Testing the response of wheat models to heat stress at anthesis and grain filling

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Crop models for assessing climate impacts on crop production.

However, uncertainties of crop models have been reported, especially under extreme high temperature.

**Objective:**

To evaluate the response of wheat models to heat stress at anthesis and grain filling stages and identify gaps for crop model improvement.
## Methods

### Environmental controlled phytotron experiments

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Growing season</th>
<th>Site</th>
<th>Starting time of treatment</th>
<th>Duration</th>
<th>Temperature regime ($T_{\text{min}}/T_{\text{max}}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yangmai16</td>
<td>2010-2011</td>
<td>Nanjing</td>
<td>Anthesis, Grain filling</td>
<td>D1 (3d), D2 (6d)</td>
<td>T1 (17°C/27°C), T2 (21°C/31°C), T3 (25°C/35°C), T4 (29°C/39°C)</td>
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<td>2013-2014</td>
<td>Rugao</td>
<td>Anthesis, Grain filling</td>
<td>D1 (3d), D2 (6d), D3 (9d)</td>
<td>T1 (17°C/27°C), T3 (25°C/35°C), T4 (29°C/39°C), T5 (33°C/43°C)</td>
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Methods

- **Wheat crop models:**
  1. DSSAT-CERES-Wheat
  2. DSSAT-Nwheat
  3. APSIM-Wheat
  4. WheatGrow

- **HDD**: degree days above 30°C
Results - Grain filling duration

- **Cultivar:**
  - ○ Yangmai16
  - △ Xumai30
Results - Total above-ground biomass

<table>
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<tr>
<th>Observed</th>
<th>Simulations</th>
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Cultivar: ○ Yangmai16 ▲ Xumai30
Results - Leaf area index (LAI) dynamic

Observed = symbols      Simulation = lines
Results - Grain yield

Observed | Simulations ...

Cultivar: ○ Yangmai16  △ Xumai30
Results - Grain number

Cultivar: ○ Yangmai16  △ Xumai30
Results - Grain size

Observed | Simulations ...

Cultivar: ○ Yangmai16 △ Xumai30
Conclusions

- Heat stress at anthesis reduced observed grain numbers and grain size, while heat stress during grain filling mainly decreased the grain size.

- The tested 4 models could reproduce some of the observed reductions in grain filling duration, final total aboveground biomass and grain yield due to heat stress.

- Most of the crop models tended to reproduce heat stress impacts better during grain filling than at anthesis.

- Some of models require improvements in the response to heat stress during grain filling, but all models need improvements in simulating heat stress effects on grain set during anthesis.

- The observed genetic variability in wheat response to heat stress needs to be considered in future simulation studies.