td>1.31</td>
<td>$242</td>
<td>65%</td>
<td>136%</td>
<td>$241</td>
<td>$214</td>
<td>$187</td>
<td></td>
</tr>
<tr>
<td>Calingiri</td>
<td>1.63</td>
<td>$408</td>
<td>81%</td>
<td>100%</td>
<td>$352</td>
<td>$352</td>
<td>$352</td>
<td></td>
</tr>
<tr>
<td>Carnamah</td>
<td>1.78</td>
<td>$492</td>
<td>88%</td>
<td>91%</td>
<td>$333</td>
<td>$333</td>
<td>$333</td>
<td></td>
</tr>
<tr>
<td>Arrino</td>
<td>2.02</td>
<td>$506</td>
<td></td>
<td></td>
<td>$436</td>
<td>$436</td>
<td>$436</td>
<td></td>
</tr>
<tr>
<td>LSD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.31</td>
<td></td>
</tr>
</tbody>
</table>

### Time sow - 1: 16/5/01

Time sow - 2: 5/6/01

## Time Sown Comparison

- **Gairdner**
  - Yield: 2.77 t/ha
  - Gross Income: $615/ha
  - Yield as % of highest income wheat: 121%
  - Yield required as % of highest income wheat for equal income: 125%
  - Range: 121% to 125%

- **Stirling**
  - Yield: 2.70 t/ha
  - Gross Income: $620/ha
  - Yield as % of highest income wheat: 118%
  - Yield required as % of highest income wheat for equal income: 121%
  - Range: 118% to 121%

- **WABAR2080**
  - Yield: 2.68 t/ha
  - Gross Income: $620/ha
  - Yield as % of highest income wheat: 117%
  - Yield required as % of highest income wheat for equal income: 120%
  - Range: 117% to 120%

- **WABAR2110**
  - Yield: 2.73 t/ha
  - Gross Income: $608/ha
  - Yield as % of highest income wheat: 119%
  - Yield required as % of highest income wheat for equal income: 125%
  - Range: 119% to 125%

- **WABAR2109**
  - Yield: 2.66 t/ha
  - Gross Income: $602/ha
  - Yield as % of highest income wheat: 116%
  - Yield required as % of highest income wheat for equal income: 123%
  - Range: 116% to 123%

- **Caligiri**
  - Yield: 2.29 t/ha
  - Gross Income: $638/ha
  - Yield as % of highest income wheat: 100%
  - Yield required as % of highest income wheat for equal income: 121%
  - Range: 100% to 121%

- **Carnamah**
  - Yield: 2.05 t/ha
  - Gross Income: $524/ha
  - Yield as % of highest income wheat: 91%
  - Yield required as % of highest income wheat for equal income: 111%
  - Range: 91% to 111%

- **Arrino**
  - Yield: 2.23 t/ha
  - Gross Income: $622/ha
  - Yield as % of highest income wheat: 97%
  - Yield required as % of highest income wheat for equal income: 100%
  - Range: 97% to 100%

### LSD
- **Gairdner**: 0.28
- **Stirling**: 0.21
- **WABAR2080**: 0.21
- **WABAR2110**: 0.21
- **WABAR2109**: 0.21
- **Caligiri**: 0.21
- **Carnamah**: 0.21
- **Arrino**: 0.21
The T1 sowing at Bolgart shows Gairdner barley out performing all wheat varieties in terms of gross margin with the new malting barley varieties performing similarly to wheat in terms of gross margin. Calingiri performed poorly due to dropping into ASW with low protein in T1 and T2. The figures on the right hand side of the table show the scenario using 5 year average prices with grower probability of achieving malting, compared to actual 2001 trial results and gross margins. T1 at Cunderdin was the only other timing where barley performed well relative to wheat. At the T2 timings barley falls away from wheat in terms of performance, with the low rainfall site at Wubin showing wheat to be the crop of choice in terms of returns to growers.

GRDC Project No.: AGT17
Paper reviewed by: Gary Fawell
Evaluating stress tolerance to terminal drought by Western Australian wheats

Dean Diepeveen and Dr Tim Setter, Department of Agriculture

AIM
To evaluate the genetic diversity for escape from water deficits and heat during grain filling by accumulation of pre-flowering stem carbohydrates (CHO) with a focus on stress tolerance during grain filling in wheat grown in medium and low rainfall areas.

METHODS
Sow forty Western Australian/overseas varieties at three times-of-sowing at two locations over two year’s (1997,1998) and measure stem carbohydrate weekly from pre-flowering until maturity. Develop and validate laboratory techniques for the measurement of CHO (1997, 1998).

Conduct several small trials (1998,1999) with a subset of varieties over a range of water stress and/or shaded conditions to validate whether CHO can be manipulated pre-grainfilling. Conduct two variety-screening trials at two locations over two years (1999, 2001) measuring CHO at several stages of plant development to identify ‘high-storage CHO’ varieties. Statistical Analyses used included one-way Analysis of Variance (ANOVA), Residual Maximum Likelihood (REML), and Principal Components Analysis (PCA) from S-PLUS Statistical Software.

RESULTS
- Variation was found amongst Western Australian germplasm (40 varieties) with remobilised stem CHO accounting for up to 25 to 35% of final grain yield for some varieties. Even greater diversity was found in stem CHO in ICARDA and CIMMYT lines showing CHO concentrations greater than 40% of dry weight.
- Agronomic factors were also found to influence stem CHO% with earlier sowings generally resulting in a reduction in the maximum stem CHO%.
- In general, later sowings result in higher levels of stem CHO. For the majority of the lines tested, high nitrogen (80 kg N/ha) as compared with standard fertiliser practice (40 kg N/ha) did not increase stem CHO concentrations with later sowings.
- In Western Australian varieties with similar carbon assimilation patterns, based visually on similar leaf chlorosis during grain filling, high stem CHO levels is highly correlated with high yields.
- High levels of CHO (5-10% CHO) at maturity in some high yielding Western Australian wheats (e.g. Westonia and Brookton), points to further potential for genetic/agronomic improvement by increasing grain numbers/ear.
- When selecting varieties with high yields, high concentrations of pre-flowering stem carbohydrates was found to be positively linked to high yield.
- Grain yield potential of low CHO types can be increased through manipulation of pre-flowering stem CHO one to two weeks before flowering. When supplementary light is used to experimentally increase stem CHO (i.e. by 50%) there is an equivalent increase (i.e. 50%) in grain yield (Perenjori).
### Table 1. Carbohydrate storage classification for common WA varieties

<table>
<thead>
<tr>
<th>Variety</th>
<th>CHO-storage</th>
<th>Maturity</th>
<th>Pedigree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ajana</td>
<td>High</td>
<td>Early</td>
<td>Blade/2*Kulin</td>
</tr>
<tr>
<td>Bodallin</td>
<td>High</td>
<td>Early</td>
<td>Bokal/Siete Cerros</td>
</tr>
<tr>
<td>Westonia</td>
<td>High</td>
<td>Early</td>
<td>Spica Timgalen.Tosca/Cranbrook...Jacup*2.Bobwhite</td>
</tr>
<tr>
<td>Brookton</td>
<td>High?</td>
<td>Late</td>
<td>Torres/Cranbrook/Emblen.P1640...Nuri70/Cranbrook</td>
</tr>
<tr>
<td>Carnamah</td>
<td>Medium</td>
<td>Medium</td>
<td>Bolsena-1CH/77W:660 comp</td>
</tr>
<tr>
<td>Spear</td>
<td>Medium</td>
<td>Late</td>
<td>Sabre/Mec-3(RAC111)/Insignia</td>
</tr>
<tr>
<td>Tammin</td>
<td>Medium</td>
<td>Medium</td>
<td>Bodallin/3/Ciano/Gamenya/2/XBVT223/4/Atlas66/2*Madden</td>
</tr>
<tr>
<td>Tincurlin</td>
<td>Medium?</td>
<td>Medium?</td>
<td>Glucub/3/Chile 1B/Insigna/Falcon</td>
</tr>
<tr>
<td>Arrino</td>
<td>Medium?</td>
<td>Medium?</td>
<td>77W:660/Eradu</td>
</tr>
<tr>
<td>Calingiri</td>
<td>Medium?</td>
<td>Late</td>
<td>Chino/Kulin/Reeves</td>
</tr>
<tr>
<td>Camm</td>
<td>Medium?</td>
<td>Late</td>
<td>VPM1.5<em>Cook/4</em>Spear</td>
</tr>
<tr>
<td>Cunderdin</td>
<td>Medium?</td>
<td>Medium?</td>
<td>Cranbrook sister/Sunfield sister</td>
</tr>
<tr>
<td>Silverstar</td>
<td>Medium?</td>
<td>Medium?</td>
<td>Pavon’s/(TM56) Cocamba sib</td>
</tr>
<tr>
<td>Wyalkatchem</td>
<td>Medium?</td>
<td>Medium?</td>
<td>Machete/crossbred W84-129*504</td>
</tr>
<tr>
<td>Bt-Schomburgk</td>
<td>Low</td>
<td>Early</td>
<td>Halbert/Aroona/3*Schomburgh/Boron-tol-Schomburgh</td>
</tr>
<tr>
<td>Karlgarin</td>
<td>Low</td>
<td>Medium</td>
<td>Spear///(79W781)Bodallin/Eradu</td>
</tr>
<tr>
<td>Perenjori</td>
<td>Low?</td>
<td>Medium</td>
<td>Bodallin/Hyden</td>
</tr>
</tbody>
</table>

Note: ‘?’ indicates likely classification.

**CONCLUSION**

These results suggest that varieties with a high-storage CHO capacity will give higher yields in normal years and much higher yields when there is a dry finish to the season.

**KEY WORDS**

stem carbohydrate, water deficits, wheat, stress tolerance

**ACKNOWLEDGMENTS**

Doug Abrecht, Iain Barclay, Irene Waters, Paula Reeve, Peter Clarke, Robin Wilson, Rod Hunter, Steve Penny, Sue Broughton, Department of Agriculture, WA.

Previous DAW 548 staff: Danica Goggins, Leisa Armstrong, Beth Conocono and Andreas Neuhaus.

GRDC for funding collaborative research project DAW 548 ‘Improving stress tolerance of wheat during grain filling’.

**Paper reviewed by:** Rod Hunter/Paula Reeve
Broadscale wheat variety comparisons featuring Wyalkatchem

Jeff Russell, Department of Agriculture

BACKGROUND

The evaluation of crop varieties is often done in small scale intensive research plots. This is beneficial for screening a large number of varieties in a controlled environment. However, such sites are costly and the number of sites that can be established is limited by the financial resources available.

To complement this work, growers can carry out farm scale research themselves. The principles outlined in the ‘Test As You Grow’ kit and the service provided through the kit could help growers to conduct sound farm-scale research on their own properties. Such research can provide additional information of a practical nature and display the performance of the treatments in an environment closer resembling that found in the paddock.

The new APW wheat variety Wyalkatchem (WAWHT2212) was released in August 2001. Wyalkatchem has a number of features that make it to be a suitable replacement variety for Westonia. These are disease resistance and straw height. Previous comparisons have been made between the two varieties in small plot Crop Variety Test (CVT) sites prior to release. In 2001, three large scale sites (Table 1) were established to complement variety comparisons conducted by Agritech. One site with the Liebe Group (Wubin) and two with the Kunjin TOPCROP group (Kunjin and Lomos).

Table 1. Site details of the three large scale variety comparisons

<table>
<thead>
<tr>
<th>Sites</th>
<th>Wubin</th>
<th>Kunjin</th>
<th>Lomos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot size and replication</td>
<td>200 m x 12 m, harvested width 10.9 m. Two replicates of each variety with Westonia used as a control every third plot (nearest neighbour).</td>
<td>200 m x 12 m, harvested width 9.3 m. Two replicates of each variety with Westonia used as a control every third plot (nearest neighbour).</td>
<td>200 m x 13 m, harvested width 9.3 m. Two replicates of each variety with Westonia used as a control every third plot (nearest neighbour).</td>
</tr>
<tr>
<td>Soil type</td>
<td>Acidic yellow sandplain, loamy sand. Topsoil pH = 5.0</td>
<td>Gravelly grey sandy loam. Topsoil pH = 4.5</td>
<td>Grey loamy sand. Topsoil pH = 4.9</td>
</tr>
<tr>
<td>Sowing date</td>
<td>14 May 2001</td>
<td>31 May 2001</td>
<td>5 June 2001</td>
</tr>
<tr>
<td>Seeding rate</td>
<td>67 kg/ha</td>
<td>50 kg/ha</td>
<td>50 kg/ha</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>2 April - Muriate of Potash spread across whole of paddock and across plots. 14 May - Agstar, 110 kg/ha at seeding. Flexi N - 40 L/ha applied 8 weeks after seeding.</td>
<td>31 May - Agras 1, 120 kg/ha 29 June - 55 kg/ha Urea topdressed</td>
<td>5 June - Agstar, 100 kg/ha</td>
</tr>
</tbody>
</table>
RESULTS

Table 2. Yield and quality characteristics of the 3 wheat varieties compared

<table>
<thead>
<tr>
<th>Variety</th>
<th>Plants (sqm)</th>
<th>Yield (t/ha)</th>
<th>% Yield of Westonia</th>
<th>Protein (%)</th>
<th>Screen (%)</th>
<th>Specific weight (kg/hL)</th>
<th>Staining (%)</th>
<th>Grade</th>
<th>Income ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Westonia</td>
<td>87</td>
<td>1.64</td>
<td>100</td>
<td>11.1</td>
<td>1.54</td>
<td>80.4</td>
<td>1.5</td>
<td>APW</td>
<td>434</td>
</tr>
<tr>
<td>Wyalkatchem</td>
<td>90</td>
<td>1.81</td>
<td>110</td>
<td>11.0</td>
<td>0.9</td>
<td>82.1</td>
<td>1.5</td>
<td>APW</td>
<td>483</td>
</tr>
<tr>
<td>Calingiri</td>
<td>110</td>
<td>1.64</td>
<td>100</td>
<td>11.4</td>
<td>0.7</td>
<td>82.5</td>
<td>1.5</td>
<td>ASWN</td>
<td>448</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>42</td>
<td>0.18</td>
<td></td>
<td>0.6</td>
<td>0.3</td>
<td>1.0</td>
<td>ns</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

Kunjin

<table>
<thead>
<tr>
<th>Variety</th>
<th>Plants (sqm)</th>
<th>Yield (t/ha)</th>
<th>% Yield of Westonia</th>
<th>Protein (%)</th>
<th>Screen (%)</th>
<th>Specific weight (kg/hL)</th>
<th>Staining (%)</th>
<th>Grade</th>
<th>Income ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Westonia</td>
<td>49.2</td>
<td>2.54</td>
<td>100</td>
<td>9.9</td>
<td>3.08</td>
<td>79.6</td>
<td>0.5</td>
<td>APW</td>
<td>624</td>
</tr>
<tr>
<td>Wyalkatchem</td>
<td>51.5</td>
<td>2.24</td>
<td>88</td>
<td>9.7</td>
<td>1.86</td>
<td>82.0</td>
<td>0</td>
<td>APW</td>
<td>559</td>
</tr>
<tr>
<td>Calingiri</td>
<td>50.4</td>
<td>2.08</td>
<td>82</td>
<td>9.8</td>
<td>2.67</td>
<td>80.7</td>
<td>0</td>
<td>ASWN</td>
<td>592</td>
</tr>
</tbody>
</table>

Lomos

<table>
<thead>
<tr>
<th>Variety</th>
<th>Plants (sqm)</th>
<th>Yield (t/ha)</th>
<th>% Yield of Westonia</th>
<th>Protein (%)</th>
<th>Screen (%)</th>
<th>Specific weight (kg/hL)</th>
<th>Staining (%)</th>
<th>Grade</th>
<th>Income ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Westonia</td>
<td>84.0</td>
<td>1.97</td>
<td>100</td>
<td>8.1</td>
<td>1.82</td>
<td>81.3</td>
<td>0</td>
<td>APW</td>
<td>453</td>
</tr>
<tr>
<td>Wyalkatchem</td>
<td>69.1</td>
<td>1.82</td>
<td>92</td>
<td>8.6</td>
<td>1.14</td>
<td>83.1</td>
<td>0</td>
<td>APW</td>
<td>417</td>
</tr>
<tr>
<td>Calingiri</td>
<td>75.6</td>
<td>1.70</td>
<td>86</td>
<td>8.4</td>
<td>1.66</td>
<td>81.3</td>
<td>0</td>
<td>ASWN</td>
<td>429</td>
</tr>
</tbody>
</table>

AWB base rates used for income, APW $247.00, ASWN $280.00 (21/01/02).

COMMENT

The acceptance of these results needs to be taken with caution. A problem that occurred at seeding at the Wubin site meant the actual area of Westonia harvested was less by about 10%. The Westonia yield shown in Table 2 has been adjusted upwards from the actual plot yields to take this into account. The actual plot yields averaged 1.46 t/ha for Westonia, which would be significantly less than Wyalkatchem. It would be very useful to compare the results found here with those gained from the respective Agritech sites that were located close by at Wubin and Kunjin, before making decisions on variety performance. These can be found in the extended version of this paper on the CD.

SUMMARY

- At the Wubin site the variety Wyalkatchem out performed Westonia and Calingiri. While at Kunjin it was considerably lower in return.
- Wyalkatchem seemed to have slightly improved quality features with less screenings and greater weight than Westonia.
- When comparing varieties it is important to limit variability by obtaining seed from a common source.
- On-farm research activities such as these are designed to be simple and quick to do and can be used to complement intensive small plot research.

ACKNOWLEDGMENTS

Thanks goes to Ron Carlhausen, Brad Talbot and Clive Turner who gave of their time to conduct these on-farm variety comparisons.

GRDC Project No.: DAW 599
Paper reviewed by: John Blake

There is an extended version of this paper on the Crop Update 2002 CD.
Australian crop accreditation system variety selector

Tony Seymour, Australian Crop Accreditation System

With the click of a computer mouse, farmers and farm advisors can now compare the performance of different crop varieties at trial sites across Australia. This new FREE computer-based tool called Variety Selector is a computer database that is simple and fast to use.

Developed by the Australian Crop Accreditation System (ACAS), Variety Selector is a searchable computer database providing access to information on 350 grain varieties from 800 test sites comprising nearly 4,500 trials across Australia.

For the first time, farmers will be able to see how varieties perform in conditions and locations similar to their own, and relative to other varieties in a single national database. With support from plant breeders around the country the data warehouse will eventually provide information on over 1,300 varieties.

Variety selector also recognises that growers are interested in varieties from all over the country and from public and private plant breeding programs. Previously this type of information has been State specific and often only available in hard copy. With Variety Selector, ACAS has created a national database that can be accessed via a CD ROM and updated regularly through the Internet. Variety Selector is free and a CD ROM can be obtained by registering on-line at www.acas.on.net or fax (03) 9328 5302.

WHAT INFORMATION IS VARIETY SELECTOR DESIGNED TO PROVIDE?

Trial reports

Trial reports compare variety results provided by plant breeders from over 800 test sites across Australia. Using parameters including year, site, crop and trial type, the user can search for specific trials and view trial reports.

Variety reports

These reports show predicted average yield comparisons between a base variety and selected variety, based on region, site, sowing period, rainfall range and disease and pest resistance. This report also allows the user to search specific characteristics (e.g. maturity, disease/pest tolerance, grain quality et al.) relating to a crop or variety.

Variety comparison reports

Variety comparison reports allow the user to compare varietal performance for a selected reference variety against other varieties across a range of combined trial results.

HOW OFTEN WILL THE DATABASE BE UPDATED?

ACAS hope to update information whenever it becomes available. Twice-yearly updates are planned and Variety Selector subscribers will be notified when updates can be downloaded.

HOW RELIABLE IS THE INFORMATION?

Reports are based on accredited information and rely on plant breeders providing quality information according to the protocols established by ACAS. ACAS has used predicted yields obtained by a combined analysis of all trials over the past years. The analysis and the resultant predicted yield allows for yield variation from site to site and year to year. It is considered that this is the best way of showing growers likely yields in specific regions - and how varieties compare in those regions. Note that these analyses are carried out each year when the latest years trial results are available. For example, after 1998 the yield analyses may have covered the years 1992 to 1998; after the 1999 harvest they include the years 1992 to 1999. This can result in changes in variety relativity with time, which if significant would require interpretation.
The Australian Crop Accreditation System (ACAS) is a coordinating body that represents the Grains Council of Australia, Grains Research and Development Corporation, Seed Industry Association of Australia and State government agriculture/natural resources departments. Its objective is to provide sound information on the performance and characteristics of field and grain crop varieties to Australian farmers. To achieve this aim, ACAS oversees the work of four national accreditation advisory committees (wheat, barley and course grains, oilseeds and pulses) to ensure that information from variety trials meets its accreditation requirements. The collected information is then made available to farmers through the Variety Selector website.

**HOW THE ACCREDITATION PROCESS WORKS**

ACAS establishes, develops and publishes protocols for evaluating the quality, disease and agronomic characteristics of grain crop varieties. These protocols are objective, scientific methods for measuring the performance of a variety.

ACAS invites plant breeders, or their agents, to submit the variety information they wish to have accredited. The Accreditation Advisory Committees check the procedures used by the plant breeders to generate this information against the established protocols and provide advice and recommendations to the ACAS Board.

These advisory committees are made up of marketers, end users, processors (where appropriate), grain growers, an expert for agronomy, disease, quality, and a plant breeder.

After considering the recommendations of the advisory committees, ACAS will accredit the information where it conforms to the established protocols and publish this information in a form which makes it easy for users to make valid comparisons between varieties available to them in the marketplace – Variety Selector.

**HOW ACAS WORKS**

ACAS does not approve varieties in the sense of controlling their release, nor does it provide recommendations on a variety’s use. The right to release varieties rests with plant breeders (public and private) and they exercise their own business, professional and legal responsibilities.

ACAS is a national voluntary system to provide information on the performance of grain and field crop varieties for growers and their advisors. It does not approve them in the sense of controlling their release - nor does it provide recommendations on use.

Its partners representing Government agencies and private industry are the Grains Council of Australia, Grains Research and Development Corporation, Seed Industry Association of Australia and the Standing Committee on Agriculture and Resource Management.

**CONTACT FOR FURTHER INFORMATION**

For further information in Western Australia contact: Tony Seymour 0419 933 644.

For a program CD please send contact details and e-mail address to Australian Crop Accreditation System: (03) 9328 5302 or PO Box 2054, HOTHAM HILL VIC 3051.

For a program demonstration look for the ACAS stand in the poster section at the Agribusiness Crop updates and at the Regional Crop updates series.
Future wheat varieties

Robin Wilson, Iain Barclay, Robyn McLean, Robert Loughman, Jenny Garlinge, Bill Lambe, Neil Venn and Peter Clarke
Department of Agriculture

The Department of Agriculture Western Australia, in partnership with GRDC, will release one or two new wheat varieties in August 2002. Highlights of these and possible releases for the future follow. Comments are made on the most promising varieties from the Eastern States and their possible place in Western Australia.

WHEAT VARIETY RELEASE IN 2002

WAWHT2281 - An Australian Hard wheat outyielding Carnamah
- The highest yielding AH variety in Western Australia.
- Higher than Carnamah but not as high as Wyalkatchem.
- Better than Carnamah on aluminium and probably on boron toxic soils.
- Similar maturity to Carnamah or slightly earlier.
- AWB classification - AH. A high protein achiever.
- Similar disease resistance to Carnamah:
  - Useful stem rust resistance.
  - Leaf rust resistance better than Carnamah.
  - Useful septoria nodorum blotch resistance.
  - Moderate resistance to yellow spot.
- Susceptible to stripe rust but meets minimum standard.
- Low screenings and more tolerant to black point.
- Likely to be similar or better than Carnamah for sprouting.
- Parents are two unnamed lines based on Aroona, Bodallin and Millewa.

POTENTIAL RELEASE IN 2002

Australian Soft wheat

A Public Forum was about to be held at the time of preparation of this paper, where Farmers and Industry stakeholders are to discuss the possible release of a new Australian Soft wheat variety. The forum is to discuss the viability of releasing this wheat with a conditional licence incorporating a strict rust management plan. This is in view of its susceptibility to leaf rust and the need to protect rust resistance genes currently deployed in commercial varieties.

As a variety, this release would make a substantial contribution to the viability of the Australian Soft wheat grade as it addresses some major concerns such as yield performance relative to APW, and the screenings issue. While susceptible to leaf rust, the variety is an improvement on leaf rust compared to Corrigin and Tincurrin, and has superior stem rust resistance to both these varieties.

WAWHT2248 - Very high yielding, non-club Australian Soft wheat with low screenings
- Yield similar to, or higher than, Westonia.
- Higher yielding than all Australian Soft varieties.
- Nine days earlier than Tincurrin.
- AWB classification - Australian Soft.
- Very low screenings and black point.
- Tendency to produce higher protein levels than other varieties.
• Useful stem rust resistance.
• Susceptible to leaf rust (below our minimum disease standards).
  Will need a spray management regime developed to enable it to be released.
• Harrismith will provide the rust resistant alternative in this grade.
• May have better sprouting tolerance than other Australian Soft varieties.

POSSIBLE RELEASES FOR THE FUTURE

'Rust resistant Westonias'
Two rust resistant backcross versions of Westonia (WAWHT2530 and WAWHT2531) were in stage 4 trials in 2001. Early quality results indicate they line up well with the quality of Westonia. It is anticipated that one could be released in 2004. Three others (WAWHT2527 to 2529) are in Stage 3 trials. All are very similar to Westonia but with the stem and leaf rust resistance that is in Janz.

'Rust resistant Arrinos’
Five rust resistant backcross versions of Arrino (WAWHT2549 to WAWHT2553) were in Noodle wheat trials in 2001. All are similar to Arrino but with the triple rust resistance that is in Camm. Quality tests including noodle sensory tests have been very encouraging. The trials in 2001 will provide samples for further quality evaluation of these lines. One could be released in 2004.

Doubled Haploid wheats - the new technology showing results
Two wheats produced by the Doubled Haploid technique entered stage 4 trials in 2001. WAWHT2470 is from the cross Westonia/Carnamah. WAWHT2471 has useful resistance to all the major diseases in Western Australia. Its resistance to septoria nodorum blotch is one of the best we have seen.

Wheats for new markets
Testing of our wheats through the National Wheat Quality Evaluation Program (NWQEP) has revealed a diversity of end-product performance beyond our existing range of quality types. The Department is seeking opportunities to develop wheats suitable for potential new markets that would enhance the diversity of uses and value of Western Australian wheat exports.

INTERSTATE WHEATS
Many recent varieties from the east have been tried and the following appear to be of the most interest.

STYLET (RAC892) - A Camm type with possibly higher yield than Camm in WA
• The highest yielding wheat in South Australia (the Cereal cyst nematode resistance helps).
  - Good in Western Australia but not as high as Wyalkatchem.
• The same rust resistance source as Camm.
• Compare to Camm to assess its role in Western Australia.

H45 - An early maturing, moderate to high yielding wheat
• Moderate yield in 2001, very good in 2000.
  - Sometimes does not perform.
• Good resistance to rusts and yellow spot.
• Did not make screening standards in many trials in 2000.
• Samples we submitted to National tests do not support upgrade to AH.

GRDC Project No.: DAW 516
Paper reviewed by: Rob Loughman, Iain Barclay and Robyn McLean
Beware of wheat variety interactions with row spacing and seed rate
Mohammad Amjad and Wal Anderson, Department of Agriculture

KEY MESSAGES

- New wheat varieties may be responsive to higher seeding rate but may also be sensitive to wider row spacing.
- The long season variety Camm was found to be better suited to wide row spacing at five seeding rates compared to the short season variety Westonia and the mid-season variety Cascades. This result has implications for seeding systems that use wider rows as a tool to improve stubble and weed management.

AIM

The aim of this work was to establish the effect of row spacing on optimum seeding rate for some of the newer wheat varieties grown on the South Coast.

METHOD

Experiments were conducted on sandplain and mallee soils at Gibson and Salmon Gums during 2000. There were 90 treatments with three replications:

- 3 varieties - Westonia, Cascades, Camm (i.e. early, medium and late maturity).
- 5 target plant populations (50, 100, 150, 200, 250 plants/m²).
- 3 row spacings (180 mm, 240 mm, 360 mm); and
- 2 nitrogen rates (23 kg N/ha and 46 kg N/ha for mallee soils, 37 kg N/ha and 60 kg N/ha for sandplain soils).

RESULTS

Average yield responses to plant population and row spacing at Salmon Gums are presented in Figures 1 and 2. There were no significant interactions of N rate with variety, row spacing or seed rate.

![Figure 1](image1.png)  
**Figure 1.** Yield response of wheat sown at 3 row spacings and 5 target plant populations.

![Figure 2](image2.png)  
**Figure 2.** Yield response of 3 wheat varieties sown at 3 row spacings.
• The higher yield was achieved with the narrow row spacings (180 mm) at all plant populations (Figure 1).
• On average, higher seeding rates (over 150 plants/m² or 70 kg/ha) had no beneficial impact, or reduced yield, at the wider row spacing. Similar effects were recorded for weed competition (data not shown).
• The yield decline in wider rows was greater in Westonia and Cascades than in Camm (Figure 2). This effect was consistent across both sites (Table 1).
• The response of Camm at wider row spacing can be partially explained by its higher green leaf area and dry matter production. This may also help to explain the observed advantage of weed competition at all row spacing and plant populations.
• Grain protein and screenings were higher with wider rows than narrower rows in both experiments (data not shown).

Table 1. Effect of row spacing on wheat yield on mallee and sandplain soils (yield from 180 mm row spacing taken as 100% and in bracket is actual grain yield)

<table>
<thead>
<tr>
<th>Soil type/variety</th>
<th>Row spacing</th>
<th>180 mm</th>
<th>240 mm</th>
<th>360 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grain yield (% of 180 mm treatment yield)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mallee soils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All varieties</td>
<td>100 (1.59 t/ha)</td>
<td>96</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>Camm</td>
<td>100 (1.68 t/ha)</td>
<td>95</td>
<td>91</td>
<td></td>
</tr>
<tr>
<td>Cascades</td>
<td>100 (1.32 t/ha)</td>
<td>96</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Westonia</td>
<td>100 (1.77 t/ha)</td>
<td>97</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sandplain soils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All varieties</td>
<td>100 (3.30 t/ha)</td>
<td>92</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Camm</td>
<td>100 (3.60 t/ha)</td>
<td>98</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Cascades</td>
<td>100 (2.80 t/ha)</td>
<td>90</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>Westonia</td>
<td>100 (3.50 t/ha)</td>
<td>93</td>
<td>78</td>
<td></td>
</tr>
</tbody>
</table>

CONCLUSION
Variety interaction with plant population and row spacing is a complex issue and needs to be considered in the scenario of current farming systems where it may be desirable to increase row spacing and plant population to improve soil, weed and stubble management.

ACKNOWLEDGMENTS
The research was undertaken as a joint venture between the Department of Agriculture and the South East Premium Wheatgrowers Association (SEPWA). The project is funded by GRDC (DAW 584) and the Department. Thanks to all the participating farmers and project advisory team. The cooperation and technical assistance of Veronika Reck and Pam Burgess are gratefully acknowledged.

KEY WORDS
wheat agronomy, row spacing, seeding rate, plant population

GRDC Project No.: DAW 584
Paper reviewed by: Wal Anderson
Yield and falling numbers of wheat varieties on the South Coast

Mohammad Amjad and Wal Anderson, Department of Agriculture

KEY MESSAGES

- Wheat varieties performed differently both for yield and grain quality (falling numbers) during wet harvests in 2001 and 1999 and a dry harvest in 2000 in the Esperance port zone.
- Camm performed consistently well over the 3 years showing wide yield adaptation with relatively stable grain quality and disease resistance.
- Selection of correct variety and sowing time is essential to ensure high productivity (grain yield and quality) and to reduce risk during the wet and dry growing seasons.

AIM

To assess the performance of local and interstate wheat varieties for yield and quality under South Coast conditions.

METHOD

A number of new wheat varieties with potential to the South Coast environment were tested in 16 agronomic experiments over three years from 1999 to 2001. The experimental sites were located throughout the Esperance port zone on the sandplain soils (high rainfall > 450 mm) and mallee soils (low rainfall < 350 mm) under rotations including canola, lupins, peas and pastures. Wheat varieties from Western Australia and other States from early, medium and late maturity groups were tested. Experiments were monitored for growth, foliar diseases, grain yield and quality.

In two experiments with multiple harvest dates, grains were analysed for falling numbers. The falling number is a measure of the amount of starch breakdown by the alpha-amylase enzyme generally associated with grain sprouting due to high moisture at harvest. Falling numbers of 300 or more are required for premium wheat grades.

RESULTS

The growing seasons of 1999 and 2001 had wet harvest periods and the 2000 harvest was dry on the South Coast.

1999

- Generally wheat yields were lower due to leaf rust, both septorias, and stem rust late in the season on the South Coast. Westonia was susceptible to stem rust in 1999.
- On the sandplain at a mid May sowing, the early varieties Ajana and Westonia yielded relatively less. The mid-season varieties Cunderdin, Perenjori and Karlgarin and the late varieties Camm and Krichauff were the highest yielding varieties (more than 3 t/ha).
- On the mallee soils at mid May sowing, the early variety Ajana, the mid-season varieties Carnamah and Cunderdin, and the late varieties Brookton, Camm and Krichauff were the highest yielding (more than 3 t/ha).
- Grain quality problems such as sprouting, staining and low falling numbers downgraded some of the high yielding varieties on the sandplain soils. Brookton, Carnamah, Cunderdin, Krichauff and Westonia yielded well but were downgraded because of low falling number particularly from mid-May and early June sowing. Grain from the mid-June sowing was of comparatively better quality for most of the new varieties. Camm gave the higher falling number (over 300) on all six sites throughout the Esperance port zone.
- No grain quality problems were found in the 16 wheat varieties when grown in the mallee soils at three sowing dates.
2000

- A dry start of the season followed by consistently dry conditions around grain filling, generally resulted in lower wheat yield. High screenings were a problem in some situations.
- Westonia yielded the highest followed by H45, Carnamah, Yitpi and Camm.
- Camm was highest in quality (i.e. protein, hectolitre weight and falling number) followed by Kukri and Sunlin. These conservative varieties also produced better yield, particularly in mallee soils in the dry season of 2000.
- Yitpi was susceptible to stem rust during 2000. Such high yielding varieties could be a risky option particularly in a high disease season.
- In a delayed harvest trial, 7 out of 17 cultivars (Sunelg, Camm, Wyalkatchem, Baxter, Giles, Kukri and Karlgarin) achieved falling numbers over 300. Three varieties including Camm, Whistler and Sunelg (control) gave falling numbers of over 400. The high moisture environment on the South Coast during November appears to have led to poor quality of the other cultivars.

2001

- A dry winter followed by a wet spring and a wet harvest resulted in relatively higher grain yield but with low falling numbers and fungal staining. A complete grain quality analysis will be available at the time of Updates, 2002.
- Preliminary results indicate that new varieties like Camm, H45, Wyalkatchem, Yitpi, Mitre, Stylet and Kukri performed best both for yield and falling numbers on the South Coast. Carnamah and Westonia also yielded well but falling numbers were lower and more variable.

CONCLUSION

Camm seems to be one of the most robust options for South Coast cereal growers if combined with appropriate agronomic management.

Based on three years research in years with both wet and dry harvests, farmers may select two or three varieties with varying maturity, disease resistance, and quality characteristics (high falling number) that would reduce weather and climatic risks and provide safer returns.

ACKNOWLEDGMENTS

The research is being undertaken as a joint venture between the Department of Agriculture and the South East Premium Wheatgrowers Association (SEPWA). The project is funded by GRDC (DAW 584) and the Department of Agriculture. Thanks to all the participating farmers and project advisory team. The cooperation and technical assistance of Veronika Reck and Pam Burgess are gratefully acknowledged.

KEY WORDS

wheat agronomy, varieties, grain quality, falling numbers

GRDC Project No.: DAW 584
Paper reviewed by: Wal Anderson
Maximising wheat variety performance through agronomic management

Wal Anderson, Raffaele Del Cima, James Bee, Darshan Sharma, Sheena Lyon, Melaine Kupsch, Mohammad Amjad, Pam Burgess, Veronika Reck, Brenda Shackley, Ray Tugwell, Bindi Webb and Steve Penny Jr
Department of Agriculture

KEY MESSAGES

• Each of the major wheat varieties grown in Western Australia has a unique set of responses to sowing time, nitrogen fertiliser and seed rate.

• Maximising yield from each variety depends on adjusting management accordingly.

• Among seven leading varieties considered Brookton and Camm are the choices for early May sowing, with Arrino suited to June sowing. Carnamah, Westonia and Wyalkatchem are suited to sowing from mid-May onward and Calingiri performs best when sown in the second half of May.

• Several varieties had medium responsiveness to nitrogen (N). Carnamah was more responsive while Wyalkatchem and Calingiri were less responsive to applied N.

• Arrino, Carnamah, Camm and Wyalkatchem had average responses to seed rate with Brookton and Calingiri performing optimally at slightly higher plant densities, and Westonia performing optimally at lower plant densities.

INTRODUCTION

Wheat producers in the State recognise that particular varieties require particular agronomic inputs. It takes some time after release to collect sufficient data to adequately characterise new varieties. The information below has been derived since 1999 and concerns four of the most commonly grown varieties, plus the new release, Wyalkatchem. Agronomic responses should be considered in conjunction with yielding ability, grain quality, disease resistance, maturity response, and tolerance to defects such as weather damage, shedding, threshing ability and lodging, when assessing variety performance.

METHODS

All data were collected from field experiments at locations ranging from Geraldton to Esperance. The number of experiments used to assess performance varied from 3 to 18 for particular responses.

Response to sowing time was based on experiments usually with three sowing times (the first at the break and thereafter at 15-20 day intervals). The rate of yield decline after the optimum time and the relative yield at each period was assessed. Sowing time response is based on the spread and frequency of dates at which the variety achieved its maximum yield.

Nitrogen (N) response as used here is the change in grain yield between zero and the first N rate used (usually 30-50 kg/ha of N) in responsive situations. Data from experiments where there was no significant response to N were not used for assessment of N response. In situations where an N response is found; Low response is < 10 kg/ha of grain/kg of applied N; Medium response is 10-15 kg/kg N; and High response is > 15 kg/kg N.

Response to seed rate was assessed as the estimated optimum plant population, from experiments containing target populations of 50 to 250 plants/m². Average seed size for each variety, and a field establishment of 75% were assumed in calculating seed rate. Plant density response is based on the optimum plant population estimated as an increase of 2.5 kg/ha of yield for each additional 1 plant/m². It is the minimum population (or seed rate) required under good conditions in a weed-free environment.
RESULTS

*Carnamah* is the most adaptable wheat for mid-season sowing (mid-May onwards). It is still competitive for grain yield even after mid-June. It is very responsive to N fertiliser (about 15 kg grain for every kg of N in responsive situations) and it is probably worthwhile to keep the rate relatively high to ensure that the protein required for the AH grade is achieved. It has an average response to plant population and requires about 100 plants/m² to reach its maximum yield (50+ kg/ha seed rate).

*Westonia* is adapted to sowing from mid-May onwards, reaching its top yields from slightly later sowing than Carnamah. It does not require high plant populations to reach its maximum yield (80 plants/m², or about 40+ kg/ha seed rate), and is moderately responsive to N fertiliser (about 10 kg/kg of N).

*Arrino* is the variety of choice for June sowing. Its yield is not higher than other varieties adapted to this time but its value should be higher if the premium for ASWN (Noodle grade) is achieved. Its responses to N fertiliser and plant population are average (10 kg/kg of N, 100 plants/m², 45+ kg/ha seed rate).

*Calingiri* appears to have a rather restricted optimum sowing range in the second half of May. It could be considered for sowing outside this range however, if the yield x price equation is favourable. It has a low response to N (< 10 kg/kg of N) and its grain protein can sometimes exceed the requirements of the ASWN grade. It needs a high plant population to achieve maximum yield (120 plants/m², or 60+ kg/ha seed rate).

*Brookton* is the variety of choice for early sowing. However, it requires a high plant population to reach its potential yield (120 plants/m², or 60+ kg/ha seed rate). It has an average response to nitrogen (10 kg/kg N applied). Protein percentages are mostly lower than other varieties for the same level of yield.

*Cammy* is the alternative variety for early sowing where sprouting and leaf diseases are considered a high risk. At later sowing it slightly out-yielded Brookton. There are insufficient data to assess N response, and on limited data the response to seed rate is assessed as medium (100 plants/m², or 45+ kg/ha).

*Wyalkatchem* has a very similar response to sowing time as Westonia. However, the preliminary data show that it is not very yield responsive to applied N (< 10 kg/kg of N). This result is supported by the generally higher grain protein percentage of Wyalkatchem, suggesting that it is a protein responsive, rather than a yield responsive variety. It responds to average plant populations (100 plants/m², or 55+ kg/ha seed rate). Overall, this variety could be considered for low input situations as well as better soil conditions.

ACKNOWLEDGMENT

Thanks to GRDC for some of the funding, the Managers and Staff of the Crop Variety Testing team and the Research Support Units.

GRDC Project No.: Wheat Agronomy

Paper reviewed by: Frances Hoyle
High impact of soil type and seasonal rainfall on optimum wheat seed rate

Raffaele Del Cima and Wal Anderson
Department of Agriculture

KEY MESSAGES

- Our results suggest that soil type and seasonal rainfall were the major factors influencing the differences in optimum seed rate of wheat.

- Experiments in clay loam soils, especially on sites that received more rainfall during the growing season (> 325 mm), had higher optimum seed rate [rainfall < 325 mm, optimum seed rate 61 kg/ha; rainfall 325-450 mm, optimum seed rate 75 kg/ha].

- In sandy soils, the optimum seed rate was greater with higher seasonal rainfall but lower than in clay loam soils [rainfall < 325 mm, optimum seed rate 41 kg/ha; rainfall > 450 mm, optimum seed rate 67 kg/ha].

- Higher optimum seed rates were only associated with high yields on clay soils.

AIM

The objective of the experiments was to investigate factors such as rotation, soil type, and rainfall that could affect the optimum seed rate of wheat, which is defined to be at the optimum yield level.

METHODS

Seventeen experiments (cultivar x seed rate) were conducted in 1996-1998 in the central and northern wheatbelt under a range of crop rotations, soil types and seasonal rainfall. Yield response curves were fitted to each data set to estimate the optimum seed rate and a regression technique was used to indicate the site factors that most affected the optimum seed rate. The relationship between yield and optimum seed rate was also examined using graphical techniques.

RESULTS

The results are summarised through the figures below.

Figure 1. Regression tree showing the relationship between optimum seed rate, soil type (S, with labels s, c, sl and cl for sand, clay, sandy loam and clay loam), and rainfall during the growing season (RF, with labels L indicating < 325 mm, M from 325 mm to 450 mm and H more than 450 mm). Y indicates the yield (t/ha). Numbers inside the ellipses and rectangles (nodes) are the average seed rates for each group. Numbers below these shapes are a measure of the variability accounted for by each grouping of records from the experiments.
Figure 2. Relationship between optimum seed rate and yield at optimum with site number. Results were produced for each soil type examined (where s, sl, c and cl denote sand, sandy loam, clay and clay loam respectively) and rainfall range (H > 450 mm, M from 325 to 450 mm and with no labels if less than 325 mm). Each envelope represents the spread of the responses of the cultivars in each experiment, the bold triangles represent the mean optimum yield and optimum seed rate of each experiment.

ACKNOWLEDGMENT

Mario D'Antuono provided the statistical analyses. Melanie Kupsch gave competent technical assistance. GRDC and the Department of Agriculture jointly financed the project.

GRDC Project No.: DAW 487
Paper reviewed by: Shahajahan Miyan
101 seasons in one day: Using the ‘WA Wheat’ database to predict wheat yield

James Fisher¹, Bill Bowden¹, Craig Scanlan¹, Senthold Asseng² and Michael Robertson²
¹Department of Agriculture, ²CSIRO

KEY MESSAGE
The Western Australian Wheat database provides information on wheat production in Western Australia for different combinations of season, soil type and management. The database enables you to predict the impact of particular combinations of location, soil type and management on wheat yield, protein content and the leakage of water and nitrate beyond the root zone based on historical data for 101 seasons. We invite you to preview WA Wheat, at the 2002 Crop Updates.

BACKGROUND AND AIMS
Agronomic packages tend to deliver recommendations to growers based on what will happen ‘on average’, because there is never enough research information to allow site-specific recommendations for each region, farm or paddock. Research information can be enhanced using a validated simulation model. Such models enable data to be generated for a larger range of season, environment and management. In this project we are using the Agricultural Productions Systems Simulator (APSIM) model to produce such information for wheat production in Western Australia.

METHOD AND RESULTS
Predictions of wheat yield, protein content, flowering date, drainage and nitrate leaching from the APSIM model have been validated against several Western Australian data sets (1-5). Through these studies, the model has been shown to be suitable for use in Western Australia and as such provides a useful tool for adding value to existing agronomic data.

We have used the APSIM model to produce data on the production of short, mid and long season varieties of wheat and the leakage of water and nitrate beyond the root zone for 101 seasons (1900 to 2001) at 19 locations, 5 rates of nitrogen, 3 rotational histories, 21 sowing dates and 12 broad soil types (over 7 million data points). This information is being incorporated into a database called WA Wheat. The database has a user-friendly interface that enables specific combinations to be selected for analysis.

Information from the database can be examined using a number of graphical outputs, including time series, differences, cumulative probabilities, box and whisker plots, frequency distributions and pie charts. The graphs provide a quick and easy means for users to examine data, for example, regarding the likelihood of achieving a particular yield based on historical weather data (Figure 1a). More specific information can be examined, such as the effect of finishing rains on the likely frequency of yields (Figure 1b). In this example there is a greater likelihood of achieving higher yields in years with greater than 50 mm of post-anthesis rainfall, compared with years in which post-anthesis rainfall was 50 mm or less.
Figure 1. Sample output from the WA Wheat database. The graphs are probability distributions of wheat yield (t/ha) on a sandy-duplex soil at Merredin with 60 kg/ha N applied at seeding for a) all years and b) years grouped according to post-anthesis rainfall.

IMPLICATIONS

Information from models can be used to enhance recommendations by including predicted growth of wheat under a wider combination of factors than is possible through field experimentation alone. The WA Wheat database is an example of one way in which we can harness the power of these tools. The large number of data points in the database mean that it can add value to existing information and experience by allowing analyses of the probable outcomes from different management options based on data from 101 seasons.

REFERENCES


GRDC Project No.: DAW 632
Paper reviewed by: Blakely Paynter
Economics of improving compact soils

M.A. Hamza¹, G. McConnell² and W.K. Anderson¹
¹Department of Agriculture, ²Planfarm

KEY MESSAGES

- The benefit over untreated control ($/ha averaged over 4 years) of the highest-yielding treatment was as follows:
  - Merredin (clayey soil): Deep Ripping (DR) + Gypsum (G) and ‘complete’ nutrition (N) $90
  - Nungarin (loamy soil): Deep Ripping + Gypsum $33
  This indicates that heavy soils will show the highest benefit from treatment with deep ripping, gypsum and ‘complete’ nutrition, but medium and light soils should also benefit significantly.
- The DRGN treatment was considerably more profitable than the GN treatment without ripping indicating that the application of gypsum alone (no soil ripping) was ineffective in removing soil compaction and hence increasing yield.
- The DRGN treatment was also more profitable than the DRN treatment alone indicating that ripping the soil in the absence of an aggregating agent (gypsum) decreased long term returns.
- The highest economic benefit came from the wheat crop compared with the grain legumes.

BACKGROUND

Low rates of yield improvement for crops in the low rainfall shires of the eastern wheatbelt of Western Australia have been observed over a number of years. Although these rates have improved over the last few years, when the seasonal conditions have allowed, they are still well below the rates measured in the medium and higher rainfall shires. A research project was commenced in 1997 at three sites on compacted soils at Merredin (clayey soil), Nungarin (medium soil) and Tammin (sandy soil) to improve the physical properties through various combinations of deep ripping (DR), gypsum application (G) and complete nutrients (N).

This paper shows the economic feasibility of the treatments from 1997 to 2000 in a wheat-legume rotation.

METHODS

The depth of deep ripping was 0.4 m, the amount of gypsum applied was 2.5 t/ha and the form and quantity of the applied fertilisers depended on the soil chemical test. All sites had deteriorated soil structure and low organic matter. All crop residues were retained on the plots each year.

The following background information should be considered in assessing these results:
- In the very dry season of 2000, a grain legume year in our rotation, all sites suffered net losses.
- In the Nungarin site, up to 70% reduction in lupin yield occurred in 1998 due to a negative interaction between gypsum and lupin. This reduced the benefit when averaged over 4 years.

Yield analysis

The rainfall was around average for all years except 2000 where it was well below average.

The highest average yield increases were recorded for the DRGN treatment (47, 61 and 30% for Merredin, Nungarin and Tammin). The highest grain protein percentages were also found in the DRGN treatment. Significant yield increases were measured for deep ripping, gypsum and complete nutrition alone and the effects on yield were additive. Yield increases were always greatest in the wheat years. Maximum improvement in soil water infiltration, water stable aggregate, soil strength, soil bulk density and porosity, cation exchange capacity, water holding capacity, base saturation and soil organic matter content occurred under the DRGN treatment (data not shown).

Economic analysis

The deep ripping and gypsum treatments were only applied in the first year of the experiments (1997). The amount of the nutrients applied to each site depended on the soil fertility test. Table 1 shows the
economic analysis for the 4 years at the three sites. Deep ripping cost was calculated at $26.4/ha and the cost of gypsum at $75/ha, and the cost of nutrients varied depending on the site fertility ($63, $56 and $53/ha for Merredin, Nungarin and Tammin respectively). Gross Margin ($/ha) in the table refers to the gross income less total cost (normal operating costs plus the treatments costs). The average economic benefits compared to the control largely followed the increases in grain yields. For example, the DRGN treatment gave the highest returns at both Merredin and Tammin ($90 and $68/ha respectively) while the DRG treatment was most profitable at Nungarin ($33/ha).

Table 1. Economic analysis for all treatment combinations at the three sites averaged over 4 years, 1997 to 2000

<table>
<thead>
<tr>
<th>Site</th>
<th>Treatment</th>
<th>Con</th>
<th>DR</th>
<th>G</th>
<th>N</th>
<th>GN</th>
<th>DRN</th>
<th>DRG</th>
<th>DRGN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merredin</td>
<td>Gross margin ($/ha)</td>
<td>134</td>
<td>168</td>
<td>177</td>
<td>171</td>
<td>195</td>
<td>182</td>
<td>209</td>
<td>224</td>
</tr>
<tr>
<td></td>
<td>Benefit over control ($/ha)</td>
<td>na</td>
<td>33</td>
<td>43</td>
<td>37</td>
<td>61</td>
<td>48</td>
<td>74</td>
<td>90</td>
</tr>
<tr>
<td>Nungarin</td>
<td>Gross margin ($/ha)</td>
<td>89</td>
<td>97</td>
<td>83</td>
<td>111</td>
<td>90</td>
<td>104</td>
<td>123</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>Benefit over control ($/ha)</td>
<td>na</td>
<td>6</td>
<td>-6</td>
<td>20</td>
<td>-1</td>
<td>12</td>
<td>33</td>
<td>23</td>
</tr>
<tr>
<td>Tammin</td>
<td>Gross margin ($/ha)</td>
<td>189</td>
<td>201</td>
<td>219</td>
<td>188</td>
<td>230</td>
<td>224</td>
<td>237</td>
<td>258</td>
</tr>
<tr>
<td></td>
<td>Benefit over control ($/ha)</td>
<td>na</td>
<td>13</td>
<td>31</td>
<td>-1</td>
<td>39</td>
<td>35</td>
<td>48</td>
<td>68</td>
</tr>
</tbody>
</table>

The relative profitability of any of the treatment combinations can be observed from the table so that the likely reductions in net returns of applying some combination of the treatments other than the full DRGN ‘package’ can be assessed for each soil type.

The results for the Nungarin site should be treated with caution since the apparent advantage of the DRG treatment over the DRGN treatment was largely due to the negative impact of the gypsum treatment on lupins in 1998. Since lupin is not a crop that is likely to be grown on the heavier soils, it is probable that rotation with another grain legume would have produced a different result. The low rainfall in 2000, when field peas were grown at all sites, resulted in negative returns for the nutrient treatments. It is clear from the economic analyses that the DRGN treatment was profitable after four years on each of the three soil types. Care should be taken in applying combinations of the treatments other than the full DRGN ‘package’. Ripping without gypsum resulted in a return to the previous poor soil structure after 1-2 years. Applying nutrients alone did not always provide a benefit, especially in the drier years when there was insufficient water to achieve efficient nutrient uptake.

SUMMARY AND CONCLUSION

Economic analysis from experiments over four years at three sites in the low rainfall areas has indicated that deep ripping to 40 cm, the addition of 2.5 t/ha of gypsum and the addition of 'complete' nutrients on clay, loam and sandy soils produced profitable returns ranging from $23 to $90/ha. The expected returns from combinations of these treatments were also assessed and should give farmers an indication of the likely profits foregone by using other combinations. It is recognised that the expense of deep ripping compacted soils may make this treatment too expensive, and impractical for some farmers. Further experimentation is required to determine if similar results can be achieved with shallower cultivation, and to examine possible extension of the effects over time, through further additions of organic matter to the soil. Ripping without gypsum resulted in a return to the previous poor soil structure after 1-2 years. Applying nutrients alone did not always provide a benefit, especially in the drier years when there was insufficient water to achieve efficient nutrient uptake.

GRDC Project No.: DAW 343
Paper reviewed by: Darshan Sharma

There is an extended version of this paper on the Crop Update 2002 CD.
Reducing the risks in producing durum wheat in Western Australia

Md Shahajahan Miyan and Wal Anderson, Department of Agriculture

KEY MESSAGE

The grain yield and quality data obtained from the trials do not support the use of high rates or split applications of nitrogen in the low and unreliable rainfall environments.

BACKGROUND

Current durum production in Western Australia is mainly concentrated in the low and medium rainfall cereal zones of the Western region. At the low rainfall sites, moisture is the major limiting factor and so chemical fallowing or good legume rotation influence the crop growth, grain yield and quality where the cropping options available to growers are limited. Returns from durum wheat can be more profitable compared to bread wheat when farmers achieve grain protein over 11.5% (DR1 or 2 grades), but much less than bread wheat where protein is lower. The purpose of this research is to develop recommendations for the management of grain yield and quality of durum wheat based on rotations and N-fertiliser strategies.

METHODS

In 2001, two trials were conducted at Mukinbudin comparing rotations and N rates, and one trial at Narembeen comparing two durum varieties with one bread wheat at 2 N rates. Both trials used farm scale machines on soil types and rotations common in the region. Site details are in Table 1.

Table 1. Site details

<table>
<thead>
<tr>
<th>Site</th>
<th>Soil type</th>
<th>Previous crop</th>
<th>Top soil pH (CaCl₂)</th>
<th>P bicarb.</th>
<th>OC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Mukinbudin</td>
<td>Clay</td>
<td>Lentil</td>
<td>6.8</td>
<td>19</td>
<td>0.63</td>
</tr>
<tr>
<td>B. Mukinbudin</td>
<td>Loam</td>
<td>Fallow</td>
<td>7.1</td>
<td>12</td>
<td>0.70</td>
</tr>
<tr>
<td>C. Narembeen</td>
<td>Clay</td>
<td>Medic</td>
<td>7.9</td>
<td>18</td>
<td>1.21</td>
</tr>
</tbody>
</table>

The Mukinbudin trials were sown on 27 May 2001. The plots were completely randomised with three replications, and five rates of N (0N, 25 kg N/ha, 50 kg N/ha, 25 kg N/ha at seeding + 25 kg N/ha at tillering, 60 kg N/ha at seeding). Site B was sown following a chemical fallow in the previous season.

At the Narembeen site, Tamaroi and Wollaroi durum and Machete bread wheat were sown on 18 May 2001. The experiment was laid out as a completely randomised design with three replications.

RESULTS

Results in Table 2 show that there was no significant effect of the N application on grain yield, 1000-grain weight and gross margin despite the increase in grain protein. It appears that an N application of less than 25 kg/ha would have ensured protein sufficient to achieve DR1 (13%), thus maximising the gross margin. Splitting the N application between sowing and tillering did not increase yield or protein at either site.

At Narembeen, Machete out yielded the two durums, but only Wollaroi responded significantly to the addition of N fertiliser (Table 3). Grain protein was also increased by N fertiliser, lifting the level in both durums to DR2 (11.5%), but 35 kg/ha was insufficient to increase protein in Machete to the level required for Australian Hard (11.5%). The relatively low legume content in the pasture year could probably explain the disappointing contribution of the medic pasture to grain protein at this site.
Table 2. Effect of chemical fallow and a lentil crop on grain yield and quality of Tamaroi durum wheat at Mukinbudin, 2001

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Chemical fallow</th>
<th>Lentil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yield (kg/ha)</td>
<td>1000 grain wt. (g)</td>
</tr>
<tr>
<td>0N</td>
<td>2010</td>
<td>41</td>
</tr>
<tr>
<td>25N</td>
<td>2034</td>
<td>43</td>
</tr>
<tr>
<td>50N</td>
<td>2024</td>
<td>42</td>
</tr>
<tr>
<td>25N + 25N</td>
<td>2024</td>
<td>42</td>
</tr>
<tr>
<td>60N</td>
<td>2054</td>
<td>42</td>
</tr>
<tr>
<td>LSD: 0.05</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

Despite the lower grain yield of Wollaroi its gross margin at 35 kg/ha of N was as good as that of Machete. This illustrates the capacity of durum to achieve equal or better returns than bread wheat where soil and rotational conditions suit.

Table 3. Effect of nitrogen fertiliser on grain yield and quality of durum and bread wheat at Narembeen, in 2001 following medic pasture

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (kg/ha)</th>
<th>Kernel weight (mg)</th>
<th>Grain protein (%)</th>
<th>Gross margin ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machete N0</td>
<td>2770</td>
<td>42</td>
<td>8.7</td>
<td>573</td>
</tr>
<tr>
<td>Machete N35</td>
<td>2920</td>
<td>41</td>
<td>10.5</td>
<td>723</td>
</tr>
<tr>
<td>Tamaroi N0</td>
<td>2030</td>
<td>42</td>
<td>8.4</td>
<td>465</td>
</tr>
<tr>
<td>Tamaroi N35</td>
<td>1990</td>
<td>40</td>
<td>12.7</td>
<td>637</td>
</tr>
<tr>
<td>Wollaroi N0</td>
<td>2030</td>
<td>43</td>
<td>10</td>
<td>518</td>
</tr>
<tr>
<td>Wollaroi N35</td>
<td>2430</td>
<td>42</td>
<td>12.1</td>
<td>745</td>
</tr>
<tr>
<td>LSD: 0.05</td>
<td>230</td>
<td>ns</td>
<td>1.1</td>
<td>65</td>
</tr>
</tbody>
</table>

CONCLUSIONS

These results confirm earlier data presented at UPDATES from trials in the eastern wheatbelt which have shown that if durum is grown on neutral to alkaline clay soils following good quality legume pastures or crops, its profitability will equal or exceed that from bread wheat. The risk of failing to meet the protein standards for DR1 or DR2 can be reduced by the addition of relatively low rates of N fertiliser which are usually more than repaid through the premiums obtained. The evidence from these trials, plus considerable data from bread wheat trials in the eastern wheatbelt, indicates that the expectation of an economic return from split applications of N is low.

ACKNOWLEDGMENT

Ms Louise Evans for technical assistance, Mr Kennedy Miller and Mr Dudley Squire for the use of their land, time and equipment.

GRDC Project No.: DAW 503

Paper reviewed by: Wal Anderson
Taking the Why out of Wyalkatchem - the new widely adapted wheat variety

Steve Penny, Department of Agriculture

KEY MESSAGE

Performance of the wheat variety Wyalkatchem both in crop variety testing over the last five years, and commercially in 2001, indicate that it is widely adapted. The additional attributes of sturdy grain quality, disease resistance and tolerance to aluminium and boron toxicity make the variety a competitive option over other major wheat varieties grown in Western Australia.

ADAPTATION

Wyalkatchem has stable yield performance both across the Agzones and in a range of different seasons. In the two contrasting seasons of 1999 and 2000 Wyalkatchem has been ranked amongst the top varieties and was consistently the highest yielding variety in trials in the dry season of 2000. Preliminary data suggest the variety also performed well in 2001.

Table 1. Yield of Wyalkatchem and other major wheat varieties over the last ten years, expressed as % of Westonia (number of trials in brackets)

<table>
<thead>
<tr>
<th></th>
<th>Agzone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wyalkatchem</td>
<td>101 (16)</td>
<td>99 (22)</td>
<td>100 (11)</td>
<td>101 (24)</td>
<td>105 (25)</td>
<td>99 (4)</td>
<td>101 (102)</td>
<td></td>
</tr>
<tr>
<td>Brookton</td>
<td>100 (34)</td>
<td>97 (45)</td>
<td>101 (24)</td>
<td>95 (52)</td>
<td>96 (51)</td>
<td>99 (10)</td>
<td>97 (216)</td>
<td></td>
</tr>
<tr>
<td>Carnamah</td>
<td>99 (43)</td>
<td>98 (54)</td>
<td>97 (31)</td>
<td>93 (61)</td>
<td>95 (58)</td>
<td>95 (16)</td>
<td>96 (263)</td>
<td></td>
</tr>
<tr>
<td>Westonia</td>
<td>100 (38)</td>
<td>100 (44)</td>
<td>100 (21)</td>
<td>100 (55)</td>
<td>100 (56)</td>
<td>100 (13)</td>
<td>100 (227)</td>
<td></td>
</tr>
</tbody>
</table>

Wyalkatchem regularly attains higher grain protein than other high yielding varieties, with a mean of 11.6% protein compared to 10.9% for Westonia in variety trials in 1998 and 1999 (18 observations). This is complimented by lower screenings than other varieties in many cases, with 0.5% for Wyalkatchem compared to 0.7% for Westonia (27 observations).

Grain quality data indicate that Wyalkatchem is a preferable variety over Westonia in areas of high black point risk. Trial sites selected based on a high incidence of black point pressure indicate that Wyalkatchem had a mean incidence of 5.7% compared to 8.8% for Westonia (55 observations).

Trial data from 1998 through to, and including, 2001 indicates that Wyalkatchem is similar to Westonia in its tolerance to both acid and boron toxic soils. Only Westonia and Ajana have consistently out yielded Wyalkatchem in acid tolerance trials. Westonia is the only variety that marginally out yields Wyalkatchem in boron tolerance trials.

AGRONOMIC FACTORS

Wyalkatchem is the shortest variety released in Western Australia, being 16 cm shorter than Spear. This gives it an advantage over Westonia in situations where stubble handling is a potential problem. Despite the very short straw of this variety it has a coleoptile length similar to Calingiri and 5-10 mm shorter than Westonia.

Wyalkatchem is a mid season variety that reaches flowering two days later than Westonia and 10 days earlier than Carnamah, on average, making it suitable for sowing in mid May onwards. The yield response of Wyalkatchem to plant density appears to plateau in the average population range of around 100 plants/m², which is equivalent to a seeding rate of around 45 kg/ha and above.

Where other high yielding varieties, including Arrino, Brookton, Calingiri and Westonia, have given average yield responses to applied nitrogen of around 10 kg/kg of N, Wyalkatchem responds at a
lower rate of 5 kg/kg of N. Wyalkatchem has shown to be more protein responsive than yield responsive to inputs of nitrogen, when compared to these other varieties. This suggests that Wyalkatchem is, whilst still competitive in high input situations, more suitable for low input farming systems than other high performing varieties. This variety may be of particular benefit in wheat on wheat situations.

**DISEASE MANAGEMENT**

Wyalkatchem has useful resistance to several diseases that should enhance the performance of this variety under various disease pressures. It is intermediate in resistance to septoria nodorum blotch and moderately resistant to yellow spot. These characteristics should reduce the need for fungicide control in high input crops. It is susceptible to septoria tritici blotch, similar to Westonia, although this disease has had low impact in Western Australia over the past 5 years.

Wyalkatchem is highly resistant to leaf rust and has moderate resistance to stem rust in Western Australia, and should not require fungicide protection for these diseases. Future changes in the leaf or stem rust strains in Western Australia could impact on the usefulness of this resistance, as with other varieties with specific resistance genes. In the event that stripe rust occurred in Western Australia, Wyalkatchem has intermediate resistance. This may afford it modest protection under late stripe rust attack or enable the disease to be readily managed with fungicide when under greater pressure.

Wyalkatchem is moderately susceptible to powdery mildew (similar to Calingiri) and less prone than Brookton or Cunderdin and marginally less prone than Spear or Westonia.

Limited testing indicates Wyalkatchem is susceptible to flag smut. Routine use of a smuticide seed dressing is recommended for flag smut and stinking bunt.

**ABiotic STRESS MANAGEMENT**

The herbicide tolerance to 26 commonly used herbicides was tested across some of the major varieties in field trials at both Mullewa and Merredin in 2001 (Dhammu 2002). The yield of Wyalkatchem was reduced by 1.0 L/ha dicamba at both sites. The yield reduction observed at the Mullewa site from this treatment was in the order of 85%. Although significant yield reductions were induced by this treatment across the other varieties in these trials, which included Westonia and Carnamah, they were not of this magnitude. Both 375 mL Argold® (a.i. cynmethalin), incorporated at seeding, and 0.5 L/ha Paragon® (a.i. picolinafen + MCPA) caused yield reductions of around 10% in Wyalkatchem at the Merredin site (not statistically significant). Wyalkatchem was the only variety that was affected by the Paragon treatment at this site.

Studies of carbohydrate storage and its role in drought tolerance indicate that Wyalkatchem is classified in the medium range when compared to other major varieties. Based on this research Wyalkatchem may be less tolerable to terminal drought conditions than the varieties Ajana, Brookton and Westonia.

Wyalkatchem has been classified as susceptible to sprouting under Western Australian conditions, making it slightly more tolerable than Brookton or Cunderdin, which are very susceptible. Therefore Wyalkatchem may not be the ideal choice in areas with a high risk of sprouting.

**ACKNOWLEDGMENTS**

This work has been funded by the GRDC. Thanks go to Wal Anderson, Rob Loughman, Robin Wilson, Bill Lambe, Harmohinder Singh, Darshan Sharma, Dean Diepeveen, Noel Murphy, Paula Reeve, Fran Hoyle, Ben Curtis and Mohammad Amjad.

**REFERENCE**


**Paper reviewed by:** W. Anderson and R. Loughman
Influence of nutrition and environmental factors on seed vigour in wheat

Darshan Sharma, Wal Anderson and Daya Patabendige
Department of Agriculture

KEY MESSAGES

- The appropriate strategy for quality seed production would be to sow early and to apply sufficient quantities of NPK (may be slightly higher than the grain crop to avoid any deficiency). An adequate level of trace elements is also essential to ensure high quality seed.
- Frost can affect seed germination and a germination test is required in spite of seed grading.
- Preliminary tests on seeds of different falling numbers did not indicate any relation between falling numbers and seed viability. More results are likely to be available by the time of the crop updates.

AIMS

High germination percentage and rapid field emergence are essential features of seed vigour. While high field emergence is important to ensure optimum plant density, germination speed is important for competitive advantage against weeds and early establishment under unfavourable conditions. Also, some reports in the literature indicate that an advantage of just a fraction of a day in emergence time can ultimately lead to a significant advantage for vigorous seedlings.

METHOD

Tests

All data reported here comes from field tests. The tests were conducted on a weed free, sandy loam soil. Moisture level throughout the experiment was sufficient to support unhampered emergence.

Fifty seeds were evenly spaced in 5 mm wide, 3 cm deep and one-meter long furrows made in softened and levelled soil. Soil was gently pressed from both sides to ensure even depth of seeding. The fusion line was sealed using a small press wheel. All treatments were replicated six times and a control was planted after every five experimental rows.

Material

Seeds for time of sowing contrasts were collected from trials in 1998, 1999 and 2000 seasons. Seeds for frost contrasts were made available by Craig White. Seeds for nutrition contrasts were collected from two factorial experiments involving N, P, K and trace elements.

RESULTS

Results from some of the factors influencing seed vigour are presented here. It is important to note that the magnitude of these differences may be expected to vary under less favourable conditions. Current experiments were conducted under minimal environmental stress. As such they indicate trends and not magnitudes.

Nutrition

All of the applied nitrogen, potassium, phosphorous and trace element treatments applied to the grain crop influenced vigour of the seed. However, the response to some nutrients differed between sites and varieties. This is not unexpected given that the sites could differ for nutrient status while varieties are known to differ for nutrient uptake.

Emergence percentage: Application of N, K and trace elements improved speed of emergence of Brookton, which had a lower average germinability than Carnamah. The data suggests that there was a genetic factor that resulted in reduced emergence vigour at both levels of applied nutrients. Data from a wider range of varieties and field conditions are needed to understand this result completely.
**Emergence speed**: Within a given seed production site, Carnamah germinated faster than Brookton. Vigour was improved with appropriate nitrogen, potassium and trace element applications (see Figure below). Phosphorous applied to the grain crop at another site also improved emergence speed (see Figure below).

![Days to 80% Field Emergence](image)

---

**Frost**

**Emergence percentage**: Per cent emergence declined in some but not all the sites. Emergence declined for the variety Perenjori, which experienced 20% stem and 80% head frost, while no difference was seen in Brookton which experienced only 10% frost on each of the stem and head. Furthermore, when seeds of the same size (2.8-3.1 mm) from the frosted and unfrosted bulks were compared, similar reductions were apparent. This suggests that frost associated reduction in germinability is independent of seed size.

**Emergence speed**: Contrary to expectation, seed lots that suffered seed viability decline with frost did not show significant reductions in speed of emergence.

**Time of sowing**

**Emergence percentage**: Per cent emergence did not decline for any of the varieties in seasons that had a relatively unstressed finish in 1998 and 1999. However, in seeds from 2000, Brookton suffered a heavy decline in germinability with delayed seeding in comparison to the 1999 seed lot despite similar viability at earlier TOS.

VARIETAL differences in seed germinability related to time of sowing were also evident. Viability declined significantly for Brookton and Wyalkatchem but not for Carnamah. Comparison of yield components reveals that TOS-related decline was associated with both the maturity group and the ability to adjust the number of grains per unit area in response to stress.

**Emergence speed**: Speed of field emergence was not influenced with time of sowing in any trials or varieties.

**CONCLUSION**

Seed for next year should be kept from an early sown crop. Adequate nutrition of seed crops is a must for high seed vigour. Do not assume that seed graded from frosted crops will have normal germinability. While every effort should be made to produce quality seed, seed testing is always worthwhile!

**KEY WORDS**

wheat, seed vigour, germination, field emergence

**ACKNOWLEDGMENTS**

Anne Smith and Sheena Lyon for technical support, Craig White for supplying frosted seed samples, and Stan Johnson (Narangalu) for the field site.

**GRDC Project No.** DAW 563
**Paper reviewed by** Wal Anderson
N and K are important for oat yield and quality
Patrick Gethin, Stephen Loss, Tim O’Dea, Ryan Guthrie and Lisa Leaver
CSBP Futurefarm

KEY MESSAGE
Oaten hay and grain yields improved significantly with nitrogen (N) application in three trials. Apart from hay protein content, N had no effect on the hay quality parameters measured. Potassium (K) appeared less important than N for hay and grain yields, but in one trial, K addition improved the hay quality parameters. Oaten hay producers should not shy away from high rates of N and K.

BACKGROUND AND AIM
Limited farmer experience suggested that high rates of fertilisers may reduce oaten hay quality. However, a CSBP trial conducted in 2000 showed that N increased oaten hay yield and protein content. The addition of K did not affect hay yield, but improved other quality parameters. The aim of this work was to investigate the effects of N and K on oaten hay and grain production and quality.

METHODS
Three field trials were conducted (Table 1). The treatments were a complete factorial of 4 N rates and 3 K rates. N was applied as Flexi-N through a boomspray before seeding, except the highest rates where N was split before sowing and 6-8 weeks later. K was applied as Potash topdressed before sowing. The trials included 3 replicates. Plots were 2.1 m (11 rows) x 40 m long and were sown with Conserva Pak or Primary Sales Superseeder points on 22.5 cm row spacings. 78-123 kg/ha AgstarCZM was banded 4 cm below the seed. Winjardie oats were sown at 100 kg/ha at Yerecoin and Williams. At Aldersyde 120 kg/ha Carrolup was used. A soil compaction layer was noted at Yerecoin at 15-20 cm, and half the trial was ripped to 30-40 cm two days after sowing. Spring hay production was measured in 4 x 0.5 m² quadrats/plot. Grain yields were harvested at Yerecoin and Williams.

Table 1. Experimental site and 0-10 cm soil characteristics

<table>
<thead>
<tr>
<th>Site</th>
<th>Yerecoin</th>
<th>Aldersyde</th>
<th>Williams</th>
</tr>
</thead>
<tbody>
<tr>
<td>History</td>
<td>oaten hay 99 and 00</td>
<td>poor pasture 99, wheat 00</td>
<td>poor pasture 99, oaten hay 00</td>
</tr>
<tr>
<td>Soil type</td>
<td>grey brown sandy loam</td>
<td>brown grey sandy loam</td>
<td>grey brown sandy loam</td>
</tr>
<tr>
<td>P mg/kg</td>
<td>18</td>
<td>28</td>
<td>58</td>
</tr>
<tr>
<td>N(Nit) mg/kg</td>
<td>13</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>N(Amm) mg/kg</td>
<td>10</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>K mg/kg</td>
<td>24</td>
<td>70</td>
<td>60</td>
</tr>
<tr>
<td>S mg/kg</td>
<td>6</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>OC %</td>
<td>1.03</td>
<td>0.73</td>
<td>2.75</td>
</tr>
<tr>
<td>Reactive Fe mg/kg</td>
<td>176</td>
<td>284</td>
<td>415</td>
</tr>
<tr>
<td>pH 1:5 CaCl₂</td>
<td>4.5</td>
<td>4.3</td>
<td>5.2</td>
</tr>
<tr>
<td>Sowing time</td>
<td>23 May 2001</td>
<td>23 May 2001</td>
<td>29 May 2001</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION
At Yerecoin, deep ripping increased hay production significantly from about 6.2 to 8.4 t/ha (Figure 1, P < 0.05). Hay production failed to respond to N or K in the unripped area, but increased significantly in the ripped area, from 5.9 t/ha in the nil to 8.2 t/ha at 120 kg N/ha in the absence of K (P < 0.05). Although the K effect was not statistically significant, the addition of 120 kg N/ha and 80 kg K/ha produced the maximum hay production of 10.9 t/ha. Hay protein increased significantly with N application from 6.4% in the nil to 9.1% at 120 kg N/ha (P < 0.05), while K application and deep ripping had no consistent effect on protein. Other hay quality parameters failed to respond to N or K but achieved export standards. Grain yields were greater in the ripped (3.4 t/ha) than the unripped areas (2.9 t/ha; Figure 2). Grain yields in both areas responded significantly to N application reaching a maximum at 80 kg N/ha (P < 0.05), but did not respond significantly to the addition of K.
At Aldersyde, hay production increased significantly from 3.5 t/ha in the nil up to 5.5 t/ha at 90 kg N/ha in the absence of K (Figure 3; P < 0.05). The addition of 25 kg K/ha increased yields from 5.0 to 6.0 t/ha, at 60 kg N/ha, but this difference was not significant (P > 0.1). Hay quality parameters achieved export standards. Hay protein increased from 5.7% in the nil to 7.0% at 120 kg N/ha, while the addition of K did not have a significant effect on protein or other parameters measured (Figure 4; P > 0.1).

At Williams hay production increased significantly from 5.2 t/ha in the nil to 6.2 t/ha at 90 kg N/ha (Figure 5; P < 0.05). The addition of 25 kg K/ha increased yields to 7.0 t/ha, but these differences were not significant (P > 0.1). Hay protein increased significantly from 4.7% in the nil to 6.0% at 90 kg N/ha but the addition of K had no effect on protein (P < 0.05). N application had no effect on other quality parameters, but quality improved significantly with K application. Digestible dry matter increased from 60.6% in the nil to 61.8% at 50 kg K/ha. Neutral digestible fibre was 58.3% in the nil treatment but this fell to 56.8% at 25 kg K/ha. Acid digestible fibre fell from 30.6% in the nil to 29.1% at 50 kg K/ha. Grain yields increased from 3.0 t/ha in the nil to 3.5 t/ha at 90 kg N/ha, and the addition of 25 kg K/ha significantly increased grain yields further, especially at low N rates (Figure 6).

**KEY WORDS**
fertiliser, hay, plant nutrition

There is an extended version of this paper on the Crop Update 2002 CD.
Effects of nitrogen and phosphorus on the grain yield and quality of noodle wheat

Tyrone Henning\textsuperscript{1}, Lionel Martin\textsuperscript{1} and Wal Anderson\textsuperscript{2}
\textsuperscript{1}Muresk Institute of Agriculture, \textsuperscript{2}Department of Agriculture

KEY MESSAGES

- Noodle grade wheat (ASWN) was achieved on a duplex sandy loam, with an immediate legume history, through different treatment combinations of N and P.
- Additions of P fertiliser significantly increased grain yield.
- N fertiliser increased grain protein but did not increase grain yield.

AIMS

Noodle wheat is grown in the drier areas in the eastern wheatbelt of Western Australia where its high quality and price premium can combat yield reductions encountered through drought, while providing a high return to the producer. The interactions between N and P may change over time, so that the optimum rates and amounts of both fertilisers will also vary. The main aim of our experiment was to test which combination of N and P gave the most economical ASWN grading.

METHOD

The experiment was conducted 25 km east of Koorda and 18 km west of Cadoux, in the eastern central wheatbelt of Western Australia. The site was located on grey sandy loam on a duplex soil, with the previous year growing a poor yielding lupin crop (cv. Myallie, 0.3 t/ha). The soil contained a Phosphorus Retention Index (PRI) of 1-3 in the topsoil, 13-16 in the subsoil with a pH of 4.9.

Treatment combinations consisted of 3 rates of P (0, 10, 20 kg/ha), and four of N (0, 25, 37.5, 50 kg/ha). The trial was laid out in a randomised block design with three replicates. Plots (15 m wide x 40 m long) were sown with cv. Arrino using a no-till bar, with 22.5 cm spacing (knifepoints) and attached trifluralin boom, on 2 June 2001. P (Triple superphosphate) was placed down the tube at sowing, while N (Urea) was applied with a broadcast spreader 3 weeks after sowing. The plots were sampled for growth analysis at tillering (64 DAS), stem elongation (82 DAS), flowering (107 DAS), grain fill (128 DAS) and maturity (171 DAS). Plots were harvested with a conventional combine harvester with grain weighed through a weigh trailer and samples collected for quality analysis. Rainfall for the growing season was 190 mm.

RESULTS

Grain yield was significantly increased by the addition of P (Table 1). P significantly affected the growth of the crop from the seedling stage through to the harvested yield. P significantly increased tiller and spikelet numbers, early seedling vigour and interception of photosynthetically active radiation (PAR). P significantly increased wheat competition to ryegrass (data not shown), which ultimately meant P significantly affected yield. Dry weight responded significantly to P for the first sample period, demonstrating the early effects of P nutrition on plant development. These dry weight measurements were significant through to maturity.

| Table 1. Main significant effects of Phosphorus on Arrino wheat |
|---------------------------------|----------|----------|----------|----------|----------|
| Phosphorus (kg/ha)          | P 0     | P 10    | P 20    | Sig.     | LSD(P = 0.05) |
| Grain yield (t/ha)           | 1.02    | 1.43    | 1.54    | ***      | 0.08      |
| Protein: Yield ratio         | 0.11    | 0.08    | 0.07    | ***      | 0.01      |
| Interception of PAR (%) (64 DAS) | 13      | 25      | 25      | ***      | 2         |
| Total DW (g/m\textsuperscript{2}, 64 DAS) | 29      | 50      | 54      | ***      | 4         |
| Leaf dry weight (g/m\textsuperscript{2}, 64 DAS) | 18      | 33      | 32      | ***      | 3         |
| Stem dry weight (g/m\textsuperscript{2}, 64 DAS) | 11      | 17      | 22      | ***      | 2         |
| Grain weight (g/m\textsuperscript{2}) | 170     | 211     | 246     | *        | 28        |
N mainly affected grain protein and number of grains per head (Table 2).

### Table 2. Main significant effects of nitrogen on Arrino wheat

<table>
<thead>
<tr>
<th>Nitrogen (kg/ha)</th>
<th>N 0</th>
<th>N 25</th>
<th>N 37.5</th>
<th>N 50</th>
<th>Sig.</th>
<th>LSD (P = 0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain protein (%)</td>
<td>10.6</td>
<td>10.8</td>
<td>11.0</td>
<td>11.1</td>
<td>*</td>
<td>0.2</td>
</tr>
<tr>
<td>Grains/head</td>
<td>18</td>
<td>23</td>
<td>20</td>
<td>17</td>
<td>**</td>
<td>2</td>
</tr>
<tr>
<td>Total DW (g/m², 128 DAS)</td>
<td>299</td>
<td>407</td>
<td>327</td>
<td>352</td>
<td>**</td>
<td>36</td>
</tr>
</tbody>
</table>

Neither N, nor the combination of N and P had any significant effect on grain yield. N treatments yielded below 1 t/ha, P treatments yielded between 1 to 1.5 t/ha, while 50N and 20P yielded up to 2 t/ha. The effect of trace elements in a neighbouring trial produced 2.74 t/ha (37.5 N, 20P - Legume Special). All combinations met the noodle grading, however high N and P rates produced high protein of up to 11.2%.

The most economic rate of N and P for the area was 25N and 10P, producing a gross margin of $256.84/ha, while 50N and 20P produced $297.59/ha. The former was chosen as the most economical due the probability of crop failure being a real possibility, along with the associated transport and storage costs of extra fertiliser.

**CONCLUSION**

ASWN grading can be achieved through most fertiliser regimes, providing that the crop is grown on a duplex soil with an immediate legume history. The most economical rate of N to P being 25N and 10P may be challenged by the most profitable option of N50, P20, in that increased nutrition increases competition to problematic weeds such as resistant ryegrass (*Lolium rigidum*). This may ultimately increased future profitability from decreased control costs and opportunistic yield from favourable seasons or season finishes.

Options such as deep-banding with trace-element fertilisers need to have their viability tested in regards to increasing drought tolerance, along with increasing the wheat plants ability to out-compete surviving resistant weeds to ultimately increase returns to the producer in the highly variable eastern wheatbelt of Western Australia.

**Paper reviewed by:** Wal Anderson and Lionel Martin
Assessment of a high input fertiliser regime on the yield and quality of Gairdner barley

Narelle Hill¹, Simon Wallwork² and Laurence Carslake²
¹Department of Agriculture, ²Wesfarmers Landmark

KEY MESSAGES

• Extra nitrogen at mid tillering increased protein from 10.1% to 11.6% and screenings from 6.25% to 18%, although the grain still achieved malting grade.

• Highest crop yield of 5.6 t/ha exceeded the potential crop yield for the season of 3.6 t/ha, indicating that yield was not limited by any factors including nutrition and water supply.

AIM

Assess the yield and grain quality response of Gairdner barley to nutrition in the southern high rainfall zone of Western Australia.

BACKGROUND

Average yields for barley of 2.5 t/ha in the high rainfall zone (400-700 mm) are well below the potential yields of 6 to 10 t/ha obtained from the French and Schultz equation, where yield potential = (crop water use-110)*20. Crop nutrition has been identified as a major limiting factor to increasing the average crop yields in the southern high rainfall zone. This trial assesses whether no-tillage, deep banded, high input fertiliser regimes have the potential to economically increase crop production.

METHOD

The trial was sown on a sandy loam soil 5 km west of Arthur River. The soil tests in the top 10 cm were 1.25% Organic Carbon (OC), 67 ppm Phosphorus (P), 132 ppm Potassium (K), 12 ppm Sulphur (S), 0.1 ppm Copper (Cu) and 0.7 ppm Zinc (Zn). Phosphorus Retention at the trial site was low.

Gairdner barley was sown on 19 May 2001 at 70 kg/ha with knifepoints and press wheels at 18 cm spacings. Nutrients were deep banded at the rates (kg/ha) shown in Table 1, with extra nitrogen and trace elements applied mid tillering. Optimum management was practised before and throughout the growing season to ensure only water and nutrition could limit crop yield and quality.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Nutrients and rates/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control - No inputs</td>
<td>0</td>
</tr>
<tr>
<td>District practice (DP)</td>
<td>34 N, 13 P, 25 K, 5S, 0.2 Cu, 0.2 Zn, 0.01 Mn</td>
</tr>
<tr>
<td>DP + Trace elements (Trace)</td>
<td>34 N, 13 P, 25 K, 5S, 0.4 Cu, 2.6 Zn, 0.5 Mn</td>
</tr>
<tr>
<td>DP + Trace + extra Nitrogen (N)</td>
<td>98 N, 13 P, 25 K, 5S, 0.4 Cu, 2.6 Zn, 0.5 Mn</td>
</tr>
<tr>
<td>DP + Trace + P + S + extra N</td>
<td>104 N, 24 P, 25 K, 9S, 0.6 Cu, 2.7 Zn, 0.5 Mn</td>
</tr>
<tr>
<td>DP + Trace + K + extra N</td>
<td>99 N, 13 P, 37 K, 5S, 0.4 Cu, 2.6 Zn, 0.5 Mn</td>
</tr>
<tr>
<td>DP + Trace + P + S + K + extra N</td>
<td>104 N, 24 P, 37 K, 9S, 0.6 Cu, 2.7 Zn, 0.5 Mn</td>
</tr>
</tbody>
</table>
RESULTS AND DISCUSSION

Dry matter and grain yield
Adding extra nutrients, including N, P, K and S, at sowing significantly increased early dry matter production by 27% over the control. The increase resulted from more leaves and tillers per plant. After the addition of extra N and trace elements at mid tillering, dry matter production increased to 47% over the control (Figure 1). At this developmental stage, the addition of extra P, S and K to the extra N and trace elements did not further increase dry matter. Plant analysis showed that these nutrients were already high.

Adding extra nutrients, including N, P and S at sowing and extra N and trace elements at mid tillering significantly increased grain yield by 33% over the control, and by 10% over the district practice (Figure 1).

The highest harvest index (%) was the district practice treatment (47%). Figure 1 suggests that the extra N and trace elements stimulated vegetative growth much more than the reproductive growth of the crop. Harvest index and grain yield could be increased through the capacity of the crop to utilise the added N more efficiently. High levels of nutrients appear to boost the crop too early, thus to improve harvest index a good balance of nutrients is required when the ears of the main stem and tillers are being formed (terminal spikelet stage) thus improving growth rates.

Figure 1. Seed yield (t/ha) on 20 December 2001 and associated harvest index (%) for Gairdner barley at Arthur River with different nutrition treatments.

Grain quality
Grain protein was increased from 10.1% for the district practice plus trace to 11.6% for the treatment with the additional P, S and N. Screenings for the same two treatments were 6.25% and 18.4%. Hectolitre weight was above the minimum for all treatments and the significant differences between the protein and screenings did not prevent the barley from achieving the malting grade.

Nutrition increased actual crop grain yields above the ‘potential’ crop yield of 3.6 t/ha based on French and Schultz’s assumptions of 110 mm for losses of water, a transpiration efficiency of 20 kg/ha/mm, and GSR of 291 mm. However, assuming water losses as low as 80 mm, and crop transpiration efficiencies as high as 25 kg/ha/mm, the equation can account for 5.3 t/ha (there was no effective stored water prior to sowing). This is a realistic assumption as the pattern of rainfall for each month was very even and the season was mild and warmer than usual. The key to achieving potential yields in this type of season would appear to have been to keep a balance of nutrition by using a combination of soil and plant analysis beforehand.

KEY WORDS
barley, nutrition

GRDC Project No.: DAW 673
Paper reviewed by: Bill Bowden and Wal Anderson
The use of Flexi-N to achieve high yielding, high protein wheat
Darren Hughes¹, Lionel Martin¹, Wal Anderson² and Stephen Loss³
¹Muresk Institute of Agriculture, ²Department of Agriculture, ³CSBP Futurefarm

KEY MESSAGES
- Grain protein suitable for the Australian Hard wheat grade can be successfully produced in the Avon Valley of Western Australia using Flexi-N (urea ammonium nitrate solution), with substantial benefit to the grower.
- Increasing the rate of nitrogen did not increase grain yield but substantially increased grain protein percentage.
- Possibility of late application of Flexi-N at booting stage allows the growers to evaluate the yield potential of the crop and weather outlook before deciding on the final application of N.

AIMS
Hard wheat has long been achieved in the northern and eastern wheatbelt, where hot, dry conditions often experienced during grainfill, reduces carbohydrate deposition in the grain, subsequently resulting in higher grain protein. Western regions of the wheatbelt often experiences cool, moist conditions during grainfill, which consequently results in low grain protein. The aim of the research was to determine whether hard wheat could be successfully grown in the western regions of the wheatbelt using different nitrogen rates and application strategies.

METHOD
The experiment was conducted 10 km north-east of Northam on a non-calcic brown soil following clover. It was laid out in a randomised block design with 10 treatments, replicated three times. Treatments consisted of Tamaroi durum wheat, Carnamah bread wheat, and five rates of nitrogen (0 and 30 kg N/ha at seeding, 30 kg N/ha at seeding + 30 kg/ha at tillering, 30 kg N/ha at seeding, tillering and booting, and 45 kg N/ha at seeding and tillering). Flexi-N was applied with a hand sprayer at each application time. Plots where 1.8 m x 20 m and sown, using an eight-row cone seeder with super seeder points, on 22 May 2001. Superphosphate with copper, zinc and molybdenum was drilled with the seed at 200 kg/ha as a basal fertiliser. Carnamah was seeded at 55 kg/ha and Tamaroi at 70 kg/ha to account for the larger seed of the durum variety.

RESULTS
Tables 1 and 2 show the effects of cultivar and nitrogen on grain yield, yield components and grain quality. Neither cultivar, nor nitrogen (rate or timing) had a significant effect on grain yield. On average, Carnamah yielded 3.06 t/ha and Tamaroi 2.91 t/ha. There were no significant interactions between nitrogen treatment and variety for any yield or quality traits.

Table 1. Effects of cultivar on grain yield, yield components and grain quality

<table>
<thead>
<tr>
<th></th>
<th>Tamaroi</th>
<th>Carnamah</th>
<th>LSD (P = 0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (t/ha)</td>
<td>2.91</td>
<td>3.06</td>
<td>ns</td>
</tr>
<tr>
<td>Harvest index</td>
<td>33%</td>
<td>32%</td>
<td>ns</td>
</tr>
<tr>
<td>Plants/m²</td>
<td>104</td>
<td>131</td>
<td>11</td>
</tr>
<tr>
<td>Tillers/m²</td>
<td>541</td>
<td>557</td>
<td>ns</td>
</tr>
<tr>
<td>Ears/m²</td>
<td>352</td>
<td>508</td>
<td>54</td>
</tr>
<tr>
<td>Grains/ear</td>
<td>31</td>
<td>27</td>
<td>2</td>
</tr>
<tr>
<td>1000 Seed weight (g)</td>
<td>38</td>
<td>33</td>
<td>2</td>
</tr>
<tr>
<td>Grain protein (%)</td>
<td>11</td>
<td>11.5</td>
<td>ns</td>
</tr>
<tr>
<td>Screenings (%)</td>
<td>9</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Hectolitre weight</td>
<td>82</td>
<td>81</td>
<td>1</td>
</tr>
<tr>
<td>Grain moisture (%)</td>
<td>10.4</td>
<td>10.8</td>
<td>0.2</td>
</tr>
</tbody>
</table>
Table 2. Effects of nitrogen on grain yield, yield components and grain quality

<table>
<thead>
<tr>
<th>Rate of N (kg/ha)</th>
<th>LSD (P = 0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.06</td>
</tr>
<tr>
<td>30</td>
<td>3.06</td>
</tr>
<tr>
<td>30/30</td>
<td>3.06</td>
</tr>
<tr>
<td>30/30/30</td>
<td></td>
</tr>
<tr>
<td>45/45</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grain yield (t/ha)</th>
<th>3.06</th>
<th>3.06</th>
<th>3.06</th>
<th>2.89</th>
<th>2.88</th>
<th>ns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest index (%)</td>
<td>39</td>
<td>34</td>
<td>33</td>
<td>30</td>
<td>29</td>
<td>0.1</td>
</tr>
<tr>
<td>Plants/m²</td>
<td>121</td>
<td>142</td>
<td>131</td>
<td>155</td>
<td>175</td>
<td>ns</td>
</tr>
<tr>
<td>Tillers/m²</td>
<td>432</td>
<td>534</td>
<td>484</td>
<td>593</td>
<td>701</td>
<td>157</td>
</tr>
<tr>
<td>Ears/m²</td>
<td>354</td>
<td>436</td>
<td>438</td>
<td>481</td>
<td>440</td>
<td>ns</td>
</tr>
<tr>
<td>Plants/m²</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>29</td>
<td>29</td>
<td>ns</td>
</tr>
<tr>
<td>Tillers/m²</td>
<td>432</td>
<td>534</td>
<td>484</td>
<td>593</td>
<td>701</td>
<td>157</td>
</tr>
<tr>
<td>Ears/m²</td>
<td>354</td>
<td>436</td>
<td>438</td>
<td>481</td>
<td>440</td>
<td>ns</td>
</tr>
<tr>
<td>1000 seed weight (g)</td>
<td>38</td>
<td>37</td>
<td>35</td>
<td>34</td>
<td>33</td>
<td>3</td>
</tr>
<tr>
<td>Grain protein (%)</td>
<td>9</td>
<td>9.7</td>
<td>11.5</td>
<td>13</td>
<td>12.9</td>
<td>0.7</td>
</tr>
<tr>
<td>Screenings (%)</td>
<td>8</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>ns</td>
</tr>
<tr>
<td>Hectolitre weight</td>
<td>84</td>
<td>83</td>
<td>81</td>
<td>80</td>
<td>80</td>
<td>1</td>
</tr>
<tr>
<td>Grain moisture (%)</td>
<td>10.7</td>
<td>10.7</td>
<td>10.6</td>
<td>10.6</td>
<td>10.6</td>
<td>ns</td>
</tr>
</tbody>
</table>

Cultivar had no significant effect on grain protein. On average, Carnamah produced 11.5% protein and Tamaroi 11.0% protein. Rate of nitrogen had a significant effect on grain protein (P < 0.001). As nitrogen increased from 0 kg N/ha to 90 kg N/ha (the triple split) grain protein increased from 9% to 13%. Timing of nitrogen had no significant effect on grain protein.

Applying 60 kg N/ha on Carnamah, split between 30 kg N/ha at seeding and tillering, returned 11.6% protein and 3.22 t/ha, generating a gross margin of $650/ha. Applying 90 kg N/ha on Tamaroi split between 30 kg N/ha at seeding, tillering and booting, returned 12.5% protein and 3 t/ha, generating a gross margin of $722/ha.

CONCLUSION

Hard wheat (durum and bread) can be successfully grown in the western regions of the Western Australian wheatbelt, with substantial benefit to the grower. The optimum nitrogen strategy to achieve the Australian Hard grade was found by applying 30 kg N/ha at seeding and at tillering. The study failed to determine the optimum strategy to achieve the Durum 1 grade. Tamaroi achieved a maximum of 12.8% protein, by applying 45 kg N/ha at seeding and at tillering.

KEY WORDS

wheat, grain protein, Flexi-N, nitrogen

Paper reviewed by: Lionel Martin, Wal Anderson and Stephen Loss
Are liquid phosphorus fertilisers more efficient than solid fertilisers in Western Australia?

Stephen Loss, Lisa Leaver, Ryan Guthrie, Patrick Gethin and Tim O'Dea
CSBP Futurefarm

KEY MESSAGE
In five field trials conducted across Western Australia in 2001, liquid nitrogen and phosphorus (NP) fertilisers produced significantly better early plant growth and P uptake than solid fertilisers at three sites. At two contrasting sites (an acid soil high in iron and aluminium oxide, and an alkaline soil containing a small amount of calcium carbonate), liquid NP fertilisers produced 7 and 10% more yield than solids, such that 5 kg P/ha applied as a liquid was equally as effective as 10 kg P/ha as a solid. Further work is required to better quantify the benefits of liquid NP fertilisers and assess their economic advantages.

BACKGROUND AND AIM
Research on alkaline calcareous soils in low rainfall environments of the upper Eyre Peninsula in SA has shown considerable advantages with liquid phosphorus fertilisers compared to solid granular fertilisers. Two trials conducted in WA during 2000 by CSBP showed early wheat growth and P uptake benefits with liquid fertilisers. One trial showed a 5-10% yield advantage at low P rates. The aim of the 2001 trials was to compare liquid and solid NP fertilisers over a wider range of soils in WA.

METHODS
Five field experiments were conducted across the WA agricultural region in 2001 (Table 1). Only the Salmon Gums site had any significant calcium carbonate content (1.5%). The trials compared 4 rates of solid mono-ammonium phosphate (MAP; 5, 10, 20 and 40 kg P/ha) with 3 test liquid products (NP1, NP2 and NP3) applied at two rates (5 and 10 kg P/ha) and a nil treatment. Urea was topdressed immediately before seeding to basal out the N application to 35-100 kg/ha depending upon the site, and 40 kg/ha of Muriate of Potash was also topdressed at the Kalannie site. Liquid treatments were diluted with water and applied at 220 L/ha. The trials included 3 replicates and were a randomised block design. Plots were 2.1 m (11 rows) x 40 m long and were sown with Conserva Pak or Primary Sales Superseeder points on 22.5 cm row spacings. Solid and liquid products were banded about 4 cm below the seed.

Table 1. Experimental site and 0-10 cm soil characteristics

<table>
<thead>
<tr>
<th></th>
<th>Kalannie</th>
<th>Moora</th>
<th>Mukinbudin</th>
<th>Williams</th>
<th>Salmon Gums</th>
</tr>
</thead>
<tbody>
<tr>
<td>History</td>
<td>Poor pasture 99 and 00</td>
<td>Poor pasture 99, canola 00</td>
<td>Wheat 99 and 00</td>
<td>Oats 99, Canola 00</td>
<td>Wheat 99, Pasture 00</td>
</tr>
<tr>
<td>Soil type</td>
<td>brown sandy loam</td>
<td>brown loamy sand</td>
<td>brown loam</td>
<td>brown gravel sandy loam</td>
<td>dark brown clay loam</td>
</tr>
<tr>
<td>P mg/kg</td>
<td>27</td>
<td>42</td>
<td>14</td>
<td>19</td>
<td>13</td>
</tr>
<tr>
<td>N(Nit) mg/kg</td>
<td>15</td>
<td>14</td>
<td>18</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>N(Amm) mg/kg</td>
<td>3</td>
<td>13</td>
<td>6</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>K mg/kg</td>
<td>60</td>
<td>981</td>
<td>965</td>
<td>116</td>
<td>544</td>
</tr>
<tr>
<td>S mg/kg</td>
<td>7</td>
<td>13</td>
<td>7</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>OC %</td>
<td>0.79</td>
<td>2.58</td>
<td>1.08</td>
<td>2.60</td>
<td>1.01</td>
</tr>
<tr>
<td>Reactive Fe mg/kg</td>
<td>745</td>
<td>1170</td>
<td>235</td>
<td>535</td>
<td>408</td>
</tr>
<tr>
<td>pH 1:5 CaCl₂</td>
<td>5.3</td>
<td>5.7</td>
<td>7.5</td>
<td>4.9</td>
<td>8.0</td>
</tr>
<tr>
<td>Sowing time</td>
<td>16 May</td>
<td>24 May</td>
<td>17 May</td>
<td>28 May</td>
<td>29 May</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION
At Kalannie, there were no differences between the early plant growth and P uptake of the solid and liquid NP treatments (P > 0.1; data not presented). Grain yields increased from about 2.2 t/ha in the nil up to 3.1 t/ha at the highest rate of P addition (Figure 1; P < 0.05). Differences between the yields of the liquid and solid fertiliser treatments were not significant (P > 0.1).
Plant sampling five weeks after sowing at Moora showed significantly better growth and P uptake with the liquid NP fertilisers than the solid MAP, with up to a 47% improvement in P uptake at 10 kg P/ha (P < 0.05; data not presented). Grain yields increased from 2.9 t/ha in the nil up to 3.9 t/ha at 10 kg P/ha (Figure 2, P < 0.05). At 5 kg P/ha, the Liquid NP3 produced 7% more grain yield than solid MAP (P < 0.1). Differences between the solids and liquids were not significant at 10 kg P/ha (P > 0.1).

Dry seasonal conditions at Mukinbudin limited yield potential and grain yields increased from 1.1 t/ha at nil P to just under 1.6 t/ha at 40 kg P/ha (P < 0.05). As was the case with the early plant growth data, there was a suggestion of a small improvement in grain yields with the liquid NP products, however, these differences were not statistically significant (P > 0.1).

Plant sampling six weeks after sowing at Williams revealed the Liquid NP1 and 2 were more efficient at supplying P to plants than solid MAP (P < 0.05; data not presented). Grain yields increased significantly from 3.7 t/ha in the nil P up to 4.6 t/ha at 20 kg P/ha (P < 0.05) and grain yields with the Liquid NP products were effectively the same as the solid MAP (Figure 4, P > 0.1).

At Salmon Gums the Liquid NP 2 and 3 appeared superior to the solid MAP at 5 kg P/ha, in terms of plant growth and P uptake. However, excessive variations in the data meant these differences were not statistically significant (P > 0.1). Grain yields increased from 2.8 t/ha in the nil up to 3.6 t/ha at 20 kg P/ha (Figure 5; P < 0.05). The Liquid NP products produced up to 10% more grain yield than the solid MAP, especially Liquid NP2 at 5 kg P/ha, which was equivalent to the 10 kg P/ha solid MAP treatment.

**KEY WORDS**

liquid fertiliser, phosphorus, plant nutrition

---

**Fig. 1. Kalannie grain yield**

**Fig. 2. Moora grain yield**

**Fig. 3. Mukinbudin grain yield**

**Fig. 4. Williams grain yield**

**Fig. 5. Salmon Gums grain yield**
Oats respond to phosphorus and potassium
Glenn McDonald, Department of Agriculture

KEY MESSAGES
- Higher profit gains were obtained for both hay and grain when 20 kg/ha phosphorous was applied.
- Adding 100 kg/ha potash increased the hay yield and profit of Hotham at 20 kg/ha phosphorous (P) whilst adding 40 kg/ha potash increased the grain yield and profit of Dalyup at 20 kg/ha P.
- Grain quality was improved with the addition of at least 20 kg/ha P.

AIM
The aim of this work was to assess the phosphorous and potash requirements of oats in a marginally fertile location.

BACKGROUND AND METHODS
The oat trial was sown in a paddock of wheat east of Woodanilling, which had lupins in 2000. Soil tests indicated that phosphorous (P) and potash (K) content in the top 10 cm were 15 ppm and 50 ppm, respectively. P and K levels in the 20-30 cm soil samples were 12 ppm and 60 ppm, respectively. The reactive iron level was described as low. For a medium production level of wheat 15 kg/ha of P and 35 kg/ha of K was recommended. Basal levels of nitrogen and sulphur were applied at 44 kg/ha and 27 kg/ha as urea and gypsum. Approximately 11 kg/ha P and 25 kg/ha K were applied to the surrounding wheat crop, which yielded 2.5-3.0 t/ha and was accepted into the noodle grade.

RESULTS AND DISCUSSION
Grain yield
For every K rate tested there was a significant (10%) increase in yield when applied P was increased from 0-20 kg/ha (Figure 1). The only significant increase from the 20-50 kg/ha P rate was for the variety Dalyup at the nil K rate. The only significant yield response from increasing the K rate from 0-40 kg/ha was for the variety Dalyup at the 20 kg/ha P rate (Figure 1).

The costs of P and K fertilisers were assumed to be $2.20/kg and $0.92/kg, respectively, and a grain price of $180/t was used. Based on these figures, the fertiliser combinations that gave the greatest profit increase compared to the nil for each variety was 20 kg/ha P with 40 kg/ha K for Dalyup ($54.69/ha), and 20 kg/ha P with no K for Hotham ($42.76/ha; Table 1). When no P was applied profit was reduced by the application of K fertiliser. A relatively large improvement in profit was obtained when 50 kg/ha P with no K was applied for Dalyup ($40.66/ha).

Hay yield
The hay yields were calculated from 2 x 0.5 m² quadrats taken at the early milk stage within the plots. This method of sampling produces large errors. Therefore, significance levels for hay yields are expressed at the 20% level, which represents that the results are repeatable in four out of five occasions. For the variety Dalyup, hay yield was significantly increased at every K rate when applied P was increased from 0-20 kg/ha of P (Figure 2). With the application of further P to 50 kg/ha for the same K rates, hay yield was not increased. Increasing P for the variety Hotham gave no significant responses except at the highest K rate when P was increased from 0-20 kg/ha. No clear trend was observed when increasing rates of K were applied at any of the P rates. The average hay yield across all P x variety treatments increased by 0.7 t/ha when K rates increased from 0-40 kg/ha. However, the hay yield was significantly higher only for Dalyup at nil P.

The following profit figures use the same fertiliser prices as above and a hay price of $150/t. All fertiliser application combinations resulted in an increase in profit over the nil for each variety except 0 kg/ha P plus 100 kg/ha K (-$76.67/ha) and 50 kg/ha P plus no K (-$44.00/ha) for Hotham (Table 1). For Dalyup the highest profit was achieved when 20 kg/ha P and no K was applied ($306.50/ha). For Hotham the highest profit was when 20 kg/ha P and 100 kg/ha K were applied ($201.83/ha). Generally, the profit of Hotham was more responsive to additional K than the profit of Dalyup.
Table 1. Added profit of grain and hay with the application of phosphorous and potash

<table>
<thead>
<tr>
<th>Phosphorous (kg/ha)</th>
<th>Potash (kg/ha)</th>
<th>Dalyup</th>
<th>Hotham</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>$0.00</td>
<td>$0.00</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>$26.20</td>
<td>$54.69</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
<td>$40.66</td>
<td>$144.83</td>
</tr>
<tr>
<td>20</td>
<td>40</td>
<td>$54.69</td>
<td>$144.83</td>
</tr>
<tr>
<td>50</td>
<td>40</td>
<td>$77.99</td>
<td>$213.83</td>
</tr>
<tr>
<td>20</td>
<td>100</td>
<td>$42.76</td>
<td>$29.31</td>
</tr>
<tr>
<td>50</td>
<td>100</td>
<td>$72.87</td>
<td>$124.63</td>
</tr>
</tbody>
</table>

Grain quality

Hectolitre weight: The addition of more than 20 kg/ha P at any K rate for both varieties resulted in a significant (5%) increase in hectolitre weight (Table 2). The average increase for these treatments was 1.74 kg/hL. Also the addition of 100 kg/ha K gave a significant (10%) increase when no P was applied for Dalyup.

Seed weight and screenings: The application of 20 kg/ha P to Hotham resulted in a significant (5%) increase in average seed weight over the nil treatment irrespective of the K rate (Table 2). The application of 50 kg/ha P with 100 kg/ha K for Dalyup and 50 kg/ha P with 40 kg/ha K for Hotham resulted in significant (10%) increases over the nil treatment. The application of either P or K at any rate tested on Dalyup resulted in significantly (10%) less screenings through a 2.0 mm screen than the nil (Table 2). The screenings level of Hotham wasn’t significantly affected by the fertiliser treatments.

Table 2. Change in hectolitre weight, seed weight and screenings compared to nil treatment

<table>
<thead>
<tr>
<th>Hectolitre LSD 5%</th>
<th>1.02</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed weight LSD 10%</td>
<td>2.30</td>
</tr>
<tr>
<td>Screenings LSD 10%</td>
<td>1.18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phosphorous (kg/ha)</th>
<th>Potash (kg/ha)</th>
<th>Dalyup</th>
<th>Hotham</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>1.92</td>
<td>1.58</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
<td>1.70</td>
<td>2.10</td>
</tr>
<tr>
<td>20</td>
<td>40</td>
<td>1.96</td>
<td>1.68</td>
</tr>
<tr>
<td>50</td>
<td>40</td>
<td>1.65</td>
<td>1.65</td>
</tr>
<tr>
<td>20</td>
<td>100</td>
<td>1.97</td>
<td>2.07</td>
</tr>
<tr>
<td>50</td>
<td>100</td>
<td>1.42</td>
<td>1.42</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>-0.46</td>
<td>0.00</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
<td>-0.20</td>
<td>1.14</td>
</tr>
<tr>
<td>20</td>
<td>2.02</td>
<td>1.60</td>
<td>2.96</td>
</tr>
<tr>
<td>50</td>
<td>1.74</td>
<td>2.55</td>
<td>2.48</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>-1.39</td>
<td>-0.47</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
<td>-1.83</td>
<td>-0.22</td>
</tr>
<tr>
<td>20</td>
<td>-2.84</td>
<td>-3.65</td>
<td>-0.96</td>
</tr>
<tr>
<td>50</td>
<td>-1.68</td>
<td>-3.50</td>
<td>-0.58</td>
</tr>
<tr>
<td>20</td>
<td>-2.17</td>
<td>-3.50</td>
<td>-0.62</td>
</tr>
<tr>
<td>50</td>
<td>-1.68</td>
<td>-3.50</td>
<td>-0.56</td>
</tr>
</tbody>
</table>

OUTCOMES

- Both varieties needed 20 kg/ha P to reach the highest profit returns for grain. At this rate, higher yields were obtained with up to 100 kg/ha K, especially with Dalyup, but it wasn’t economical to apply more than 40 kg/ha K.
- Both varieties needed 20 kg/ha P to reach the highest profit for hay. However, the profit at this P rate decreased with increasing K for Dalyup, whilst the profit at the same P rate increased with increasing K for Hotham.
- Grain quality was improved with the addition of at least 20 kg/ha P.

KEY WORDS

oat, hay, phosphorous, potash

GRDC Project No.: DAW 705
Paper reviewed by: Stephen Loss, CSBP Ltd

There is an extended version of this paper on the Crop Update 2002 CD.
Cereal disease diagnostics and rust monitoring
Nichole Burges and Dominie Wright, Department of Agriculture

KEY MESSAGES
- A cereal rust identification service was offered again to growers in the 2001-growing season as part of the Grainguard™ initiative. Wheat leaf rust was detected in 38% of samples, and wheat stem rust in 28% of samples submitted for rust identification. Stripe rust was not detected and still remains absent in Western Australia.
- An important development was the detection of a new strain of stem rust with virulence for the resistance gene Sr38, present in Camm and some other varieties. As a result, Camm should be regarded as susceptible to stem rust in WA. Camm may be less susceptible than Westonia or Yltpi.
- The major leaf diseases identified in wheat samples submitted were septoria nodorum blotch and yellow spot.
- The major leaf diseases and disorders identified in barley samples were spot-type net blotch, powdery mildew and physiological spotting.
- The major leaf diseases identified in oat samples for the 2001-growing season were septoria avenae blotch and stripe blight.
- Leaf spot disease threats for 2002 may be reduced following two seasons of comparatively low disease.
- Significant cereal rust disease threats exist for 2002 due to the wet harvest and subsequent summer storm activity in January. Autumn rains will determine eventual risk.
- The diagnostic service is a valuable tool for sustaining productive crop industries in Western Australia. The service helps growers to respond appropriately to significant disease constraints.

SAMPLES RECEIVED
Another late start to the season and dry, warm conditions resulted in low seasonal disease impacts and lower than normal demand for broadacre diagnostic services. A total of 213 samples were received by the service this year. The number of samples has remained low over the past two years due to the late starts to cropping and dry conditions in both 2000 and 2001 growing seasons.

The majority of the samples received were for cereal leaf disease testing and clients used the diagnostic service to assist with decision making in regards to fungicide application.

CEREAL RUSTS - NEW STEM RUST STRAIN DETECTED ON CAMM
Rust in cereal crops remained low. A small number of samples, 32, were received for submission to the National Cereal Rust Program at the University of Sydney in NSW. This compared to 366 rust samples in 2000 (mostly leaf rust). In November 2001 stem rust was observed in late maturing plantings of Camm at Grass Patch and Gibson in the Esperance region. Results of analysis from virulence tests conducted by the University of Sydney have shown that a new strain of stem rust (designated 34-2,7+VPM) with virulence for the resistance gene Sr38 was present on Camm. As a result, Camm should be regarded as susceptible to stem rust in WA. Camm may be less susceptible than Westonia or Yltpi. The resistance of Camm to leaf and stripe rusts has not been affected by this change. The new strain caused no economic damage in 2001 but will represent a significant threat to Camm if it builds up in Camm crops in 2002.

CEREAL LEAF SPOT DISEASES - LOW IMPACT
Most diseases diagnosed this season in cereal samples were leaf diseases. Most were submitted from crops in the Central, South West and North East and Central regions, being part of the newly defined Agzones 2, 3 and 4. The diseases with the highest incidence were septoria nodorum blotch and yellow spot in wheat. Other diseases commonly found were septoria avenae in oats, and spot...
type net blotch and powdery mildew in barley. Overall, the impact of leaf diseases in 2001 was low, resulting from low seasonal rainfall. Two years of low winter and spring rainfall have caused a general reduction in the impact of leaf spot diseases such as yellow spot and the septoria diseases.

*Bacterial stripe blight (Pseudomonas syringae pv. striafaciens)*

Due to the warmer, humid conditions in spring this season the incidence of bacterial disease increased compared to previous seasons. A number of oat samples were received, showing symptoms of elongated spots with water-soaked margins, and brown streaks on the leaves. The soil borne bacterial pathogen that causes stripe blight was determined to be the cause of disease in these crops. These crops were from the high rainfall regions of Agzones 2 and 3. This has implications for intensive oaten hay production in regards to export quality. Crop rotation is the main means of managing this disease.

**CEREAL ROOT DISEASE**

A range of root diseases in cereal samples were diagnosed this year, with fungal and nematode related problems occurring in equal proportions. The main root disease problems diagnosed this season were due to root lesion nematodes in wheat and rhizoctonia bare patch across all cereal crops. A number of samples with Fusarium crown rot were received later in the season but crown rot samples were less than in previous years.

**CONCLUSION**

Diagnostic services provide important advice to sustain crop production in Western Australia. Diagnoses aid within season disease management tactics. Collated knowledge of disease occurrence and impact assists with between season disease management strategies.

Dry seasons in 2000 and 2001 will result in lower than average inoculum carry over for leaf spot diseases such as yellow spot and septoria diseases. This may result in lower than normal impact from leaf spot diseases in 2002. However seasonal impacts are strongly influenced by rainfall conditions within the growing season and above average rainfall in spring could reverse this likely outcome.

The late but widely distributed occurrence of leaf and stem rusts, combined with the wet harvest and subsequent summer storm activity in January, raise the potential for significant rust carryover if autumn rains precede the normal break of season. This could result in an above average rust disease risk for 2002. The occurrence of Camm-attacking stem rust will need to be factored into rust management decisions for 2002 and beyond.

**GRDC Project No.:** DAW 590

**Paper reviewed by:** Dr Robert Loughman
Distribution and incidence of aphids and barley yellow dwarf virus in over-summering grasses in the Western Australian wheatbelt

Jenny Hawkes and Roger Jones
Centre for Legumes in Mediterranean Agriculture and Department of Agriculture

KEY MESSAGES

- Large-scale surveys in 2000 and 2001 in the Western Australian wheatbelt found widespread infection with barley yellow dwarf virus (BYDV) in over-summering perennial and annual grasses.
- BYDV infection was spread throughout different rainfall zones but its incidence was higher than expected in low to medium rainfall areas. When sites were categorised according to actual rainfall data (November to April 1999/2000 and 2000/2001) rather than by rainfall zone, virus incidence corresponded with amount of rainfall.
- The magnitude and proximity to crops of BYDV infected grasses are key factors in predicting the likelihood of yield losses from BYDV in cereal crops in specific regions.

BACKGROUND

Barley yellow dwarf virus poses major limitations on grain yields in wheat, barley and oats in high rainfall agricultural zones of Western Australia (WA). It is spread in cereals by aphids, in particular the oat aphid (Rhopalosiphum padi) and in barley also by the maize aphid (R. maidis). The virus is not seed-borne as some viruses are, so must survive over summer in green plant material. In the WA wheatbelt perennial grasses surviving the summer in road-side ditches, irrigated gardens, soaks and at the edge of creeks, act as the main reservoirs of infection from which BYDV epidemics start at the beginning of the growing season. We know that the amount of pre-growing season rainfall plays an important role in determining how early aphids arrive in a crop. High pre-season rainfall leads to growth of grasses, which in turn leads to aphid build up and early flights to crops. However, early arrival and high aphid numbers do not necessarily lead to epidemic levels of BYDV as the proportion of incoming aphids carrying virus is dependent upon the amount of infected grass material available for them to feed on before flying into crops. Information was therefore sought on the magnitude of BYDV-infected grass reservoirs throughout the wheatbelt over summer.

METHODS

Between late January and early April 2000 and 2001, large-scale surveys were done to ascertain the magnitude of BYDV reservoirs and extent of aphid survival in the wheatbelt over summer. Seven trips each year encompassed sites from Geraldton to Esperance and each trip included sites in all rainfall zones. Where possible, 100 shoots of each grass weed species found were collected at every site (stopping approximately every 30 km). The majority of samples (1 sample/species = at least 50 individual shoots) were collected from roadside verges adjoining cultivated fields.

The samples were stored in eskies and transported to the Department of Agriculture’s Plant Virology laboratory at South Perth for virus testing. Likely perennial host grass species were tested for all four serotypes of BYDV. These were Couch (Cynodon dactylon), Paspalum (Paspalum dilatatum), Kikuyu (Pennisetum clandestinum), African Lovegrass (Eragrostis curvula), and Veldt grass (Erharta calycina). Samples of all other species were tested for PAV/MAV serotypes only. The presence of BYDV in grass species was detected using Tissue Blot Immunoassay (TBlIA). The presence of aphids was assessed in situ on 25 plants of each species at each site (10 cm growing tip of one tiller or shoot/plant). If no aphids were found, a single plant was removed from the ground (roots and all) and placed in a bag for further assessment for presence of any aphids in the laboratory.

RESULTS

BYDV incidence

In 2000, a total of 275 annual and perennial grass samples were collected from 190 sites in different rainfall and geographical zones. Of these, 30%, 48% and 21% of samples were collected from high, medium and low rainfall zones respectively. A total of 32% of all sites and 24% of all samples were infected with BYDV, with surprisingly little variation in extent of infection between rainfall zones; 27%
of high rainfall, 22% of medium rainfall and 26% of low rainfall zone samples were BYDV-infected. When sites were categorised according to actual rainfall data (November to April 1999/2000) rather than by rainfall zone, 60% of samples from the > 400 mm, 42% from 300-400 mm, 18% from 200-300 mm and 22% from 100-200 mm areas, were BYDV-infected.

In 2001, a total of 247 annual and perennial grass samples were collected from 176 sites at similar locations to those selected in 2000. Of these, 26%, 51% and 22% of samples were collected from the high, medium and low rainfall zones respectively. A total of 10% of sites and 15% of samples were infected with BYDV, and as in 2000 there was surprisingly little variation in extent of infection between rainfall zones; 15% of high rainfall, 14% of medium rainfall and 14% of low rainfall zone samples were BYDV-infected. When sites were categorised according to actual rainfall data (November to April 2000/2001) rather than by rainfall zone, 15% of samples from the 100-200 mm, 11% from the 50-100 mm, 14% from 25-50 mm and 9% from 10-25 mm areas, were BYDV-infected.

In both years, grass species with the highest levels of infection were the perennial species Couch grass, African Lovegrass and Kikuyu and two annual windmill grasses, Chloris virgata and C. truncata. These species were found throughout the grainbelt.

**Aphid survival**

In 2000, a total of 22% of sites were found to be supporting aphid populations, including some colonies that were very densely populated. The majority of aphids were found on annual, rather than perennial, grass species and 50% of the total number of sites found with aphids were in areas that had received between 200 mm and 300 mm rainfall from November to April 1999/2000.

In 2001, only 4% of sites were found to be supporting aphid populations, but as in 2000, the majority of these were on annual grass species. Most of the sites found with aphids were in areas that had received between 25 mm and 50 mm rainfall from November to April 2000/2001.

The predominant species of aphid in both years was identified as Hysteroneura setariae. This species is not recorded as a vector of BYDV but experiments are being done to determine its virus transmission efficiency with four different strains of this virus. *H. setariae* may possibly play a role in infecting new grass plants over summer even if it is not a significant virus disease vector in cereal crops within the growing season. Few of the primary BYDV vector cereal aphids, *Rhopalosiphum padi* or *R. maidis*, were found on over-summering grass species in either year.

**CONCLUSION**

The over-summering surveys in 2000 and 2001 have provided vital information on the distribution and incidence of aphids and BYDV on grasses in the WA wheatbelt. Larger than expected virus reservoirs were found throughout all rainfall zones of the wheatbelt. When virus test results were categorised according to actual rainfall (November to April 1999/2000 and 2000/2001) amount of rainfall corresponded better than rainfall zone with actual virus incidence.

Aphids were found at 22% of sites in 2000 but only 4% of sites in 2001. The majority of sites supporting aphid populations were annual species. It is thought that these grasses are less important than perennial grass species in acting as virus sources for spread directly into crops during the growing season, as most of them would not survive to the beginning of the next growing season. However, annual grasses are important in maintaining aphid populations and virus reservoirs during the summer, and can act as a source for virus spread to healthy perennial grass plants.

The information gained from the 2000 and 2001 over-summering surveys has been used in refining the BYDV forecasting model and decision support system for insecticide use: www.agric.wa.gov.au/bydv (UWA 234 and DAW 609).

**ACKNOWLEDGMENTS**

This work was supported by growers through the Grains Research and Development Corporation. We thank Lisa Smith, Brenda Coutts, Christine Woods, Belinda Cox and other Plant Virology staff for technical assistance and Debbie Thackray for assistance in analysing survey results.

**GRDC Project No.:** UWA 313

**Paper reviewed by:** Roger Jones and Debbie Thackray
Spring sprays for powdery mildew control in cereals

Kith Jayasena¹, Kazue Tanaka¹, Vanessa Johnson¹, Robert Loughman¹ and Josh Jury²
¹Department of Agriculture, ²Wesfarmers Landmark

KEY MESSAGES

- Powdery mildew reduced the yield of wheat and barley by up to 17% and 13%, respectively.
- Fungicides can control powdery mildew in wheat and barley and a single application of a fungicide based on 125 g triadimefon a.i./ha at the onset of the disease was the most profitable management option.

BACKGROUND AND AIMS

The powdery mildew fungi, *Blumeria* (*Erysiphe*) *graminis* f. sp. *tritici* and *B. graminis* f. sp. *hordei*, are diseases of wheat and barley, respectively. The occurrence of the two diseases has become more frequent and widespread in recent years. This may be due to the continuous growing of wheat and barley varieties and a change in weather patterns to ones that may be conducive to the development of the pathogen. High humidity with temperatures between 15 and 22°C favours the development of powdery mildew. The pathogen causing wheat powdery mildew never infects barley and vice versa.

As many of the wheat and barley varieties that are growing currently in Western Australia are rated as either susceptible or moderately susceptible to powdery mildew, their management using fungicides is a viable option to consider.

Powdery mildew in wheat and barley is poorly understood in Western Australia. The aim of this study was to determine the effect of powdery mildew on the grain yield of wheat and barley and to evaluate the management of these diseases using foliar fungicide sprays.

RESULTS

Several fungicides were screened against powdery mildew on barley in 2000 and 2001 and on wheat during 1999 and 2001.

Barley

In 2000 and 2001 the first noticeable powdery mildew was observed at flag leaf sheath opening (Z47) and first awns visible (Z49) growth stages respectively. The level of disease varied from severe to moderate over the two years (Table 1). In both years, a single application of fungicide was sprayed at Z49. The fungicides tested provided significant control of barley powdery mildew and increased the yield in two high yielding experiments (Table 1). The profit gained from controlling the disease varied from $8 to $82/ha in both years depending on the type of fungicide used.

Wheat

A single application of fungicide was sprayed on wheat at flag leaf sheath extending (Z41) in 1999 and ear emergence (Z59) in 2001 respectively. All fungicides tested controlled the disease and increased the yield (Table 2) although severe frost at the grain-filling stage reduced the potential yield in 1999. The profit gained from application of fungicides varied from $36 to $48/ha in 2001.

A trial conducted at Munglinup in 2001 by IAMA found that a single application of Triad 125EC (1000 mL/ha) Tilt 250EC (250 mL/ha) or Folicur 430EC (145 mL/ha) applied at Z49 gave significant yield increases of 7%, 10% and 8% respectively. Profit ranged from $15 to $26/ha. A two spray strategy (one spray at Z31 and a second at Z49) gave yield increases of 6-20% with a profit range from $2 to $74/ha depending on the type of fungicide used.
Table 1. Effect of late season fungicide spray on powdery mildew severity and yield of barley cv. Stirling during 2000 and 2001 at Gibson (Department of Agriculture)

<table>
<thead>
<tr>
<th>Fungicide</th>
<th>Rate (mL/ha)</th>
<th>2000</th>
<th>2001</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>% LAD* (Z83) ave (F to F-2)</td>
<td>Yield</td>
</tr>
<tr>
<td>Nil</td>
<td></td>
<td></td>
<td>t/ha</td>
</tr>
<tr>
<td>Triad 125EC</td>
<td>500</td>
<td>77</td>
<td>4.6</td>
</tr>
<tr>
<td>Triad 125EC</td>
<td>1000</td>
<td>59</td>
<td>4.5</td>
</tr>
<tr>
<td>Tilt 250EC</td>
<td>250</td>
<td>56</td>
<td>4.5</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>16</td>
<td>0.4</td>
<td></td>
</tr>
</tbody>
</table>

% LAD = Per cent leaf area disease; Assuming application cost $9/ha; price for feed grain $177/t; Triad $8.60/L; Tilt $55.00/L.

Table 2. Effect of different fungicides spray on powdery mildew severity and yield of wheat cv. Cunderdin in 1999 and cv. Cascades in 2001 (Department of Agriculture)

<table>
<thead>
<tr>
<th>Fungicide</th>
<th>Rate (mL/ha)</th>
<th>Dunn Rock 1999</th>
<th>Munglinup 2001</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Necrosis due to PM &amp; SNB (Z65)</td>
<td>Yield**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flag-1 leaf t/ha</td>
<td>% Nil</td>
</tr>
<tr>
<td>Nil</td>
<td></td>
<td>8</td>
<td>1.7</td>
</tr>
<tr>
<td>Triad 125EC</td>
<td>500</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Triad 125EC</td>
<td>1000</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td>Folicur 430EC</td>
<td>290</td>
<td>3</td>
<td>1.9</td>
</tr>
<tr>
<td>Tilt 250EC</td>
<td>250</td>
<td>63</td>
<td>3.2</td>
</tr>
<tr>
<td>Tilt 250EC</td>
<td>500</td>
<td>61</td>
<td>3.3</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LSD (10%)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

% LAD = per cent leaf area disease; PM = powdery mildew; SNB = Septoria nodorum blotch.  
** Frost damage.  Assuming application cost $9/ha; price for grain $165/t; Triad $8.60/L; Tilt $55.00/L.

CONCLUSION

The onset of disease in these experiments was generally in mid to later stages of crop development. In barley, early onset of mildew is routinely controlled with a seed dressing fungicide. Later disease onset was shown to cause yield loss in barley, ranging from 7-13% in well grown crops (where the disease is more likely to develop). A fungicide spray applied shortly after the onset of barley mildew was economic in these experiments.

Wheat mildew can also be controlled with the range of fungicides presently available and registered in Western Australia. A mildew-specific fungicide, used for experimental purposes, increased yields by 7-17%. This indicates the extent of yield loss due to mildew in wheat.

Triadimefon fungicide was effective and economical in controlling both diseases.

ACKNOWLEDGMENTS

The support of GRDC, property owners, and chemical manufacturers is acknowledged.

KEY WORDS

wheat, barley, powdery mildew, fungicides

GRDC Project No.: DAW 589

Paper reviewed by: Phil Michael
Impact of root lesion nematodes on wheat and triticale in Western Australia

Sean Kelly and Shashi Sharma, Department of Agriculture

KEY MESSAGES

- A population density at the time of seeding of one nematode per gram of soil can cause up to 29% reduction in the plant biomass during early stages of crop growth.
- Yield losses of 0-14% were observed in experiments in 2001.

AIM

Root Lesion Nematode (RLN) species are the most widespread nematode pests in the cereal growing areas of Western Australia. Studies in the State have recorded significant yield losses in barley (7-22%) and wheat (6-9%) at locations in the central and southern wheatbelt. This investigation aims to further assess the impact of RLN on wheat yields at other locations and using alternative methods.

METHOD

Experiments were established in paddocks at Doodlakine and Tammin to evaluate the performance of a susceptible wheat cultivar in *P. neglectus* infested soils. A nematicide (Temik 150G) was used to reduce the RLN population in half of the 64 1.44 m x 20 m plots sown with wheat cv. Brookton. At twelve weeks after sowing the plots were sampled to determine populations of RLN within the roots of the plants. RLN populations (log transformed) and wheat yields in the nematicide-treated and check plots were compared using analysis of variance.

Four sites were established to serve as an alternative to the use of nematicides as an experimental tool for the control of nematodes. At these sites RLN resistant triticale cv. Tahara and susceptible wheat cvs Cunderdin (2000) or Brookton (2001) were sown into paired plots to induce differential RLN population for subsequent experiments in the following year.

To ascertain the effect of RLN population density on the plant biomass of a susceptible wheat cultivar 40 pots were filled with 1600 g of pasteurised soil and sown with wheat cv. Cunderdin. The pots were inoculated with *P. thornei* at 0.5, 1, 2.5 or 5 RLN/g of soil and placed in a glasshouse (15-25ºC). Ten weeks after sowing the plants were collected, the nematodes extracted from the roots, and the plants dried and weighed. The plant biomass in the nematode infested soil was compared with the plant biomass in pots without any nematodes. RLN populations (log transformed) and plant weights were compared between initial levels of RLN inoculation using analysis of variance.

RESULTS

Under glasshouse conditions soil RLN populations of 0.5-5/g soil induced root populations of 3,000-40,000/g DW (Table 1). Soil populations of 1 RLN/g soil or more significantly reduced plant weight at ten weeks after seeding.

In the field, RLN populations were lower in 2001 than in 2000. In nematicide yield loss experiments, Temik partially controlled nematode populations. At the Tammin site, higher nematode populations were associated with a 14% yield loss of wheat cv. Brookton (Table 2). No significant yield loss was observed at the other location.

Significant differences in root nematode populations were observed between triticale and wheat when grown at Tammin and Dongara (Table 3). Two remaining sites had lower than expected nematode populations associated with seasonal conditions. Wheat was sown in 2001 to assay the effects of previous cropping history on RLN populations. Despite substantial root population effects at Tammin in 2000, treatment effects in 2001 were small. Wheat following triticale had significantly lower root populations than wheat following wheat however low RLN populations overall (associated with seasonal conditions) resulted in no significant previous crop effects on 2001 wheat yield.
Table 1. Effect of *P. thornei* soil populations on root infection and weight of 10 week old wheat plants (cv. Cunderdin) grown in field soil in a glasshouse

<table>
<thead>
<tr>
<th>Initial <em>P. thornei</em> concentration (RLN/g soil)</th>
<th>Nematode population in roots at 10 weeks (RLN/g root DW)</th>
<th>Plant weight at 10 weeks (g DW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.22&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.5</td>
<td>3,000&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.20&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>1.0</td>
<td>8,000&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.87&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>2.5</td>
<td>7,000&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.00&lt;sup&gt;xy&lt;/sup&gt;</td>
</tr>
<tr>
<td>5.0</td>
<td>40,000&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.92&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>abc</sup> Significant at P < 0.001; <sup>xy</sup> Significant at P = 0.01.

Table 2. Yield of wheat cv. Brookton in soils naturally infested with *P. neglectus* with and without Temik 150G (nematicide)

<table>
<thead>
<tr>
<th>Location</th>
<th>RLN/g root</th>
<th>Yield (t/ha)</th>
<th>Yield loss %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nil Nematicide</td>
<td>Plus Nematicide</td>
<td>Nil Nematicide</td>
</tr>
<tr>
<td>Doodlakine</td>
<td>7,800</td>
<td>2,100***</td>
<td>1.29</td>
</tr>
<tr>
<td>Tammin</td>
<td>5,600</td>
<td>2,700*</td>
<td>1.23</td>
</tr>
</tbody>
</table>

* Significant at P < 0.10, ** Significant at P = 0.05, *** Significant at P < 0.01.

Table 3. The populations of RLN in the roots of triticale cv. Tahara and wheat (cv. Cunderdin at Tammin and cv. Brookton at Dongara, Katanning and Newdegate) 10 weeks after sowing

<table>
<thead>
<tr>
<th>Location</th>
<th><em>Pratylenchus</em> species</th>
<th>Triticale RLN/g root DW</th>
<th>Wheat RLN/g root DW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tammin (2000)</td>
<td><em>P. neglectus</em></td>
<td>4,100</td>
<td>132,000***</td>
</tr>
<tr>
<td>Dongara (2001)</td>
<td><em>P. thornei</em> and <em>P. neglectus</em></td>
<td>450</td>
<td>1,400***</td>
</tr>
<tr>
<td>Katanning (2001)</td>
<td><em>P. teres</em></td>
<td>440</td>
<td>660</td>
</tr>
<tr>
<td>Newdegate (2001)</td>
<td><em>P. neglectus</em></td>
<td>14</td>
<td>17</td>
</tr>
</tbody>
</table>

*** Significant at P = 0.05.

CONCLUSION

Planting time population density of one nematode per gram of soil can cause up to 29% reduction in the plant biomass during early stages of crop growth. Early plant growth is an important determinant of yield in Western Australia’s water limited environment. Yield loss due to nematode infection ranged from 0-16% in experiments undertaken in 2001.

The resistance of triticale to RLN was supported in local field trials. Wheat following triticale had significantly lower root populations than wheat following wheat. It may be possible to use this resistance as an experimental tool to induce soil population differences that help assess the impact of RLN on yield of other crops.

GRDC Project No.: DAW 623

Paper reviewed by: Dr Robert Loughman
Cropping options for the management of root lesion nematodes in Western Australia

Sean Kelly, Shashi Sharma and Robert Loughman, Department of Agriculture

KEY MESSAGES

• Infestations of root lesion nematode (Pratylenchus neglectus) studied over three years of different crop sequences, were least on faba bean cv. Fiord and field pea cv. Dundale.
• These represent suitable crop options to aid in the rotational management of P. neglectus.

AIM

P. neglectus is widespread in cereal growing regions and is the most common root lesion nematode (RLN) in Western Australia. Studies have shown that even low population densities can have adverse effects on plant growth and yield.

A three year experiment in a paddock naturally infested with P. neglectus was initiated in 1999 to identify cropping options for the management of this nematode. The objective of this paper is to give an update on some results of this work.

METHOD

In 1999, trial plots (4 m x 40 m) at Doodlakine were sown with different crops (Figure 1). In 2000, these plots were sown with wheat cv. Cunderdin, susceptible to P. neglectus. In 2001, each plot was sown with the same crop as had been planted in 1999.

Nematode numbers in the soil before planting and in the roots at 10 weeks after sowing were assessed for each year of the trial. Wheat cv. Machete is highly susceptible to P. neglectus and was used as a check for comparison. Nematode population densities from plant roots (log transformed) were compared using analysis of variance.

RESULTS AND CONCLUSIONS

The crop species differed in their RLN hosting ability. Root infestations of P. neglectus were least in faba bean and pea and highest in cereals in the establishment year, 1999 (Figure 1a).

The extent of infestation of P. neglectus in wheat planted in 2000 varied depending on the previous crop. Double cropped wheat had significantly higher root infestations than some other treatments. Wheat sown after faba bean had least infestation (Figure 1b).

When resown with the different crops in 2001, infestations of P. neglectus were least in faba bean cv. Fiord and field pea cv. Dundale and greatest in chickpea cv. Heera, oat cv. Dalyup and canola cv. Karoo.

Infestations in 2001 were lower than previous years. Reduced infestations may have resulted from unfavourable seasonal conditions or may indicate that other unknown factors are influencing nematode plant interactions.
Figure 1. *P. neglectus* root infestations 10 weeks after sowing at Doodlakine, a) plots sown with different crop species in 1999, b) plots sown with wheat cv. Cunderdin in 2000, c) plots sown in 2001 with crop species used in 1999.

GRDC Project No.: DAW 623

Paper reviewed by: Roslyn Jettner
Cereal rust update 2002 - new stem rust on Camm wheat

Robert Loughman¹ and Robert Park²
¹Department of Agriculture, ²University of Sydney

KEY MESSAGES

- The stem rust resistance gene Sr38, which is part of the VPM rust gene complex present in the variety Camm, has been overcome in Western Australia by a mutational change in a stem rust strain designated as 34-2,7+VPM.
- Results of analysis from virulence tests conducted by the University of Sydney have shown that the new strain of stem rust occurred twice on Camm sampled at the end of last season (2001).
- Camm should be regarded as susceptible to stem rust in Western Australia. Camm may be less susceptible than Westonia or Yitpi.
- The new strain caused no economic damage in 2001 but could represent a significant threat to Camm if it builds up in Camm crops in 2002 or beyond.
- The resistance of Camm to leaf and stripe rusts has not been affected by this change.
- Summer hygiene, particularly in paddocks of Camm and Westonia, will be critical to minimise the carryover of this new strain.
- Westonia should be immediately phased out of production in traditional stem rust prone environments of the south east (Esperance region) and north west (Geraldton region) because of its ability to promote some strains of stem rust, including 34-2,7+VPM.
- Camm crops should be monitored for stem rust in 2002 and samples submitted to AGWEST Plant Laboratories (08 9368 3721).
- The National Cereal Rust Control Program at the University of Sydney conducts annual rust surveys which are vital to the ongoing management of rusts in Australia. The survey is coordinated in Western Australia by AGWEST Plant Laboratories Diagnostic Service.

RUST OCCURRENCE IN WA IN 2001

Wheat leaf rust - Puccinia triticina

Leaf rust levels were very low. Samples were submitted from the north central, central and south eastern wheatbelt. No change in the leaf rust strains was observed in 2001. Samples submitted from Camm in the Esperance area represent the normal leaf rust strain in Western Australia. Some occasionally higher than normal development of leaf rust on Camm appears to be due to variation in expression of the adult plant resistance for leaf rust in this variety.

Wheat stem rust - Puccinia graminis f.sp. tritici

A Westonia crop west of Esperance became infected with stem rust in August and required fungicide spray treatment. Slight amounts of late stem rust were observed in the Geraldton region and the Esperance region. All samples were identified as being the older Gabo strain of stem rust or its derivatives. These strains currently dominate the stem rust flora of Western Australia. Stem rust with added virulence for Camm was detected in two separate locations, Grass Patch and Gibson.

Barley leaf rust - Puccinia hordei

This rust has become more evident in Western Australia since the development of a Franklin virulent strain in 1997. On rare occasions it has required fungicide to control infections on early sown Gairdner barley on the South Coast. A new strain of barley leaf rust was detected in Western Australia in 2001. This strain (pt. 5435P-) is distinct from other Australian strains of Puccinia hordei. It was detected in northern and southern areas. Preliminary field data indicates that the advanced barley line WABAR2110 is highly susceptible to this new strain. Further testing of material in the breeding program with this strain is required to better understand the implications of its development.
RECENT RUST DEVELOPMENTS IN EASTERN AUSTRALIA

Virulence for leaf rust resistance gene *Lr24*, present in varieties Harrismith, Datatine, Nyabing and Janz (and others) is now established throughout eastern Australia since its occurrence in South Australia in 2000. It has not been detected in Western Australia.

Virulence for stripe rust resistance gene *Yr17*, present in varieties Camm, Trident and Stylet (and others) is now established throughout eastern Australia since its occurrence in Victoria in 1999. No stripe rust has yet been detected in Western Australia.

OUTLOOK FOR 2002 AND VARIETY RESPONSES

**General outlook**

Levels of leaf and stem rusts in cereals in 2001 were the lowest observed for several years although late wet conditions did enable some late season activity. The lack of January rains in most areas has helped reduce carryover risk but rainfall in the February-March period will be the most important factor in determining risk going into 2002.

Despite the low impact of rusts in 2001, important changes to rust strains have been recognised following last season. These need to be taken into account in preparing for future rust outbreaks.

**Camm**

The newly virulent stem rust 34-2,7+VPM appears to induce a susceptible reaction on this variety. Initial results of tests at the University of Sydney indicate that Camm may have some residual resistance to the new strain. However the residual resistance will not be highly effective. As a result, Camm should be regarded as susceptible to stem rust in Western Australia until further information is available. Camm may be less susceptible than Westonia or Ytpi.

Reduced reliance for stem rust resistance must be placed on Camm in future. This is particularly so in the Esperance and adjacent areas. Plantings of Camm will need to be carefully monitored for stem rust in 2002 if the season favours rust development.

**Alternatives to Camm for stem rust resistance**

Varieties Wyalkatchem, Carnamah, H45 and Harrismith represent competitive wheats combining stem and leaf rust resistance across a range of wheat grades. Perenjori and Cascades are also resistant to stem rust but can develop leaf rust.

**Westonia**

Because Westonia is highly susceptible to the currently dominant Gabo forms of stem rust it should be immediately phased out of production in stem rust prone environments of the south east (Esperance region) and north west (Geraldton region). This variety has the ability to promote some strains of stem rust, including 34-2,7+VPM. It should not be grown in the Esperance region in 2002.

**Controlling volunteers over summer**

It will be critical to control cereal volunteers over summer, should they develop prior to planting. In particular, paddocks of Camm and Westonia in all areas and particularly in the Esperance region, should be grazed or sprayed out immediately volunteers start to develop.

**GRDC Project No.:** DAW 590, US 221, DAW 516

**Paper reviewed by:** Robin Wilson and Robyn McLean
Cereal aphids and direct feeding damage to cereals
Phil Michael, Department of Agriculture

KEY MESSAGES
- Cereal aphids can directly reduce yield and increase screenings in crops with potential 3 t/ha yields.
- Aphids are sporadic so populations should be monitored.
- Sprays should be applied at the threshold (15 aphids on 50% of tillers) to reduce feeding damage.
- Parasitic fungi can control populations but spraying may still be required.

BACKGROUND
In earlier work near the south coast of Western Australia, large yield losses were measured in dense cereal crops infested with aphids, and a spray threshold was suggested (Farmnote 56/94). Aphids are known to affect cereals directly through feeding and indirectly when they introduce and spread barley yellow dwarf virus (BYDV), but information on yield losses in Australia, due to direct aphid feeding alone, has been lacking. This project has enabled an examination of cereal aphid populations together with testing for BYDV levels so that the causes of yield loss are known with certainty.

METHODS
Crops with a potential yield of three t/ha and with high aphid numbers were sought throughout the cereal growing area from 1998 to 2001. Stirling barley was seeded in 1998 and commercial crops of Carnamah wheat and Gairdner barley were used in 1999 and 2001 respectively. Insecticides were applied twice by boomspray to maintain low aphid numbers in spray treatments, and aphid numbers were counted in the field. Aphids were collected and placed in individual containers on floating leaves for observations on fungal diseases. Stems were collected from the field for BYDV testing. Plot harvesters and hand cuts were used for yield and quality assessment determinations.

RESULTS AND DISCUSSION
Over the wheat growing area in the four years, threshold populations of cereal aphids (15 or more on at least half the tillers) were only occasionally exceeded for short periods, and very few aphids were found during the 2000 growing season. Abundance of cereal aphids (mostly oat aphid) and the period of aphid colonisation varied greatly in time and space as illustrated in the three experimental sites (Figure 1). At these sites, the aphid threshold was reached for a short period at Kendenup in 1998, was exceeded for three weeks at Northam in 1999, and was greatly exceeded for four weeks at Kendenup in 2001. BYDV was not detected or was detected at very low and non damaging levels at these sites.

Yield data in Table 1 shows that there were significant differences between sprayed and unsprayed treatments at two sites where the yield level was high and aphids were abundant, but not at the other site where the yield level was considerably lower and aphids were less abundant. Aphids present in mid-season at Northam significantly reduced the Harvest Index (proportion of grain to total biomass above ground), but did not significantly affect the percentage of screenings. At Kendenup in 2001, high numbers of aphids present toward the end of season significantly increased the screenings (above 20%), but did not affect the Harvest Index.

All of the observed cereal aphid populations declined rapidly while crops were growing and conditions appeared favourable for aphids. At times very early populations declined even before the main growing period. Crop damage would be more serious if populations persisted longer. Parasitic fungi appeared to be the cause of population decline at the 1998 and 2001 experimental sites under different aphid situations. In 1998 fungi controlled a moderate population in the unsprayed plots while numbers were increasing in plots sprayed at the three-leaf stage. In 2001, 29% of aphids on plants in early October were dead from fungal disease. Out of a collection of over 100 live aphids, 76% died of fungal infection, 14% were parasitised and only 10% were healthy. All colonies in southern areas
were affected, and it is unlikely that high numbers could persist under these epidemic conditions. The fungi (*Pandora neopahidis* and *Conidiobouls obscurus*) affected both the oat aphid and corn aphid.

**Figure 1.** Aphid numbers in unsprayed treatments of cereal crops at three sites.

**Table 1.** Cereal yields from three sites where aphids were either sprayed or left unsprayed

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>Sprayed</td>
<td>Unsprayed</td>
<td>Sprayed</td>
</tr>
<tr>
<td>Machine harvest (t/ha)</td>
<td>2.23</td>
<td>1.99</td>
<td>5.33</td>
</tr>
<tr>
<td>Not significant</td>
<td>P &lt; 0.05, LSD (5%) = 0.26</td>
<td>P &lt; 0.01, LSD (5%) = 0.248</td>
<td></td>
</tr>
<tr>
<td>Hand harvest (t/ha)</td>
<td>2.52</td>
<td>2.25</td>
<td>7.22</td>
</tr>
<tr>
<td>Not significant</td>
<td>P &lt; 0.01, LSD (5%) = 0.70</td>
<td>P &lt; 0.05, LSD (5%) = 0.401</td>
<td></td>
</tr>
<tr>
<td>Harvest index (%)</td>
<td>42.4</td>
<td>45.0</td>
<td>37.4</td>
</tr>
<tr>
<td>Not significant</td>
<td>P &lt; 0.01, LSD (5%) = 1.45</td>
<td>Not significant</td>
<td></td>
</tr>
<tr>
<td>Screenings (wt as %)</td>
<td>11.29</td>
<td>12.87</td>
<td>18.3</td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

Cereal aphids can at times directly cause yield reductions in high yielding crops, and increase screenings when in high numbers toward the end of the season. The cost of aphid control is small compared to possible gains under these circumstances and the usefulness of the spray threshold to reduce direct feeding damage to cereals is confirmed. Cereal aphids are not regularly abundant pests and should be monitored but not sprayed routinely. Parasitic fungi may control aphid populations, but this may occur after threshold numbers have been exceeded.

**ACKNOWLEDGMENTS**

The work was partly funded by GRDC. The help of Tony Dore, David Highman, Debbie Thackray, Jenny Hawkes and Plant Virology staff at Department of Agriculture, WA is gratefully acknowledged. David Holdom, Queensland Department of Primary Industry identified the aphid pathogens.

**KEY WORDS**

cereal aphid, feeding damage, threshold

**GRDC Project No.:** DAW 609

**Paper reviewed by:** Dr D. Thackray
A decision support system for control of aphids and BYDV in cereal crops

Debbie Thackray, Jenny Hawkes and Roger Jones
Department of Agriculture and Centre for Legumes in Mediterranean Agriculture

KEY MESSAGES

• Aphid outbreaks and BYDV epidemics are sporadic in cereal crops so insecticides should not be applied routinely to control BYDV spread or direct aphid feeding damage.

• A decision support system (DSS), developed for use by advisers and growers, forecasts the need for and timing of insecticide applications to control aphids spreading BYDV, thereby avoiding costly prophylactic use, and providing an environmentally responsible approach to control.

• The DSS successfully forecasted aphid arrival and build-up, and BYDV spread in cereal blocks in different locations within the high and medium rainfall zones of the Western Australian grainbelt.

• A general forecast for the growing season will be available from April 2002 through the Internet (http://www.agric.wa.gov.au/bydv), PestFax, TopLine, rural radio, etc. and updated regularly.

• Personalised forecasts of likely yield losses from BYDV and need for and optimal timings of insecticide applications, based on rainfall and temperature data for the user’s location and sowing details, will be obtainable using the Website.

• The Website also provides background information on BYDV and aphids, current management recommendations, photographs of aphids and virus symptoms, maps predicting different risk areas, and an explanation of the forecasting model and DSS.

BACKGROUND

Widespread barley yellow dwarf virus (BYDV) infection poses major limitations on grain yields in wheat, barley and oats, particularly in high rainfall agricultural zones of Western Australia, but its epidemics are sporadic. BYDV is spread in cereal crops by aphids, mostly the oat aphid (Rhopalosiphum padi) and also, in barley, by the maize aphid (R. maidis). Perennial grass weeds surviving the summer act as the main reservoirs of infection from which aphids carry BYDV into cereal crops. In high risk situations, two applications of registered systemic pyrethroid insecticides like alpha-cypermethrin applied during the critical first 12 weeks of growth after crop emergence effectively control BYDV with consequent substantial yield increases. However, need for and timing of the sprays cannot be judged by observing aphids in the crop since by the time they are seen readily, spread is well underway. This has led to a trend towards applying insecticides prophylactically every year, regardless of need. A forecasting/decision support system (DSS) will allow growers to anticipate BYDV epidemics and apply insecticides only when necessary, avoiding unnecessary costs and providing an environmentally responsible approach.

METHODS

In the grainbelt of south-west Australia, with its Mediterranean climate, the survival of aphids over the summer/early autumn period determines the likelihood of early aphid arrival and damaging virus epidemics in cereal crops. The abundance of over-summering green plant material is dependent on rainfall. The simulation model developed to forecast aphid outbreaks and epidemics of BYDV in cereal crops therefore uses rainfall during late summer and early autumn to calculate an index of aphid build-up on grasses and cereal volunteers in each locality before the winter growing season starts. The index is used to forecast the timing of aphid immigration into crops in different localities. A variable proportion of aphids is designated as carrying BYDV from external infection source plants into crops. The subsequent build-up and movement of aphids in the crop, BYDV spread, and yield losses are calculated. For each location, recommendations on whether or not spraying is warranted and optimal timings for one or two insecticide applications to control spread of BYDV by aphids are given.
RESULTS
The model was validated with four years’ detailed field validation data from four different grainbelt sites, representing a wide range of pre-growing season rainfall scenarios. It gave reliable predictions for aphid arrival in cereals for all sites and years. Predictions for BYDV spread in high and medium rainfall zones were also reliable but those for low rainfall zones proved too great (Figure 1). Predictions for peaks in aphid population numbers during the growing season were good in 1998-2000 but too low for one site in 2001. Predictions for yield loss due to BYDV compared favourably with historical field experiment results for different sites. The model was incorporated into the DSS for use in targeting insecticide sprays to control BYDV spread. The inputs required from the user are location, variety type, sowing date and plant density. Predictions for aphid arrival date, BYDV spread, potential yield losses, necessity for insecticide use and optimal insecticide spray dates are given. Maps illustrating the BYDV risk for different areas in the Western Australian grainbelt can be produced from the DSS outputs for different localities.

Figure 1. Actual incidence of BYDV (measured in laboratory tests) in cereal blocks compared with model predictions for BYDV incidence at Mount Barker over four years.

BYDV/APHID WEBSITE AND DECISION SUPPORT SYSTEM
A general forecast of BYDV risk based on DSS predictions for the coming growing season in the Western Australian grainbelt will be made available in late April each year through a BYDV/aphid Website (http://www.agric.wa.gov.au/bydv), PestFax, TopLine, rural radio, etc. Forecasts will be updated regularly throughout the growing season using the latest climate data. The website will provide growers and advisers with access to the general forecast, using maps to illustrate BYDV risk in different areas, and will offer personalised predictions of likely yield losses from BYDV and need for and optimal timing of insecticide applications. These predictions will be based on climate data for the user's location and seeding details (variety type, sowing date and plant density). The Website also provides background information on BYDV and cereal aphids, photographs of cereal aphids and BYDV symptoms, management recommendations for BYDV and aphid control and an explanation of the basis for the forecasting model and DSS. Further refinement of the DSS aims to provide reliable forecasts for BYDV in low rainfall zones and for peaks in aphid populations and the need for insecticide applications to control aphid feeding damage.

ACKNOWLEDGMENTS
This work was supported by the Grains Research and Development Corporation. We thank Art Diggle, Phil Michael, Laura Ward, and Plant Virology Technical Staff for their contributions to the work.

KEY WORDS
BYDV, aphids, model, decision support system

GRDC Project Nos: UWA 290 and DAW 609
Paper reviewed by: Roger Jones and Phil Michael
Aeration - opportunity for profit

Christopher Newman, Department of Agriculture

Aeration of grain is a system used extensively in grain harvest and storage systems across the world. It has largely been overlooked in Western Australia because grain was grown in areas where the harvest conditions were reliable and it could be left on the stalk until it was sufficiently dry to deliver it to CBH. However times change, grain is now grown in areas where the harvest weather is less predictable and specific standards dictate greater care in the delivery of the product.

AERATION OPPORTUNITIES TO PROTECT QUALITY

- Rain at harvest creates delays in the operation and can cause the downgrading of premium grain due to fungal staining and sprouting. Aeration extends the harvest day.
- Premium prices are paid for the colour of Shochu barley or pulses for the split pea trade. The longer the grain stands in the paddock, the more the colour is affected. Harvest and store under aeration after maturity.
- Providing year round supply to millers or manufacturers. Grain to be milled for flour retains baking qualities longer when stored cool. After 70 days, grain stored at 30ºC, exhibits increased mixing time, is less extensible, and produces loaves with reduced volume and softness.
- All grains, but particularly canola, generate heat in storage. Hot spots affect grain quality directly and set up favourable conditions for insects and moulds. Aeration equalises the silo temperature.
- High moisture grain is likely to develop moulds in storage. Aeration is essential to protect the grain from storage microflora.
- Aeration cools the grain and reduces damage from insect populations in high through-put storage, typically lot feed operations, where the grain is fed to stock.
- Aeration allows the grain to be stored long term at a weight and quality that will return the greatest profit to your enterprise.

THE AERATION PROCESS

Aeration passes ambient (i.e. unheated) air through bulk grain. As the air passes through the grain, heat and moisture are exchanged between the air and the grain. If the air has low enough relative humidity (RH) compared to the air surrounding the grain, then moisture moves from the grain to the air until equilibrium is reached. This moisture is carried from the silo through an open hatch or exhaust vents.

During this process heat is also lost as the moisture evaporates, cooling the grain. This is the same principle as a canvas waterbag and the grain can be cooled by warm, dry air as well as by cool, moist air. The most rapid cooling effect occurs on high moisture grain.

Aeration keeps temperatures even and cool which preserves the quality of stored grain by slowing the physiological processes of deterioration. Grain stored under aeration can be held safely at a higher moisture content and retain it’s viability and vigour longer.

The success of aeration depends on uniform distribution of air through the grain bulk. A suitable ducting system must be designed and installed, relevant to the aeration outcome, whether this be drying, cooling or storage. Upward flow of air is recommended. The upper levels in a storage vessel are then the last to dry and/or cool and can be checked more easily by the operator.

Exhaust air must be able to escape freely from the top of the storage. Airflow must be sufficient to move the drying and/or cooling front through the grain before spoilage occurs in the upper layers of the grain mass. Airflow is measured in litres per second per tonne (l/s/t), the amount needed depends on the storage strategy.

EARLY HARVESTING

Grain matures before it is ready to be harvested and stored. Harvesting ‘over moisture’ and then drying the grain can effectively preserve the quality of the mature grain. Selected air that has a RH below the RH of the stored grain will commence the drying process.
The initial effect of aeration is equalisation of moisture content throughout the stack. In this process moisture is redistributed from moist grains to dry grains. Sometimes this process may be confused with drying and is most noticeable in early direct harvested canola because of the wide variation of colour and moisture between individual seeds. This equalisation is very dependent on ambient conditions and the same ‘apparent’ drop in total moisture, could take weeks in the absence of low RH or low airflows.

REMOVING SURFACE MOISTURE
When harvesting in the early morning or late evening, dew on the grain surface may elevate the moisture content of the grain. If this grain is harvested and placed immediately under aeration at up to 15% moisture content (mc), it is possible to remove this moisture from the surface of the grain, with airflows of 4-0 l/s/t. Low ambient RH speeds the process.

COOLING
Cooling can be used to hold high moisture grain safely if drying facilities are not immediately available. As well as keeping the grain safe, it evens out temperature and moisture so the dryer operator can maintain constant heat and speed settings. Aeration cooling can also be used to remove heat after grain comes out of a hot-air dryer. This can be used to reduce time spent in the dryer. If high moisture grain is being cooled prior to drying, larger fans and ducts are needed to deliver 4-10 l/s/t because mould growth is much faster in high moisture grain. To hold the grain in a safe condition aim for a temperature of 20ºC at a maximum moisture content of 15%.

DRYING
The equipment used for this process is normally high airflow. Aeration drying can be achieved in Western Australia over time, given the low RH during summer in many parts of the grain belt. Supplemental heating to lower the ingoing RH will accelerate the process. This form of drying is less risky but much slower than hot air-drying and reduces the chance of damaging the milling, baking, malting and germination qualities.

To remove moisture from inside the grain takes longer because the moisture must travel to the grain surface to be evaporated. Moist grain will need airflows in the range 10-20 l/s/t to provide reasonable opportunities for removing moisture. The success of ‘aeration drying’ depends heavily on the availability of suitable air for removing moisture. For example during periods of prolonged rainfall or high humidity, aeration will have little chance of removing moisture from the grain.

LONG TERM STORAGE
Aeration is ideal for preserving grain quality for many months in storage and has the added advantage of slowing the development of insect populations. To hold the grain in a safe condition a fan capacity of 2-3 l/s/t will usually be adequate. This type of storage is particularly useful for lot feeders or piggeries that have a high throughput of grain with limited opportunities for fumigation. Cool grain slows the development of insect populations, minimising damage. It is also useful for preserving the quality of grain for processing and in particular for flour production.

CONCLUSION
Aeration presents many opportunities in Western Australia to increase the profitability of grain production. If you are contemplating using aeration it is suggested that you consult with equipment manufacturers and the Department of Agriculture to determine appropriate strategies for your grain operation. The aeration equipment can be used every year to preserve grain quality and allow a quicker harvest. When the harvesting conditions are difficult it will prove to be of immense value to be able to continue harvesting before rain downgrades the grain.

Paper reviewed by: Dr Graham White, QDPI Toowoomba

There is an extended version of this paper on the Crop Update 2002 CD.
Financial impact of frost on the Western Australian grains industry
Garren Knell and Kim Povey, ConsultAg

KEY MESSAGES
- In an average season the financial cost of lost yield from frost is estimated to be $4.98 million.
- A 1 in 20 year frost in the low rainfall areas of the central region would cause an estimated loss in yield of $44.6 million.
- The opportunity cost of delaying seeding to avoid frost could be $18 million in any given year.
- Throughout the State farmers did not rank frost as an important issue for grain yield and quality, however it was ranked more important in regions where the probability of frost is higher.

INTRODUCTION
Southern areas of the Western Australian wheatbelt regularly receive frost damage. When crop varieties are sown at the correct time for that location the damage from frost is usually relatively minor, and confined to high risk areas that are low in the landscape, and have a sandy surface. However on occasions severe frosts cause wide spread yield loss, such as that observed in the Lakes District in 1998 and 1999. The aim of this report was to quantify the financial impact of frost on the Western Australian grains industry, and to point out future research priorities.

METHODOLOGY
In determining yield losses across agricultural regions we developed frost risk matrixes based on:
1. known frost damage levels at varying temperatures;
2. crop development rate in each region;
3. landscape effects.

The matrixes were validated by researchers and Agronomists (Foley, White, Sermon, Knell, Curtin).

The shape of the matrix varies according to crop type and region. Samples of estimated frost damage are displayed in Figure 1.

Australian Rainman (V3.3) was used to estimate the probabilities of a seeding opportunities in a location and to determine how long on average a farmer would have to wait until there was a follow up rainfall event to provide a second seeding opportunity. The opportunity cost of not sowing on the break of season but waiting until a second seeding opportunity when the frost risk is lower was estimated using a yield loss of 20 kg/ha/day.

Two hundred and seventy farmers from across the State were surveyed to see how Western Australian farmers rank the importance of frost for grain yield and quality against other crop perils and production issues. Farmers were asked to rank the importance of frost against leaf disease, weather damage, weed control, tillage practice, root disease, crop nutrition and insect control on grain yield and quality.

RESULTS AND DISCUSSION
In Western Australia the loss of yield has a far greater financial ramification than the loss of grain quality. Wheat accounts for 85% of the value of the loss due to the crop sensitivity to frost and the scale of planting. The two regions of the State that contribute to most of the losses due to frost are the WA Central Low (48%) and the WA Central Medium (20%). The WA Central Low region has the highest average annual frost cost per business ($4,400). After a 1 in 20 or a 1 in 60 year frost event the average farmer in the WA Central Low region is estimated to loose $89,000 and $268,000 respectively. In low rainfall regions, the financial impact of frost on the farm business can be more severe than higher yielding regions because there is a greater likelihood of returning a negative gross margin.

Figure 1 shows the frost yield loss matrix for wheat and barley in the Central High South region. They are contrasted to illustrate the crop damage potential differences between crops. Barley is less
susceptible to frost because early head development occurs in the boot. Consequently, the matrix is narrower and potential damage is less.

You should read the charts in the following way. At the ‘arrow point’ on graph B, the potential yield loss is 30% for a temperature event of -2.0°C between 1 and 9 September.

![Graph A](image1.png) ![Graph B](image2.png)

**Figure 1.** Potential frost damage to wheat (A) and barley (B) - Central high south region.

**Opportunity cost of delaying seeding**

To date the main strategy used to reduce frost risk is to delay seeding. Farmers often miss seeding opportunities in late April or early May to reduce the risk of their wheat flowering when the probability of frost is high. The cost in lost yield associated with delaying seeding is estimated to be as high as $18.4 million per annum. Seasons with early sowing opportunities can account for up to 80% of long term farm income, hence the impact on farm financial positions can be significant. In years where early seeding opportunities are missed in order to minimise the risk of frost damage to wheat the opportunity cost is large ($53/ha). On average the yield penalty for delaying sowing of wheat is $12/ha.

**Importance of frost vs other perils and production issues**

The survey results indicate that across the State farmers feel that the most important factors for grain yield and quality are crop nutrition, leaf disease, weed control and root disease, respectively. Farmers did not place a high priority on frost for its influence on grain yield and quality. This is because many areas of the State don't receive regular or severe frost damage. When looking at the sample of farmers who indicated that they receive regular frost, the importance of frost to their grain production was much higher than those farmers who rarely receive frost damage. Of the 270 farmers surveyed only 75 farmers indicated that they received regular frost damage. Farmers in the central areas (high medium and low rain fall) and the eastern areas of Western Australia gave frost a higher ranking than farmers in the north of the State although frost still did not rank in the top 3 issues for grain yield or quality.

**CONCLUSION AND RESEARCH NEEDS**

The Western Australian grains industry is now more exposed to severe frosts due to increased crop area, improved crop yield potential and technological advancements in recent history. These advances in technology have resulted in earlier sowing opportunities and a narrower flowering window.

It is important for farmers to know their frost risk (across farm and individual paddocks) and to also understand the ability of their business to survive an income shock. On average it will be much more profitable for a farmer to sow early, however on high risk paddocks or within high risk businesses delaying seeding on at least a portion of the program may be more economically sustainable.

Future research should focus on alleviating the impact of the 1 in 5 to 1 in 20 year frost events. This should be achieved with a mix of breeding and agronomic research, changing farmer practices and options to avoid frost and the use of climatic and landscape analysis to predict high frost prone areas and events. Research funds could be directed to leading grower groups located in high frost risk areas to evaluate frost minimisation techniques, such as row spacing, claying, nutritional interactions and stubble removal on their own farms.

*A copy of the full report can be obtained from ConsultAg.*
Summary of 2001 weather and seasonal prospects for 2002

David Stephens, Department of Agriculture

KEY MESSAGE

The recent evolution in oceanic and atmospheric circulation patterns suggest that weak El Nino-type conditions are most likely to develop in the next 3-6 months. If this occurs, average to much below average rainfall is likely to occur over the next year in the south west of Western Australia. A conservative approach to cropping, especially in relation to inputs, would be appropriate in low rainfall areas (< 350 mm annual rainfall). Reducing moisture stress on crops later in the season through good weed control, minimum tillage and early sowing of long season varieties are recommended.

AIMS

This paper's aims to review the variable weather in 2001, prospects for 2002 and implications for farming in 2002.

METHODS

Rainfall for 2001 is reviewed and compared to ocean/atmosphere indicators in the Australian/Pacific region. Present conditions are reviewed along with a summary of what the majority of the forecasting models are predicting.

These predictions are compared to indicators developed in the Department of Agriculture - El Nino Prediction Index (EPI), Mid Latitude Southern Oscillation Index (MLSOI). The EPI is the largest three month mean pressure anomaly averaged at Alice Springs and Mildura between July and September, whilst the MLSOI is the standardised difference in pressure between south eastern Australia (Alice Springs and Mildura) and Rapa Island in the central South Pacific. Generally a very negative EPI (low pressure over south eastern Australia) precedes a large see-saw in pressure between Australia and the South Pacific. This results in pressures rising over Australia and falling over the Pacific Ocean and typically coincides with the development of El Nino conditions and drier weather over many parts of Australia. This see-saw in pressure is best measured by the MLSOI, with positive values generally indicating low pressure and wet conditions over Australia and negative values indicating high pressure and dry conditions. The traditional Southern Oscillation Index (SOI) is the standardised pressure difference at about 10-15°S between Darwin and Tahiti, while an Equatorial SOI (EQSOI) measures the equivalent see-saw in pressure along the equator between Indonesia and the eastern Pacific.

RESULTS

The growing season rainfall in 2001 was generally in the lowest 30% of readings, but this ranged from the driest 10% of years in the far south west and north east, average in the far north west, to above average in the far south east. However, the distinguishing feature of the 2001 season was the remarkable rainfall distribution. To the end of July, almost the whole wheatbelt had recorded the driest four month start to the crop season ever. Record dry June rainfall was recorded for most stations and the 5-8 mm recorded at many centres was well below the previous record. At this time, a majority of farmers were hand-feeding stock, with concerns in worst affected areas that crops would actually die. The turn-around that followed was one of the best in living memory. Record daily rainfalls were recorded at the very end of July and this was followed by good finishing rains that carried through to October/November. Many parts of the wheatbelt recorded the wettest three months ever between 6 October-6 December and grain quality became a problem in the south east and north west.
Figure 1. A comparison of the SOI with a mid latitude (MLSOI) and equatorial (EQSOI) equivalents over the last 2 years.

The broad-scale ocean/atmosphere pattern in the Pacific Ocean had a gradual change from La Nina conditions to more normal conditions through 2001. The EPI in late 2000 was the 9th lowest since 1950 and indicated that there was a 2/3 chance of a large see-saw in pressure and an associated El Nino developing later in 2001. As it turned out, the large see-saw in pressure did occur, but further south than expected. In the first half of the year, pressures rose dramatically south of the Australian bight, which blocked frontal activity and rain bearing depressions travelling towards south western Australia. However, the beginnings of El Nino-type conditions collapsed in late July/early August and this coincided with a turn-around to lower pressures and above average rainfall in the Australian region in spring. The MLSOI and SOI trended down until July, but then trended up in the second half of the year, whilst the more stable EQSOI has been gradually trending down over the last year (Figure 1).

In late 2001, the EPI was only slightly negative which normally suggests that there is a wide range of conditions to follow with a moderately higher chance of warming in the equatorial eastern Pacific. In December the MLSOI, EQSOI and SOI fell dramatically (Figure 1) and a warm pulse of deep water started to move east across the equatorial Pacific in December/January - a precursor to El Nino type conditions. Most statistical and coupled atmosphere-ocean models are predicting normal to moderate warming in the eastern Equatorial Pacific (El Nino) in the next 6 months. El Nino events in the past, which followed similar values of the EPI (measured in 2001), were moderate to weak in strength (1991, 1987, 1976, 1969 and 1953). Very dry conditions occurred in the Western Australian wheatbelt in 1969, 1976 (north) and 1987 (south), whereas the other two years had average to slightly below average rainfall (1991) and average to slightly above average (1953). Thus drier conditions are more likely and farming practices that efficiently use moisture and keep input costs down (minimum tillage, good weed control, early sowing) are recommended. In wetter districts cropping more waterlogging prone paddocks may be appropriate.

CONCLUSION

In 2001 a very dry start and then a good finish was related to a large see-saw in pressure in the southern mid latitudes that ultimately failed to develop into El Nino type conditions. At this early stage in the year, there appears to be more conducive set-up in the Pacific Ocean for a weak El Nino to develop in 2002. If this does develop, a conservative farming approach should be adopted in the more water limiting regions as weak El Ninos are more often than not related to drier conditions in Western Australia. If the El Nino fails to materialise in autumn, there is a higher probability of more normal rainfall being received in the growing season.

KEY WORDS
forecasting, rainfall, weather, outlook

Project No.: GCW - Grains Climate and Weather
Paper reviewed by: David Tennant