Comparative yield physiology of spring and winter wheat in a semi-arid Mediterranean environment

David Cann1, James Hunt1, Felicity Harris2, Kenton Parker3,4

1Department of Animal, Plant and Soil Sciences, La Trobe University, Melbourne, VIC, Australia; 2NSW Department of Primary Industries, Wagga Wagga Agricultural Institute, Wagga Wagga, NSW, Australia; 3Crop Sciences, Agrosciences Group, South Australian Research and Development Institute, Unley, SA, Australia,

*School of Agriculture, Food & Wine, Waite Research Institute, The University of Adelaide, Urrbrae, SA, Australia

E-mail: D.Cann@latrobe.edu.au

Introduction

• In semi-arid (200 – 400 mm rainfall p.a.) southern Australia, spring wheat is sown in late autumn (April-May)

• Sowing earlier than this period can increase wheat yield despite a decline in growing season rainfall since 1990

• Stable flowering time of winter wheat (WW) makes it more suited to early sowing than spring wheat (SW)

• Despite a longer growing season, poor harvest index often prevents early-sown WW from yielding more than SW

• Aim: determine if different phenotypic traits are important for yield in early-sown WW compared to later-sown SW

• Hypothesis: accumulation traits more important for yield in WW; partitioning traits more important in WW

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<thead>
<tr>
<th>Vernalisation</th>
<th>SPRING WHEAT</th>
<th>WINTER WHEAT</th>
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<tbody>
<tr>
<td>Weak requirement</td>
<td>Strong requirement</td>
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<thead>
<tr>
<th>Flowering time</th>
<th>SPRING WHEAT</th>
<th>WINTER WHEAT</th>
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<tbody>
<tr>
<td>Dependent on sowing date</td>
<td>Stable across sowing dates</td>
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<tr>
<th>Traditional regions</th>
<th>SPRING WHEAT</th>
<th>WINTER WHEAT</th>
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<tbody>
<tr>
<td>Low-, mid-, high-rainfall</td>
<td>High-rainfall zones</td>
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<thead>
<tr>
<th>Breeding effort</th>
<th>SPRING WHEAT</th>
<th>WINTER WHEAT</th>
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<tr>
<td>High</td>
<td>Low</td>
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<tr>
<th>Released cultivars</th>
<th>SPRING WHEAT</th>
<th>WINTER WHEAT</th>
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<tr>
<td>189</td>
<td>20 (&lt;10 suited to semi-arid zone)</td>
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Important traits for yield (hypothesised)

- Accumulation (biomass, growth rate)
- Partitioning (harvest index, fruiting efficiency)

Methods

1. Cross between two elite SW cultivars: Mace & Gauntlet
   Progeny = 75% SW; 25% WW

2. Progeny put through single-seed descent and phenotyped in glasshouse for winter habit up to F5 generation

3. 2018: 42 WW (sown 15 Apr) and 24 SW (30 Apr) selections in partially-replicated field experiment at Birchip, VIC

4. 11 WW and 10 SW lines selected for replicated experiment based on synchronous heading

5. 2019: Fully replicated plot experiment at Birchip, VIC. WW sown 15/4; SW sown 8/5

Measurements

- Z39 (flag leaf emerge) biomass
- Z55 (50% heading) biomass
- Anthesis spike biomass (SPWa)
- Anthesis spike (SPWa) date
- Harvest biomass
- Yield & components
- Harvest index – HI
- Harvest index – FE (grain no./SPWa)
- Fruiting efficiency – FE

Statistics

- Spatial analysis (ASReml)
  - Row & Col – Random effects
  - Block – Random effects
  - Line – Fixed effects
  - Habit (SW/WW) – Fixed effect
  - Linear regressions
  - Analysis of parallelism
  - Only synchronously-heading WW and SW lines included in linear regressions

Results & Conclusions

- Grain yield, grain number, HI & FE higher in SW than WW
- R2 higher in SW than WW for biomass & grain weight
- Significant yield-grain weight regression in SW; not WW
- R1 higher in WW than SW for HI & FE (partitioning traits)
- Significant yield-trait regressions for HI & FE in WW; not SW
- Low yield variation in SW makes it difficult to draw conclusions about traits important for yield in SW
- Strong yield – HI/FE relationships in WW – possible traits for early-generation selection

References


- Grain yield (g/m²)
  - SW mean
  - WW mean
  - SW slope
  - WW slope

- Harvest biomass (g/m²)
  - SW mean
  - WW mean

- Harvest index
  - SW mean
  - WW mean

- Fruiting efficiency
  - SW mean
  - WW mean

- 1000-grain weight
  - SW mean
  - WW mean

- Grain no (grains/m²)
  - SW mean
  - WW mean

Different letter groups are statistically different at p < 0.05 *p < 0.01 **p < 0.001 ***p < 0.001