Exploitation of synthetic wheat for improvement of drought tolerance

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Plant Breeding for Drought Tolerance
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Overview

- Definition of synthetic wheat
- Experimental approach
- Results to date
- Future research
Types of wheat:

- Durum (Noodle) wheat = tetraploid wheat
  Genome - AABB
- Bread wheat = hexaploid wheat
  Genome – AABBDD
- Synthetic wheat
  \((\text{AABB}) \times \text{DD}(\text{Aegilops tauschii})\)

- introduce phenotypic variation not found in local varieties

Bread wheat vs. Ae. tauschii
Overview

- Definition of synthetic wheat
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Field Studies

- 400 CIMMYT synthetics to choose from
- Back-cross derived families were created
  (Synthetic 166, 194, 274, 303, 356, 370) = 12 populations
  x ('Goodstreak', 'Hatcher') (Benziger 2004, Haley 2005)
6 synthetics and 4 cultivars; Hatcher, Goodstreak, ‘Ripper’, and ‘Byrd’ (Haley, 2007 & 2011)

6 replicated split-plots
  • Well-watered treatment – Saturated daily
  • Drought treatment – Withheld water after 10 days
    • Treatment duration – 3 weeks
Measurements

- Leaf growth rate
- Relative water content
- Water-loss (Tube weight)
- Root & shoot biomass
- Stomatal attributes
- Osmotic potential
- Root morphology
  - For each 1/3 section
  - WinRhizo
WinRhizo
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Classifying Drought Response

% Δ in RWC under water stress

Sensitive group  Tolerant group

Byrd  GS  Hatcher  Ripper  SYN166  SYN194  SYN274  SYN303  SYN356  SYN370
Production of Root Biomass

- **G** NS
- **T** ***
- **GxT** *

Root BM (g)

- **G** *
- **T** ***
- **GxT** NS

Root Depth (cm)

- **G** **
- **T** *
- **GxT** NS

- **GxT** NS

Root Section

- 0.33 cm
- 33.66 cm
- 66+ cm
- Total cm

Irrigated vs. Stressed Treatment
Difference in Root Length

Irrigated Treatment

Tolerant

Sensitive

- Diameter (mm)
  - 1.0+
  - 0.75 – 1.0
  - 0.50 – 0.75
  - 0.25 – 0.50
  - 0.0 – 0.25

Stressed Treatment

Tolerant

Sensitive

- 0-33 cm
- 33-66 cm
- 66+ cm
Stomatal Traits

Stomatal Conductance

- Sensitive
- Tolerant

Stomatal Aperture

- Sensitive
- Tolerant

High density stomates

Low density stomates
Osmotic Adjustment

The diagram illustrates the relationship between relative water content (RWC) and osmotic potential (OP) for various treatments. The graph shows multiple lines, each representing different treatments such as Byrd, Ripper, SYN194, SYN274, SYN303, SYN370, and Hatcher. Each line is associated with specific data points labeled with numbers 1 to 10.
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Future study

- In-field testing of selected lines for yield
- Select single plants from BC$_1$ population for genotyping-by-sequencing
- Identify synthetic genome regions contributing to yield and drought tolerance improvement
Conclusions

- Certain synthetic lines may improve overall yield and productivity under drought
- Capacity of roots to capture soil moisture is critical for productivity under drought
- Molecular research is needed for efficient introgression of synthetic traits
Thank you!

- Pat Byrne
- Scott Haley
- Stephen Baenziger
- Judy Harrington
- Byrne lab workers

- Bill Bauerle
- John McKay
- Scott Reid
- Graduate students
Selected three synthetic populations for advancement - SYN194, SYN274, SYN356

<table>
<thead>
<tr>
<th>Family / Genotype</th>
<th>Avg. Yield (kg/ha)</th>
<th>% of Hatcher</th>
</tr>
</thead>
<tbody>
<tr>
<td>H/SYN 194-454</td>
<td>5064.7</td>
<td>104</td>
</tr>
<tr>
<td>H/SYN 274-1153</td>
<td>5051.2</td>
<td>103</td>
</tr>
<tr>
<td>H/SYN 274-1154</td>
<td>4977.2</td>
<td>102</td>
</tr>
<tr>
<td>Hatcher</td>
<td>4889.8</td>
<td>100</td>
</tr>
</tbody>
</table>

Yield trials
- Based on yield over 8 environments in 2010-2011
Response to drought

Relative Water Content and biomass traits
Response to drought

Relative Water Content and physiology traits

The image shows a scatter plot comparing the relative water content and physiology traits under irrigated and stressed conditions. The plot is divided into two components, Component 1 and Component 2, with Component 1 showing 44% and Component 2 showing 23% of the variation. The plots indicate changes in traits such as BSAP, TSD, RWC, and others, under different conditions.